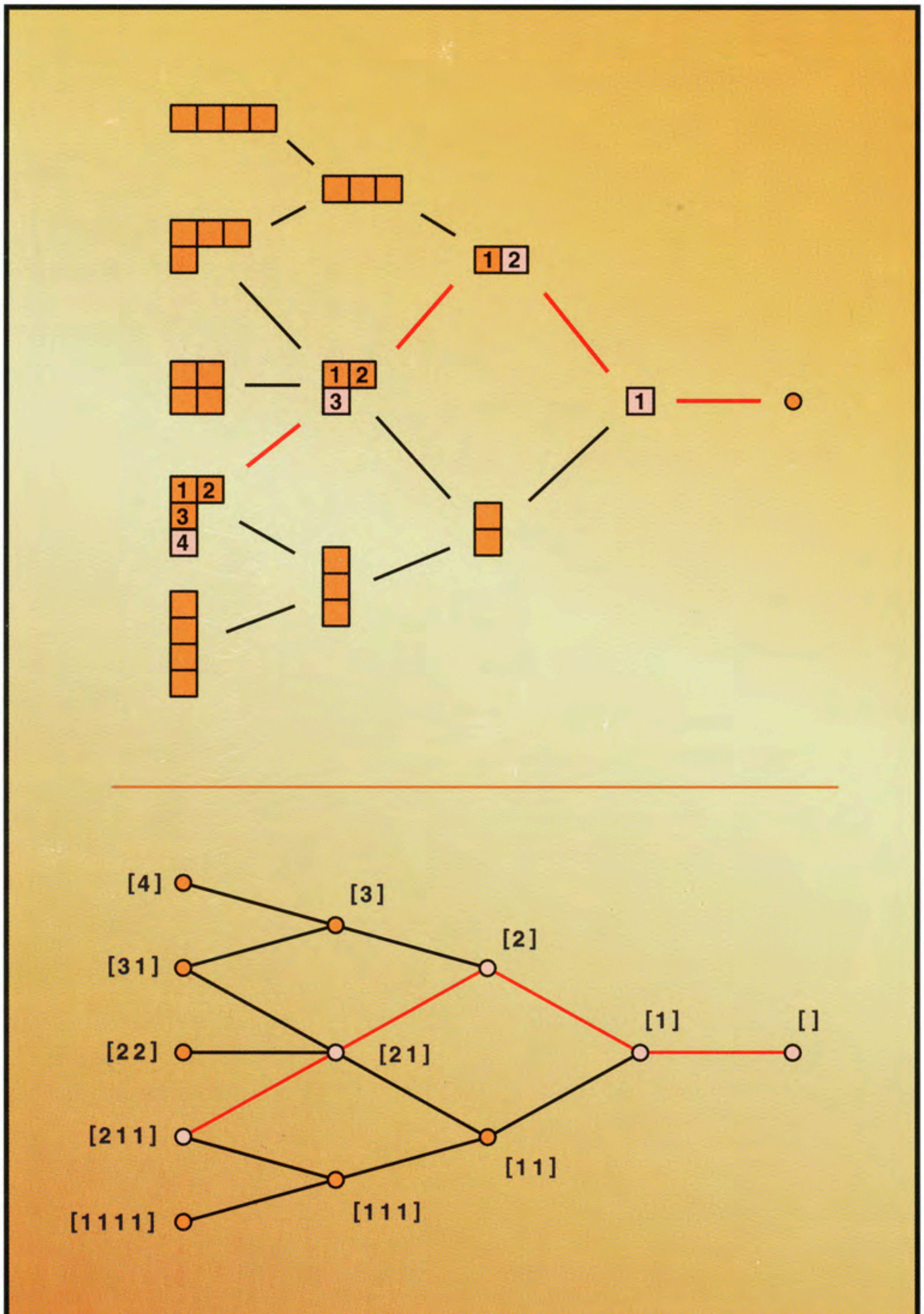
ISSN 0002-9920

Notices

of the American Mathematical Society

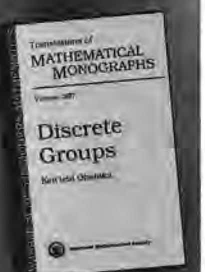
November 2001 Volume 48, Number 10

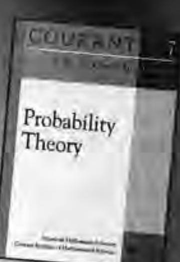


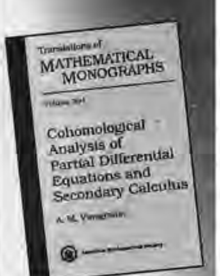
Young tableau and Bratteli diagram (see page 1193)

American Mathematical Society

New Titles from the AMS







Ramanujan: Essays and Surveys

Bruce C. Berndt, *University of Illinois, Urbana-Champaign,* and **Robert A. Rankin**, *University of Glasgow, Scotland*, Editors

This book contains essays on Ramanujan and his work that were written especially for this volume. It also includes important survey articles in areas influenced by Ramanujan's mathematics. Most of the articles in the book are nontechnical, but even those that are more technical contain substantial sections that will engage the general reader.

This volume complements the book *Ramanujan: Letters and Commentary*, Volume 9, in the AMS series, History of Mathematics. For more on Ramanujan, see these AMS publications *Ramanujan: Twelve Lectures on Subjects Suggested by His Life and Work*, Volume 136.H, and *Collected Papers of Srinivasa Ramanujan*, Volume 159.H, in the AMS Chelsea Publishing series.

Copublished with the London Mathematical Society. Members of the LMS may order directly from the AMS at the AMS member price. The LMS is registered with the Charity Commissioners.

History of Mathematics; 2001; 347 pages; Hardcover; ISBN 0-8218-2624-7; List $79; All AMS members $63; Order code HMATH-BERNDT2NT111

Classical Groups and Geometric Algebra

Larry C. Grove, *University of Arizona, Tucson*

"Classical groups", named so by Hermann Weyl, are groups of matrices or quotients of matrix groups by small normal subgroups.

Thus the story begins, as Weyl suggested, with "Her All-embracing Majesty", the general linear group $GL_n(V)$ of all invertible linear transformations of a vector space V over a field F. All further groups discussed are either subgroups of $GL_n(V)$ or closely related quotient groups.

This text provides a single source for the basic facts about the classical groups and also includes the required geometrical background information from the first principles. It is intended for graduate students who have completed standard courses in linear algebra and abstract algebra. The author, L. C. Grove, is a well-known expert who has published extensively in the subject area.

Graduate Studies in Mathematics, Volume 39; 2002; 169 pages; Hardcover; ISBN 0-8218-2019-2; List $35; All AMS members $28; Order code GSM/39NT111

Discrete Groups

Ken'ichi Ohshika, *Osaka University, Japan*

This book deals with geometric and topological aspects of discrete groups. The main topics are hyperbolic groups due to Gromov, automatic group theory, invented and developed by Epstein, whose subjects are groups that can be manipulated by computers, and Kleinian group theory, which enjoys the longest tradition and the richest contents within the theory of discrete subgroups of Lie groups. The volume would make a fine textbook for a graduate-level course in discrete groups.

Translations of Mathematical Monographs (*Iwanami Series in Modern Mathematics*); 2002; approximately 207 pages; Softcover; ISBN 0-8218-2080-X; List $34; All AMS members $27; Order code MMONO-OHSHIKANT111

Probability Theory

S. R. S. Varadhan, *New York University - Courant Institute of Mathematical Sciences*

This volume presents topics in probability theory covered during a first-year graduate course given at the Courant Institute of Mathematical Sciences. The necessary background material in measure theory is developed, including the standard topics, such as extension theorem, construction of measures, integration, product spaces, Radon-Nikodym theorem, and conditional expectation.

Additional topics covered in the book include stationary Gaussian processes, ergodic theorems, dynamic programming, optimal stopping, and filtering. A large number of examples and exercises is included. The book is a suitable text for a first-year graduate course in probability.

Courant Lecture Notes, Volume 7; 2001; 167 pages; Softcover; ISBN 0-8218-2852-5; List $24; All AMS members $19; Order code CLN/7NT111

Cohomological Analysis of Partial Differential Equations and Secondary Calculus

A. M. Vinogradov, *University of Salerno, Baronossi (SA), Italy*

This book is dedicated to fundamentals of a new theory, which is an analog of affine algebraic geometry for (nonlinear) partial differential equations. This theory grew up from the classical geometry of PDE's originated by S. Lie and his followers by incorporating some nonclassical ideas from the theory of integrable systems, the formal theory of PDE's in its modern cohomological form given by D. Spencer and H. Goldschmidt and differential calculus over commutative algebras (Primary Calculus). The main result of this synthesis is Secondary Calculus on diffieties, new geometrical objects which are analogs of algebraic varieties in the context of (nonlinear) PDE's. Secondary Calculus surprisingly reveals a deep cohomological nature of the general theory of PDE's and indicates new directions of its further progress. Recent developments in quantum field theory showed Secondary Calculus to be its natural language, promising a nonperturbative formulation of the theory.

In addition to PDE's themselves, the author describes existing and potential applications of Secondary Calculus ranging from algebraic geometry to field theory, classical and quantum, including areas such as characteristic classes, differential invariants, theory of geometric structures, variational calculus, control theory, etc. This book, focused mainly on theoretical aspects, forms a natural dipole with *Symmetries and Conservation Laws for Differential Equations of Mathematical Physics*, Volume 182 in this same series, Translations of Mathematical Monographs, and shows the theory "in action".

Translations of Mathematical Monographs; 2001; approximately 264 pages; Hardcover; ISBN 0-8218-2922-X; Order code MMONO-VINOGRADOVNT111

AMS
American Mathematical Society

To order, call: 1-800-321-4AMS (4267), in the U.S. and Canada, or 1-401-455-4000; fax: 1-401-455-4046; email: cust-serv@ams.org. Visit the AMS Bookstore and order online at www.ams.org/bookstore. Or write to: American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294. Prices subject to change without notice.

MATHEMATICS from Birkhäuser

S. Antontsev, *University of Beira Interior, Covilha, Portugal,* S. Shmarev, *Universidad de Oviedo, Spain and* J.I. Diaz, *Universidad Complutense de Madrid, Spain*

Energy Methods for Free Boundary Problems

Applications to Nonlinear PDEs and Fluid Mechanics

This book is an integrated account of modern developments in energy methods for the study of free boundary problems in partial differential equations. The theory presented has particular relevance to a number of physical applications, including heat conductivity, surface and underground water flow, gas flow, and gas filtration with absorption.

Energy Methods for Free Boundary Problems will appeal to applied mathematicians and graduate students whose research is in partial differential equations, nonlinear analysis, and continuum mechanics. Applications to a number of different problems arising in continuum mechanics (fluid dynamics) are presented, making this book of equal interest to physicists and engineers as well.

2001/350 PP./HARDCOVER/ISBN 0-8176-4123-8/$59.50 (TENT.)
PROGRESS IN NONLINEAR DIFFERENTIAL EQUATIONS

Yves Nievergelt, *Eastern Washington University, Cheney, WA*

Foundations of Logic and Mathematics

Applications to Computer Science and Cryptography

Foundations of Logic and Mathematics takes into account not only theory, but also treats in some detail applications that have substantial impact on everyday life-for example, bar codes, public cryptography (Rivest-Shamir-Adelman codes), transportation networks.

The text is a college level introduction to logic, proofs, sets, number theory, and graph theory, for undergraduates majoring in mathematics, computer science, and computer information systems.

2001/480 PP./HARDCOVER/ISBN 0-8176-4249-8/$64.95 (TENT.)

Green Sale 2001

Big savings on 30 excellent titles spanning the spectrum of Mathematics! For more information please visit our website www.birkhauser.com

Sale prices valid only in North, Central and South America and expire December 31, 2001.

Forthcoming!

Bernd S.W. Schroeder, *Louisiana Tech University, Ruston, LA*

Ordered Sets

An Introduction

This work is an introduction to the basic tools of the theory of (partially) ordered sets such as visualization via diagrams, subsets, homomorphisms, important order-theoretical constructions, and classes of ordered sets. Using a thematic approach, the author presents open or recently solved problems to motivate the development of constructions and investigations for new classes of ordered sets.

Since there are few prerequisites, the text can be used as a focused follow-up or companion to a first proof (set theory and relations) or graph theory class.

Rich in exercises, illustrations, and open problems, *Ordered Sets: An Introduction* is an excellent text for undergraduate and graduate students and a good resource for the interested researcher. Readers will discover order theory's role in discrete mathematics as a supplier of ideas, as well as an attractive source of applications.

DECEMBER 2001/420 PP., 35 ILLUS./HARDCOVER
ISBN 0-8176-4128-9/$49.95 (TENT.)

Forthcoming!

Shrawan Kumar, *University of North Carolina, Chapel Hill, NC*

Kac-Moody Groups, their Flag Varieties and Representation Theory

This is the first monograph to exclusively treat Kac-Moody (K-M) groups, a standard tool in mathematics and mathematical physics.

Kac-Moody Groups, their Flag Varieties and Representation Theory is suitable for an advanced graduate course in representation theory, and contains a number of examples, exercises, challenging open problems, comprehensive bibliography, and index. No prior knowledge of K-M Lie algebras or of (finite-dimensional) algebraic groups is required, but some basic knowledge would certainly be helpful. For the reader's convenience some of the basic results needed from other areas, including ind-varieties, pro-algebraic groups and pro-Lie algebras, Tits systems, local cohomology, equivariant cohomology, and homological algebra are included.

DECEMBER 2001/450 PP./HARDCOVER/ISBN 0-8176-4227-7
$59.95 (TENT.)
PROGRESS IN MATHEMATICS

Birkhäuser
Boston · Basel · Berlin

Forthcoming!

David E. Blair, *Michigan State University, East Lansing, MI*

Riemannian Geometry of Contact and Symplectic Manifolds

This monograph deals with the Riemannian geometry of both symplectic and contact manifolds, with particular emphasis on the latter.

The book will serve both as a general source for mathematicians requiring a reference to the basic properties of symplectic and contact manifolds and it will be an excellent resource for graduate students and those working in the Riemannian geometric arena. The prerequisite for understanding this text is a basic course in Riemannian geometry.

DECEMBER 2001/304 PP./HARDCOVER/ISBN 0-8176-4261-7
$64.95 (TENT.)
PROGRESS IN MATHEMATICS

Forthcoming!

Steven G. Krantz, *Washington University, St. Louis, MO*

Handbook of Logic and Proof Techniques for Computer Science

The book is an excellent resource for the working mathematical scientist. Graduate students, practitioners and professionals in computer science and engineering, or the systems scientist who needs a quick sketch of a key idea from logic, will find it in this self-contained, accessible, and easy-to-use reference.

DECEMBER 2001/264 PP., 16 ILLUS./HARDCOVER
ISBN 0-8176-4220-X/$49.95

Also by Krantz!

Handbook of Complex Variables

"...It collects the basic results in a very well organized form. Comprehensive table of contents and a detailed glossary help to use the book as a reference source...there are several concrete examples sometimes with pages of computation...an excellent handbook..."

–ACTA SCI. MATHEMATICARUM

1999/320 PP., 102 ILLUS./HARDCOVER/ISBN 0-8176-4011-8
$69.00

www.birkhauser.com

TO ORDER:

CALL: 1-800-777-4643

FAX: (201) 348-4505

E-MAIL: orders@birkhauser.com

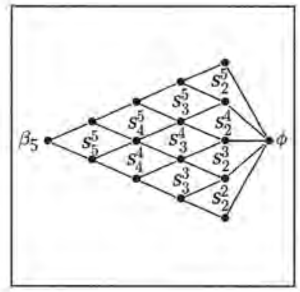
Prices are valid in North, South and Central America only and are subject to change without notice. For price and ordering information outside North America, please contact Birkhäuser Verlag AG, P.O. Box 133, CH-4010 Basel, Switzerland. Phone +41-61-205 0707; Fax +41-61-205 0792 or E-mail: orders@birkhauser.ch.

11/01 Promotion #Y4125

Notices
of the American Mathematical Society

November 2001

Feature Articles



Communications

Commentary

The American Mathematical Society is grateful to mathematicians around the world for their condolences and expressions of support for America in the wake of the tragic events on September 11, 2001.

—Hyman Bass, AMS President

Notices
of the American Mathematical Society

SUBSCRIPTION INFORMATION: Subscription prices for Volume 49 (2002) are $360 list; $288 institutional member; $216 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—$17; in India—$38; expedited delivery to destinations in North America—$35; elsewhere—$75. Subscriptions and orders for AMS publications should be addressed to the American Mathematical Society, P.O. Box 845904, Boston, MA 02284-5904. 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 e-mail at notices@math.tamu.edu, by fax at 979-845-6028, or by postal mail at Department of Mathematics, Texas A&M University, College Station, TX 77843-3368. E-mail 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* is published monthly except bimonthly in June/July by the American Mathematical Society at 201 Charles Street, Providence, RI 02904-2294. 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.] 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, e-mail: notices@ams.org.

Departments

From the AMS Secretary

A Time of Opportunity at NSF

The Division of Mathematical Sciences (DMS) at the National Science Foundation (NSF) relies on the perspective and fresh thinking of temporary program directors, or "rotators", to help manage its programs and grant proposals. These rotators are recruited from the universities for one- or two-year terms. According to Bob Eisenstein, who heads the Directorate for Mathematical and Physical Sciences (MPS), good rotators are always in short supply and are needed to apply this fall for positions that will become vacant the following fall. The term of Philippe Tondeur as director of DMS will end in July 2002, when a new director will be needed.

The presence of active researchers as DMS program directors has grown more important. The NSF budgeting process begins with a thought exercise of imagining cutbacks of roughly 20 percent; directors are then asked how they would build that amount back by funding the most exciting new ideas. The presence of rotators, fresh from their own research programs, contributes to the success of this process.

Rotators typically manage research programs that include but are not confined to their specialty. Of current DMS program directors, thirteen are rotators and eight are permanent staff, many of whom are former rotators. To fill each position, DMS finds that it has to contact about twenty people—a substantial effort.

Are the DMS rotators worth this effort? I would argue that the answer is yes. Permanent staffers are, of course, essential. These are the people who provide continuity, understand NSF structure, contribute to NSF's scientific and intellectual mission, and see new ideas through. Rotators, however, are NSF's eyes and ears into the research community. Only when program directors are intellectually involved in mathematics does NSF have the insight to pursue the most promising directions.

There is no doubt that the rotator's job is demanding. DMS receives about 2,000 proposals a year and supports close to 70 percent of the nation's mathematics research at universities. (This figure has increased with the decline in support from the Department of Defense.) Each program director handles about one hundred proposals a year, choosing reviewers, sending proposals for review, deciding on awards, documenting decisions, and writing well-documented (and diplomatic) refusal statements.

This heavy workload is one reason it is difficult to recruit top-caliber rotators, but the more common reason is that people do not want to interrupt their research at what may be the height of their careers. Most rotators find some time for their own work (NSF provides personal time, which some save to use in the summer), but determination is required to sustain research momentum.

Even so, most rotators value their time in Washington. Some find their own research is enriched by evaluating proposals and planning new initiatives. Others broaden their understanding of their field and help to define the future of mathematics. Still others find that making new professional contacts and evaluating programs outside their specialty is excellent preparation for a chairship or other senior position. And almost no one takes a pay cut to come to NSF; after cost-of-living grants, some people actually experience salary increases.

For some, the broader rewards are especially meaningful. They see how the mathematics community is viewed in Washington and have a chance to correct misperceptions. They learn empathy for those submitting proposals and find chances to build bridges between the research community and a bureaucracy of daunting size. We all hear complaints about the funding process; the rotators, with roots in the research community, can explain the system from the inside and press for changes when needed.

The time is propitious for fresh thinking about our discipline. For the past four years Bob Eisenstein has identified increased investment in mathematics as the highest priority for MPS, bringing steady budget increases to the "poor cousin" of science and engineering. This year mathematics has received more substantial budget increases than most areas of NSF, rising by more than 16 percent to $141.5 million. And NSF director Rita Colwell has strongly endorsed a foundation-wide "focus" on mathematical sciences to strengthen fundamental mathematics, the connections between mathematics and other disciplines, and mathematics education.

While it is true that the current increase builds on a low base and must be seen partly as a counterbalance to the large mathematics cuts in other agencies, it does bring new opportunities to NSF. Bob Eisenstein notes that NSF hopes to "remake" mathematics by improving its infrastructure, increasing the number of students, and enlarging grant sizes and duration. Fundamental mathematics and statistics, as well as the education of young mathematical scientists, will remain the core of DMS activities; at the same time some of the increase will go to emerging multidisciplinary fields, such as mathematical biology, information science, and string theory. At this time of new energy, good rotators will play a critical role in directing that energy toward fields of high momentum and promise.

—Phillip A. Griffiths
Director, Institute for Advanced Study

The Cooley-Tukey FFT and Group Theory

David K. Maslen and Daniel N. Rockmore

Pure and Applied Mathematics—Two Sides of a Coin

In November of 1979 there appeared in the *Bulletin of the AMS* a paper by L. Auslander and R. Tolimieri [3] with the delightful title "Is Computing with the Finite Fourier Transform Pure or Applied Mathematics?" This rhetorical question was answered by showing that in fact the finite Fourier transform and the family of efficient algorithms used to compute it (the Fast Fourier Transform (FFT), a pillar of the world of digital signal processing) are of interest to both pure and applied mathematicians.

Auslander had come of age as an applied mathematician at a time when pure and applied mathematicians still received much the same training. The ends towards which these skills were then directed became a matter of taste. As Tolimieri retells it,[1] Auslander had become distressed at the development of a separate discipline of applied mathematics which had grown apart from much of core mathematics. The effect of this development was detrimental to both sides. On the one hand, applied mathematicians had fewer tools to bring to problems, and, conversely, pure mathematicians were often ignoring the fertile bed of inspiration provided by real-world problems. Auslander hoped their paper would help mend a growing perceived rift in the mathematical community by showing the ultimate unity of pure and applied mathematics.

We will show that investigation of finite and fast Fourier transforms continues to be a varied and interesting direction of mathematical research. Whereas Auslander and Tolimieri concentrated on relations to nilpotent harmonic analysis and theta functions, we emphasize connections between the famous *Cooley-Tukey FFT* and group representation theory. In this way we hope to provide further evidence of the rich interplay of ideas which can be found at the nexus of pure and applied mathematics.

Background

The finite Fourier transform or discrete Fourier transform (DFT) has several representation theoretic interpretations: either as an exact computation of the Fourier coefficients of a function on the cyclic group $\mathbf{Z}/n\mathbf{Z}$ or a function of band-limit n on the circle S^1, or as an approximation to the Fourier transform of a function on the real line. For each of these points of view there is a natural group-theoretic generalization and also a corresponding set of efficient algorithms for computing the quantities involved. These algorithms collectively make up the *Fast Fourier Transform* or *FFT*.

Formally, the DFT is a linear transformation mapping any complex vector of length n, $f = (f(0), \dots, f(n-1))^t \in \mathbf{C}^n$, to its *Fourier transform*, $\hat{f} \in \mathbf{C}^n$. The kth component of $\hat{f}$, *the DFT of f at frequency k*, is

$$\hat{f}(k) = \sum_{j=0}^{n-1} f(j) e^{2\pi i jk/n}, \tag{1}$$

where $i = \sqrt{-1}$, and the *inverse Fourier transform* is

$$f(j) = \frac{1}{n} \sum_{k=0}^{n-1} \hat{f}(k) e^{-2\pi i jk/n}. \tag{2}$$

David K. Maslen is a mathematician at Susquehanna International Group LLP. His e-mail address is `david@maslen.net`.

Daniel N. Rockmore is professor of mathematics and computer science at Dartmouth College and on the external faculty of the Santa Fe Institute. His e-mail address is `rockmore@cs.dartmouth.edu`. *He is supported in part by NSF PFF Award DMS-9553134, AFOSR F49620-00-1-0280, and DOJ 2000-DT-CX-K001. He would also like to thank the Santa Fe Institute and the Courant Institute for their hospitality during some of the writing. Pieces of the introduction are similar to his paper "The FFT—an algorithm the whole family can use", which appeared in* Computing in Science & Engineering, *January 2000, pp. 62–67.*

[1] *Private communication.*

Thus, with respect to the standard basis, the DFT can be expressed as the matrix-vector product $\hat{f} = \mathcal{F}_n \cdot f$, where $\mathcal{F}_n$ is the *Fourier matrix* of order n whose j, k entry is equal to $e^{2\pi ijk/n}$. Computing a DFT directly would require n^2 scalar operations.[2] Instead, the FFT is a family of algorithms for computing the DFT of any $f \in \mathbf{C}^n$ in $O(n \log n)$ operations. Since inversion can be framed as the DFT of the function $\check{f}(k) = \frac{1}{n}\hat{f}(-k)$, the FFT also gives an efficient inverse Fourier transform.

One of the main practical implications of the FFT is that it allows any cyclically invariant linear operator to be applied to a vector in only $O(n \log n)$ scalar operations. Indeed, the DFT diagonalizes any cyclic group-invariant operator, making possible the following algorithm: (1) Compute the Fourier transform (DFT). (2) Multiply the DFT by the eigenvalues of the operator, which are also found using the Fourier transform. (3) Compute the inverse Fourier transform of the result. This technique is the basis of efficient digital filter (i.e., convolution) and is also used for the efficient numerical solution of partial differential equations.

Some History

Since the Fourier matrix is effectively the character table of a cyclic group, it is not surprising that some of its earliest appearances are in number theory, the subject which gave birth to character theory. Consideration of the Fourier matrix goes back at least as far as to Gauss, who was interested in its connections to quadratic reciprocity. In particular, Gauss showed that for odd primes p and q,

$$\left(\frac{p}{q}\right)\left(\frac{q}{p}\right) = \frac{\mathrm{Trace}(\mathcal{F}_{pq})}{\mathrm{Trace}(\mathcal{F}_p)\mathrm{Trace}(\mathcal{F}_q)}, \tag{3}$$

where $\left(\frac{p}{q}\right)$ denotes the Legendre symbol. Gauss also established a formula for the quadratic Gauss sum $\mathrm{Trace}(\mathcal{F}_n)$, which is discussed in detail in [3].

Another early appearance of the DFT occurs in the origins of representation theory in the work of Dedekind and Frobenius on the group determinant. For a finite group G, the group determinant Θ_G is defined as the homogeneous polynomial in the variables x_g (for each $g \in G$) given by the determinant of the matrix whose rows and columns are indexed by the elements of G with g, h-entry equal to $x_{gh^{-1}}$. Frobenius showed that when G is abelian, Θ_G admits the factorization

$$\Theta_G = \prod_{\chi \in \hat{G}} \left(\sum_{g \in G} \chi(g) x_g \right), \tag{4}$$

where $\hat{G}$ is the set of characters of G. The linear form defined by the inner sum in (4) is a "generic" DFT at the frequency χ.

[2] *At this point we must come clean about how we count operations. Our count is either the number of complex additions or the number of complex multiplications, whichever is greater.*

In the nonabelian case, Θ_G admits an analogous factorization in terms of irreducible polynomials of the form

$$\Theta_D(G) = \det\left(\sum_{g \in G} D(g) x_g \right),$$

where D is an *irreducible matrix representation* of G. The inner sum here is a generic Fourier transform over G. See [12] for a beautiful historical exposition of these ideas.

Gauss's interests ranged over all areas of mathematics and its applications, so it is perhaps not surprising that the first appearance of an FFT can also be traced back to him [10]. Gauss was interested in certain astronomical calculations, a recurrent area of application of the FFT, needed for interpolation of asteroidal orbits from a finite set of equally spaced observations. Surely the prospect of a huge laborious hand calculation was good motivation for the development of a fast algorithm. Making fewer hand calculations also implies less opportunity for error and hence increased numerical stability!

Gauss wanted to compute the Fourier coefficients a_k and b_k of a function represented by a Fourier series of bandwidth n,

$$f(x) = \sum_{k=0}^{m} a_k \cos 2\pi kx + \sum_{k=1}^{m} b_k \sin 2\pi kx, \tag{5}$$

where $m = (n-1)/2$ for n odd and $m = n/2$ for n even. He first observed that the Fourier coefficients can be computed by a DFT of length n using the values of f at equispaced sample points. Gauss then went on to show that if $n = n_1 n_2$, this DFT can in turn be reduced to first computing n_1 DFTs of length n_2, using equispaced subsets of the sample points, i.e., a subsampled DFT, and then combining these shorter DFTs using various trigonometric identities. This is the basic idea underlying the *Cooley-Tukey FFT*.

Unfortunately, this reduction never appeared outside of Gauss's collected works. Similar ideas, usually for the case $n_1 = 2$, were rediscovered intermittently over the succeeding years. Notable among these is the doubling trick of Danielson and Lanczos (1942), performed in the service of x-ray crystallography, another frequent employer of FFT technology. Nevertheless, it was not until the publication of Cooley and Tukey's famous paper [7] that the algorithm gained any notice. The story of Cooley and Tukey's collaboration is an interesting one. Tukey arrived at the basic reduction while in a meeting of President Kennedy's Science Advisory Committee, where among the topics of discussions were techniques for offshore detection of nuclear tests in the Soviet Union. Ratification of a proposed United States/Soviet Union nuclear test ban depended upon the development of a method for detecting the tests without actually visiting the Soviet nuclear facilities. One idea required the analysis of seismological time series obtained from offshore seismometers, the length and number of which would require fast algorithms for computing the DFT. Other possible applications to national security included the long-range acoustic detection of nuclear submarines.

R. Garwin of IBM was another of the participants at this meeting, and when Tukey showed him this idea, Garwin immediately saw a wide range of potential applicability and quickly set to getting this algorithm implemented. Garwin was directed to Cooley, and, needing to hide the national security issues, told Cooley that he wanted the code for another problem of interest: the determination of the periodicities of the spin orientations in a 3-D crystal of He^3. Cooley had other projects going on, and only after quite a lot of prodding did he sit down to program the "Cooley-Tukey" FFT. In short order Cooley and Tukey prepared their paper, which, for a mathematics/computer science paper, was published almost instantaneously—in six months! This publication, Garwin's fervent proselytizing, as well as the new flood of data available from recently developed fast analog-to-digital converters, did much to help call attention to the existence of this apparently new fast and useful algorithm. In fact, the significance of and interest in the FFT was such that it is sometimes thought of as having given birth to the modern field of analysis of algorithms. See also [6] and the 1967 and 1969 special issues of the *IEEE Transactions in Audio Electronics* for more historical details.

The Fourier Transform and Finite Groups

One natural group theoretic interpretation of the Fourier transform is as a change of basis in the space of complex functions on $\mathbf{Z}/n\mathbf{Z}$. Given a complex function f on $\mathbf{Z}/n\mathbf{Z}$, we may expand f in the basis of irreducible characters $\{\chi_k\}$ defined by $\chi_k(j) = e^{2\pi ijk/n}$. By (2) the coefficient of χ_k in the expansion is equal to the scaled Fourier coefficient $\frac{1}{n}\hat{f}(-k)$, whereas the Fourier coefficient $\hat{f}(k)$ is the inner product of the vector of function values of f with those of the character χ_k.

For an arbitrary finite group G there is an analogous definition. The characters of $\mathbf{Z}/n\mathbf{Z}$ are the simplest example of a *matrix representation*, which for any group G is a matrix-valued function $\rho(g)$ on G such that $\rho(ab) = \rho(a)\rho(b)$ and $\rho(e)$ is the identity matrix. Given a matrix representation ρ of dimension d_ρ and a complex function f on G, the *Fourier transform of f at ρ* is defined as the matrix sum

$$\hat{f}(\rho) = \sum_{x\in G} f(x)\rho(x). \tag{6}$$

Computing $\hat{f}(\rho)$ is equivalent to the computation of the d_ρ^2 scalar Fourier transforms at each of the individual *matrix elements* ρ_{ij},

$$\hat{f}(\rho_{ij}) = \sum_{x\in G} f(x)\rho_{ij}(x). \tag{7}$$

A set of matrix representations $\mathcal{R}$ of G is called *a complete set of irreducible representations* if and only if the collection of matrix elements of the representations, relative to an arbitrary choice of basis for each matrix representation in the set, forms a basis for the space of complex functions on G. The Fourier transform of f with respect to $\mathcal{R}$ is then defined as the collection of individual transforms, while *the Fourier transform on G* means any Fourier transform computed with respect to some complete set of irreducibles. In this case, the inverse transform is given explicitly as

$$f(x) = \frac{1}{|G|}\sum_{\rho\in\mathcal{R}} d_\rho \mathrm{Trace}(\hat{f}(\rho)\rho(x^{-1})). \tag{8}$$

Equation (8) shows us a relation between the group Fourier transform and the expansion of a function in the basis of matrix elements. The coefficient of ρ_{ij} in the expansion of f is the Fourier transform of f at the dual representation $[\rho_{ji}(g^{-1})]$ scaled by the factor $d_\rho/|G|$.

Viewing the Fourier transform on G as a simple matrix-vector multiplication leads to some simple bounds on the number of operations required to compute the transform. The computation clearly takes no more than the $|G|^2$ scalar operations required for any matrix-vector multiplication. On the other hand, the column of the Fourier matrix corresponding to the trivial representation is all 1s, so at least $|G|-1$ additions are necessary. One main goal of this finite group FFT research is to discover algorithms which can significantly reduce the upper bound for various classes of groups or even all finite groups.

The Current State of Affairs for Finite Group FFTs

Analysis of the Fourier transform shows that for G abelian, the number of operations required is bounded by $O(|G|\log|G|)$. For arbitrary groups G, upper bounds of $O(|G|\log|G|)$ remain the holy grail in group FFT research. In 1978 A. Willsky provided the first nonabelian example by showing that certain metabelian groups have an $O(|G|\log|G|)$ Fourier transform algorithm [20]. Implicit in the big-O notation is the idea that a family of groups is under consideration, with the size of the individual groups going to infinity.

Since Willsky's initial discovery, much progress has been made. U. Baum has shown that the supersolvable groups admit an $O(|G|\log|G|)$ FFT, while others have shown that symmetric groups admit $O(|G|\log^2|G|)$ FFTs (see the section below on symmetric groups). Other groups for which highly improved (but not $O(|G|\log^c|G|)$) algorithms have been discovered include the matrix groups over finite fields and, more generally, the Lie groups of finite type. See [15] for pointers to the literature. There is much work to be done finding new classes of groups which admit fast transforms and improving on the above results. The ultimate goal is to settle or make progress on the following conjecture.

Conjecture. There exist constants c_1 and c_2 such that for any finite group G there is a complete set of irreducible matrix representations for which the Fourier transform of any complex function on G may be computed in fewer than $c_1|G|\log^{c_2}|G|$ scalar operations.

The Cooley-Tukey Algorithm

Cooley and Tukey showed [7] how the Fourier transform on the cyclic group $\mathbf{Z}/n\mathbf{Z}$, where $n = pq$ is composite, can be written in terms of Fourier transforms on the subgroup $q\mathbf{Z}/n\mathbf{Z} \cong \mathbf{Z}/p\mathbf{Z}$. The trick is to change variables so that the one-dimensional formula (1) is turned into a two-dimensional formula which can be computed in two stages. Define variables j_1, j_2, k_1, k_2 through the equations

$$\begin{aligned} & j = j(j_1, j_2) = j_1 q + j_2, \\ (9) \qquad & 0 \le j_1 < p, \quad 0 \le j_2 < q; \\ & k = k(k_1, k_2) = k_2 p + k_1, \\ (10) \qquad & 0 \le k_1 < p, \quad 0 \le k_2 < q. \end{aligned}$$

It follows from (9) and (10) that (1) can be rewritten as

$$(11) \quad \hat{f}(k_1, k_2) = \sum_{j_2=0}^{q-1} e^{2\pi i j_2(k_2p+k_1)/n} \sum_{j_1=0}^{p-1} e^{2\pi i j_1 k_1/p} f(j_1, j_2).$$

We now compute $\hat{f}$ in two stages:

- Stage 1: For each k_1 and j_2 compute the inner sum

$$(12) \qquad \tilde{f}(k_1, j_2) = \sum_{j_1=0}^{p-1} e^{2\pi i j_1 k_1/p} f(j_1, j_2).$$

  This requires at most p^2q scalar operations.
- Stage 2: For each k_1 and k_2 compute the outer sum

$$(13) \qquad \hat{f}(k_1, k_2) = \sum_{j_2=0}^{q-1} e^{2\pi i j_2(k_2p+k_1)/n} \tilde{f}(k_1, j_2).$$

  This requires an additional q^2p operations.

Thus, instead of $(pq)^2$ operations, the above algorithm uses $(pq)(p+q)$ operations.

Stage 1 has the form of a DFT on the subgroup $q\mathbf{Z}/n\mathbf{Z} \cong \mathbf{Z}/p\mathbf{Z}$, embedded as the set of multiples of q, whereas Stage 2 has the form of a DFT on a cyclic group of order q. So if n could be factored further, we could apply the same trick to these DFTs in turn. Thus, if N has the prime factorization $N = p_1 \cdots p_m$, then we reobtain Cooley and Tukey's original m-stage algorithm, which requires $N\sum_i p_i$ operations [7].

A Group Theoretic Interpretation

Auslander and Tolimieri's paper [3] related the Cooley-Tukey algorithm to the Weil-Brezin map for the finite Heisenberg group. Here we present an alternate group theoretic interpretation, originally due to Beth [4], that is more amenable to generalization.

The change of variables (9) may be interpreted as the factorization of the group element j as the (group) product of $j_1q \in q\mathbf{Z}/n\mathbf{Z}$ with the coset representative j_2. Thus, if we write $G = \mathbf{Z}/n\mathbf{Z}$, $H = q\mathbf{Z}/n\mathbf{Z}$, and let Y denote our set of coset representatives, (9) can be rewritten as

$$(14) \qquad g = y \cdot h, \quad y \in Y, \quad h \in H.$$

The second change of variables (10) can be interpreted using the notion of restriction of representations. It is easy to see that restricting a representation on a group G to a subgroup H yields a representation of that subgroup. In the case of $q\mathbf{Z}/n\mathbf{Z}$ this amounts to the observation that

$$e^{2\pi i j_1 q(k_2p+k_1)/n} = e^{2\pi i j_1 k_1/p},$$

which is used to prove (11).

The restriction relations between representations may be represented diagrammatically using a directed graded graph with three levels. At level zero there is a single vertex labeled 1, called the root vertex. The vertices at level one are labeled by the irreducible representations of $\mathbf{Z}/p\mathbf{Z}$, and the vertices at level two are labeled by the irreducible representations of $\mathbf{Z}/n\mathbf{Z}$. Edges are drawn from the root vertex to each of the vertices at level one, and from a vertex at level one to a vertex at level two if and only if the representation at the tip restricts to the representation at the tail. The directed graph obtained is the *Bratteli diagram* for the chain of subgroups $\mathbf{Z}/n\mathbf{Z} > \mathbf{Z}/p\mathbf{Z} > 1$. Figure 1 shows the situation for the chain $\mathbf{Z}/6\mathbf{Z} > 2\mathbf{Z}/6\mathbf{Z} \cong \mathbf{Z}/3\mathbf{Z} > 1$.

In this way the irreducible representations of $\mathbf{Z}/n\mathbf{Z}$ are indexed by paths (k_1, k_2) in the Bratteli diagram for $\mathbf{Z}/n\mathbf{Z} > \mathbf{Z}/p\mathbf{Z} > 1$. The DFT factorization (11) now becomes

$$(15) \quad \hat{f}(k_1, k_2) = \sum_{y \in Y} \chi_{k_1,k_2}(y) \sum_{h \in H} f(y \cdot h)\chi_{k_1}(h).$$

The two-stage algorithm is now restated as first computing a set of sums that depend on only the first leg of the paths and then combining these to compute the final sums that depend on the full paths.

In summary, the group elements have been indexed according to a particular factorization scheme, while the irreducible representations (the dual group) are now indexed by paths in a Bratteli diagram, describing the restriction of representations. This

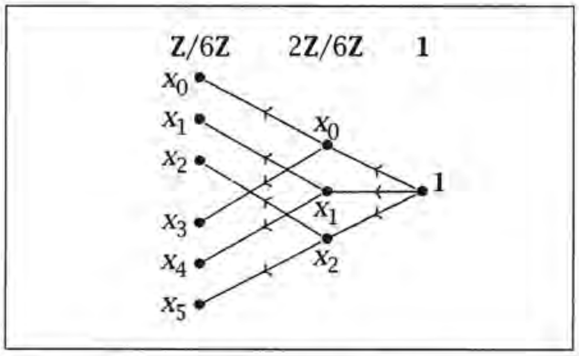


Figure 1. The Bratteli diagram for $\mathbb{Z}/6\mathbb{Z} > 2\mathbb{Z}/6\mathbb{Z} > 1$. The representation χ_k of $\mathbb{Z}/m\mathbb{Z}$ is defined by $\chi_k(l) = e^{2\pi ikl/m}$.

allows us to compute the Fourier transform in stages, using one fewer group element factor at each stage but using paths of increasing length in the Bratteli diagram.

Fast Fourier Transforms on Symmetric Groups

A fair amount of attention has been devoted to developing efficient Fourier transform algorithms for the symmetric group. One motivation for developing these algorithms is the goal of analyzing data on the symmetric group using a spectral approach. In the simpler case of time series data on the cyclic group, this approach amounts to projecting the data vector onto the basis of complex exponentials.

The spectral approach to data analysis makes sense for a function defined on any kind of group, and such a general formulation is due to Diaconis (see, e.g., [8]). The case of the symmetric group corresponds to considering *ranked data*. For instance, a group of people might be asked to rank a list of four restaurants in order of preference. Thus, each respondent chooses a permutation of the original ordered list of four objects, and counting the number of respondents choosing each permutation yields a function on S_4. It turns out that the corresponding Fourier decomposition of this function naturally describes various coalition effects that may be useful in describing the data.

To get some feel for this, notice that the Fourier transform at the matrix element $\rho_{ij}(\pi)$ of the (reducible) defining representation counts the number of people ranking restaurant i in position j. If instead ρ is the (reducible) permutation representation of S_n on unordered pairs $\{i,j\}$, then for each choice of $\{i,j\}$ and $\{k,l\}$ the individual Fourier transforms count the number of respondents ranking restaurants i and j in positions k and l. See [8] for a more thorough explanation.

The first FFT for symmetric groups (an $O(|G|\log^3|G|)$ algorithm) is due to M. Clausen. In what follows we summarize recent improvements on Clausen's result.

Example: Computing the Fourier Transform on S_4
The fast Fourier transform for S_4 is obtained by mimicking the group theoretic approach to the Cooley-Tukey algorithm. More precisely, we shall rewrite the formula for the Fourier transform using two changes of variables: one using factorizations of group elements, and the other using paths in a Bratteli diagram. The former comes from the reduced word decomposition of $g \in S_4$, by which g may be uniquely expressed as

$$g = s_2^4 \cdot s_3^4 \cdot s_4^4 \cdot s_2^3 \cdot s_3^3 \cdot s_2^2, \qquad (16)$$

where s_i^j is either e or the transposition $(i\ i-1)$, and $s_{i_1}^j = e$ implies that $s_{i_2}^j = e$ for $i_2 \le i_1$. Thus any function on the group S_4 may be thought of as a function of the six variables $s_2^4, s_3^4, s_4^4, s_2^3, s_3^3, s_2^2$.

To index the matrix elements of S_4, paths in a Bratteli diagram are used, this time relative to the chain of subgroups $S_4 \ge S_3 \ge S_2 \ge S_1 \ge 1$. The irreducible representations of S_n are in one-to-one correspondence with partitions of the integer n, with restriction of representations corresponding to deleting a box in the Young diagram. The corresponding Bratteli diagram is called Young's lattice and is shown in Figure 2.

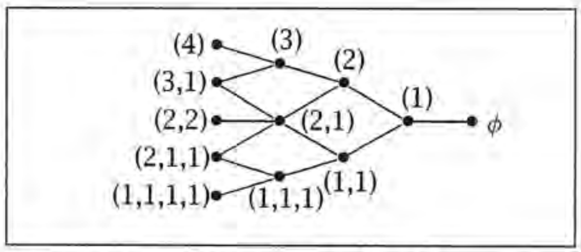


Figure 2. Young's lattice up to level 4.

Paths in Young's lattice from the empty partition ϕ to β_4, a partition of 4, index the basis vectors of the irreducible representation corresponding to β_4. Matrix elements, however, are determined by specifying a pair of basis vectors, so to index the matrix elements, we must use pairs of paths in Young's lattice, starting at ϕ and ending at the same partition of 4. Since there are no multiple edges in Young's lattice, each path may be described by the sequence of partitions $\phi, \beta_1, \beta_2, \beta_3, \beta_4$ through which it passes.

Before we can state a formula for the Fourier transform analogous to (11) and (15), we must choose bases for the irreducible representations of S_4 in order to define our matrix elements. Efficient algorithms are known only for special choices of bases, and our algorithm uses the representations in Young's orthogonal form, which is equivalent to the following equation (17) for the Fourier transform in the new sets of variables.

$$
\widehat{f}\begin{pmatrix}\beta_4\,\beta_3\,\beta_2\,\beta_1\\ \gamma_3\,\gamma_2\,\gamma_1\end{pmatrix} =
$$

$$
\sum_{g=s_2^4 s_3^4 s_4^4 s_2^3 s_3^3 s_2^2}\ \sum_{\varphi_2,\varphi_1,\eta_1}\left[P^4_{s_4^4}\begin{pmatrix}\beta_4\,\beta_3\\ \gamma_3\,\varphi_2\end{pmatrix} P^3_{s_3^4}\begin{pmatrix}\beta_3\,\beta_2\\ \varphi_2\,\varphi_1\end{pmatrix} P^2_{s_2^4}\begin{pmatrix}\beta_2\,\beta_1\\ \varphi_1\end{pmatrix} \times P^3_{s_3^3}\begin{pmatrix}\gamma_3\,\varphi_2\\ \gamma_2\,\eta_1\end{pmatrix} P^2_{s_2^3}\begin{pmatrix}\varphi_2\,\varphi_1\\ \eta_1\end{pmatrix} P^2_{s_2^2}\begin{pmatrix}\gamma_2\,\eta_1\\ \gamma_1\end{pmatrix} f(g)\right]. \tag{17}
$$

The functions $P^i_{s_i^j}$ in equation (17) are defined below, and for each i, the variables β_i, γ_i, φ_i, η_i are partitions of i satisfying the restriction relations described by Figure 3. A solid line between partitions means that the right-hand partition is obtained from the left-hand partition by removing a box.

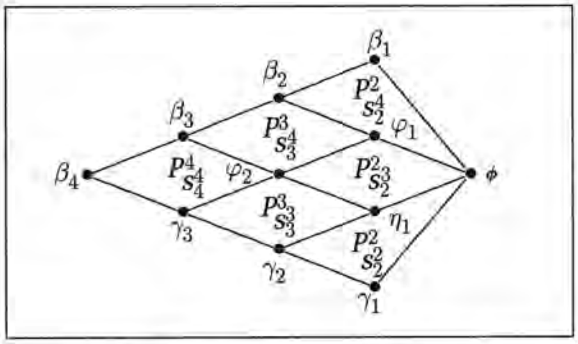


Figure 3. Restriction relations for (17).

The relationship between (17) and Figure 3 is extremely close: we derived the diagram from the reduced word decomposition first and then read the equation off the diagram. Each 2-cell in Figure 3 corresponds to a factor in the product of P functions in (17), and the labels on the boundary of each cell give the arguments of $P^i_{s_i^j}$. The sum in (17) is over those variables occurring in the interior of Figure 3. Thus, the variables describing the Fourier transformed function are exactly those appearing on the boundary of the figure.

Equation (17) can be summarized by saying that we take the product over 2-cells and sum on interior indices in Figure 3. This suggests a generalization of the Cooley-Tukey algorithm that corresponds to building up the diagram one cell at a time. At each stage multiply by the factor corresponding to a 2-cell and form the diagram consisting of those 2-cells that have been considered so far. Then sum over any indices that are in the interior of the diagram for this stage but were not in the interior for previous stages. At the end of this algorithm we have multiplied by the factors for each 2-cell and summed over all the interior indices, and have therefore computed the Fourier transform.

The order in which the cells are added matters, of course. The order s_2^2, s_2^3, s_3^3, s_2^4, s_3^4, s_4^4 is known to be most efficient. Here is the algorithm in detail.

- Stage 0: Start with $f(s_2^4 s_3^4 s_4^4 s_2^3 s_3^3 s_2^2)$, for all reduced words.
- Stage 1: Multiply by $P^2_{s_2^2}$. Sum on s_2^2.
- Stage 2: Multiply by $P^2_{s_2^3}$. Sum on s_2^3.
- Stage 3: Multiply by $P^3_{s_3^3}$. Sum on η_1, s_3^3.
- Stage 4: Multiply by $P^2_{s_2^4}$. Sum on s_2^4.
- Stage 5: Multiply by $P^2_{s_3^4}$. Sum on φ_1, s_3^4.
- Stage 6: Multiply by $P^3_{s_4^4}$. Sum on φ_2, s_4^4.

The indices occurring in each stage of the algorithm are shown in Figure 4.

To count the number of additions and multiplications used by the algorithm, we must count the number of configurations in Young's lattice corresponding to each of the diagrams in Figure 4. This yields a grand total of 130 additions and 130 multiplications for the Fourier transform on S_4.

The generalization to higher-order symmetric groups is straightforward. The reduced word decomposition gives the group element factorization, Young's orthogonal form allows us to change variables, and the formula and algorithm for the Fourier transform can be read off a diagram generalizing Figure 3. The diagram for S_5, for example, is shown in Figure 5.

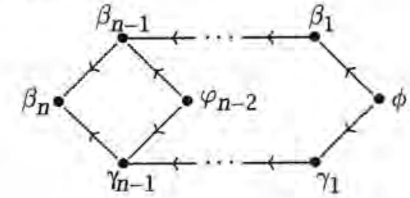
We have computed the exact operation counts for symmetric groups S_n with $n \le 50$,[3] and a general formula seems hard to come by. However, bounds are easier to obtain.

Theorem 1 [13]. *The number of additions (or multiplications) required by the above algorithm (as generalized to $S_n > S_{n-1} > \cdots > S_1$) is exactly*

$$
n! \cdot \sum_{k=2}^{n} \frac{1}{k} \sum_{i=2}^{k} \frac{1}{(i-1)!} F_i,
$$

where F_i is the number of configurations in Young's lattice of the form

(18)



Furthermore, $F_i \le 3(1 - \frac{1}{i})i!$, so the number of additions (multiplications) is bounded by $\frac{3}{4}n(n-1)\cdot n!$.

Why stop at S_n? The algorithm for the FFT on S_n generalizes to any wreath product $S_n[G]$ with

[3] *This would seem to include all cases where the algorithm might ever be implemented, but the same numbers arise in FFTs on homogeneous spaces, which have far fewer elements.*

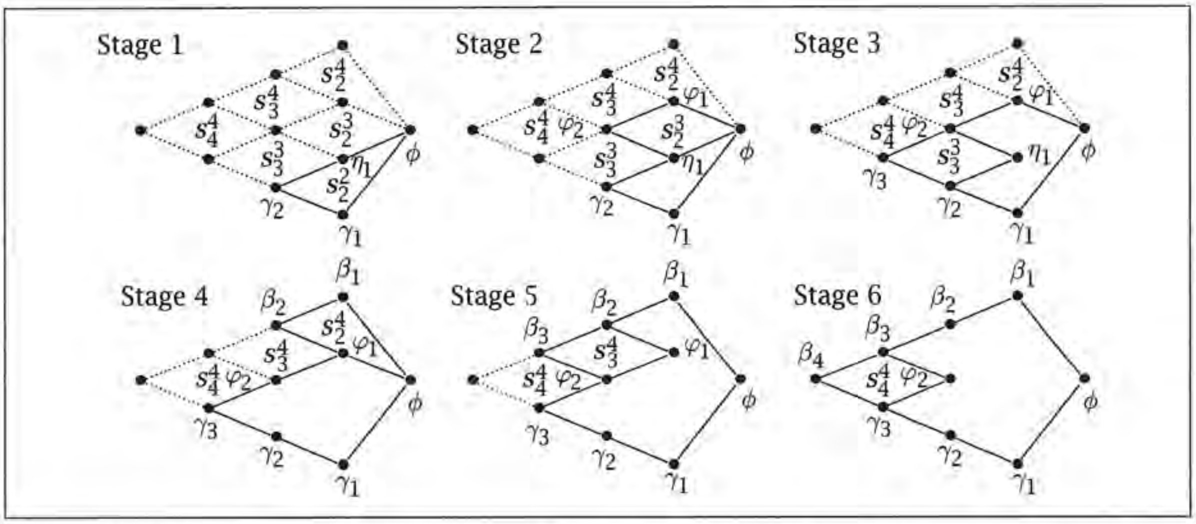


Figure 4. Variables occurring at each stage of the fast Fourier transform for S_4.

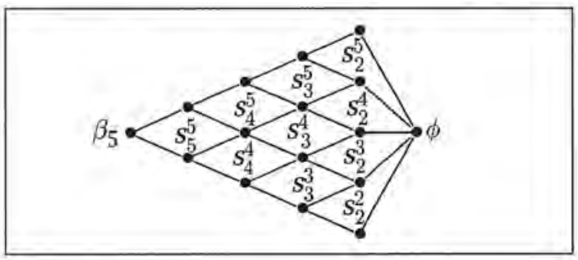


Figure 5. Restriction relations in the Fourier transform formula for S_5.

the symmetric group. The subgroup chain is replaced by the chain

$$S_n[G] > S_{n-1}[G] \times G > S_{n-1}[G] > \cdots > S_2[G] > G \times G > G, \tag{19}$$

and the reduced word decomposition is replaced by the factorization

$$x = s_2^n \cdots s_n^n g^n s_2^{n-1} \cdots s_{n-1}^{n-1} g^{n-1} \cdots s_s^2 g^2 g^1. \tag{20}$$

Adapting the S_n argument along these lines gives the following new result.

Theorem 2. *The number of operations needed to compute a Fourier transform on $S_n[G]$ is at most*

$$\left(\frac{3n(n-1)}{4}|G|d_G^2 + n\left[t_G + \frac{1}{4}|G|(h_G d_G^2 - |G|)\right]\right)|S_n[G]|,$$

where h_G is the number of conjugacy classes in G, d_G is the maximal degree of an irreducible representation of G, and t_G is the number of operations required to compute a Fourier transform on G. If G is abelian, then the inner term $h_G d_G^2 - |G| = 0$.

The functions $P^i_{s^j_i}$ defining Young's orthogonal form are defined as follows: For any two boxes b_1 and b_2 in a Young diagram, we define the axial distance from b_1 to b_2 to be $d(b_1, b_2)$, where $d(b_1, b_2) = \text{row}(b_1) - \text{row}(b_2) + \text{column}(b_1) - \text{column}(b_2)$. Now suppose $\beta_i, \beta_{i-1}, \alpha_{i-1}, \alpha_{i-2}$ are partitions and that α_{i-1} and β_{i-1} are obtained from β_i by removing a box and are obtained from α_{i-2} by adding a box. Then the skew diagrams of $\beta_i - \beta_{i-1}$ and $\beta_{i-1} - \alpha_{i-2}$ each consists of a single box, and P^i is given by

(21)

$$P^i_e\begin{pmatrix}\beta_i & \beta_{i-1}\\ \alpha_{i-1} & \alpha_{i-2}\end{pmatrix} = \begin{cases}1 & \text{if } \alpha_{i-1} = \beta_{i-1},\\ 0 & \text{if } \alpha_{i-1} \neq \beta_{i-1}.\end{cases}$$

$$P^i_{(i\ i-1)}\begin{pmatrix}\beta_i & \beta_{i-1}\\ \alpha_{i-1} & \alpha_{i-2}\end{pmatrix} = \begin{cases}d(\beta_i - \beta_{i-1}, \beta_{i-1} - \alpha_{i-2})^{-1} & \text{if } \alpha_{i-1} = \beta_{i-1},\\ \sqrt{1 - d(\beta_i - \beta_{i-1}, \beta_{i-1} - \alpha_{i-2})^{-2}} & \text{if } \alpha_{i-1} \neq \beta_{i-1}.\end{cases}$$

For a proof of this formula, in slightly different notation, see [11, Chapter 3].

Generalization to Other Groups

The FFT described for symmetric groups suggests a general approach to computing Fourier transforms on finite groups. Here is the recipe.

1. Choose a chain of subgroups

$$G = G_m \geq G_{m-1} \geq \cdots \geq G_1 \geq G_0 = 1 \tag{22}$$

for the group. This determines the Bratteli diagram that we will use to index the matrix elements of G. In the general case, this Bratteli diagram may have multiple edges, so a path is no longer determined by the nodes it visits.

2. Choose a factorization $g = g_n \cdot g_{n-1} \cdots g_1$ of each group element g. Choose the g_i so that they lie in as small a subgroup G_k as possible and commute with as large a subgroup G_l as possible.
3. Choose a system of Gel'fand-Tsetlin bases [9] for the irreducible representations of G relative to the chain (22). These are bases that are indexed by paths in the Bratteli diagram and that behave well under restriction of representations. Relative to such a basis, the representation matrices of g_i will be block diagonal

whenever g_i lies in a subgroup from the chain and block scalar whenever g_i commutes with all elements of a subgroup from the chain.

4. Now write the Fourier transform in coordinates as a function of the pairs of paths in the Bratteli diagram with a common endpoint and with the original function written as a function of $g_1, \ldots, g_n$. This will be a sum of products indexed by edges in the Bratteli diagram which lie in some configuration generalizing (3). This configuration of edges specifies the way in which the nonzero elements of the representation matrices appear in the formula for the Fourier transform in coordinates.
5. The algorithm proceeds by building up the product piece by piece and summing on as many partially indexed variables as possible.

Further Considerations and Generalizations

The efficiency of the above approach—in theory (in terms of algorithmic complexity) and in practice (in terms of execution time)—depends on both the choice of factorization and the Gel'fand-Tsetlin bases. In particular, very interesting work of L. Auslander, J. Johnson, and R. Johnson [2] shows how, in the abelian case, different factorizations correspond to different well-known FFTs, each well suited for execution on a different computer architecture. This work shows how to relate the 2-cocycle of a group extension to construction of the important "twiddle factor" matrix in the factorization of the Fourier matrix. It marks the first appearances of group cohomology in signal processing and derives an interesting connection between group theory and the design of retargetable software.

The analogous questions for nonabelian groups and other important signal processing transform algorithms, i.e., the problem of finding architecture-optimized factorizations, is currently being investigated by the SPIRAL project at Carnegie Mellon [19].

Another Abelian Idea—Rader's Prime FFT

The use of subgroups depends upon the existence of a nontrivial subgroup. Thus, for a reduction in the case of a cyclic group of prime order, a new idea is necessary. In this case, one possibility is an algorithm due to C. Rader [16] which proceeds by turning computation of the DFT into computation of convolution on a different, albeit related, group. Let p be a prime. Since $\mathbf{Z}/p\mathbf{Z}$ is also a finite field, there exists a generator g of $\mathbf{Z}/p\mathbf{Z}^\times$, a cyclic group (under multiplication) of order $p-1$. Thus, for any $f : \mathbf{Z}/p\mathbf{Z} \to \mathbf{C}$ and nonzero frequency index g^{-b}, $\hat{f}(g^{-a})$ can be written as

$$\hat{f}(g^{-b}) = f(0) + \sum_{a=0}^{p-2} f(g^a)\zeta_p^{g^{a-b}} \tag{23}$$

The summation in (23) has the form of a convolution on $\mathbf{Z}/(p-1)\mathbf{Z}$, of the sequence $f'(a) = f(g^a)$, with the function $z(a) = \zeta_p^{g^a}$, so that $\hat{f}$ may be almost entirely computed using Fourier transforms of length $p-1$ for which Cooley-Tukey-like ideas may be used. It is a very interesting open question to discover if this idea has a nonabelian generalization.

Modular FFTs

A significant application of the abelian FFT is in the efficient computation of Fourier transforms for functions on cyclic groups defined over finite fields. These are needed for the efficient encoding and decoding of various polynomial error-correcting codes. Many abelian codes, e.g., the Golay codes used in deep-space communication, are defined as $\mathbf{F}_p$-valued functions on a group $\mathbf{Z}/m\mathbf{Z}$ with the property that $\hat{f}(k) = 0$ for k in some specified set of indices S, where now the Fourier transform is defined in terms of a primitive $(p-1)$st root of unity.

These sorts of *spectral constraints* define *cyclic codes*, and they may immediately be generalized to any finite group. Recently, this has been done in the construction of codes over $SL_2(\mathbf{F}_p)$ using connections between expander graphs and linear codes discovered by M. Sipser and D. Spielman. For further discussion of this and other applications, see [17].

FFTs for Compact Groups

The DFT and FFT have a natural extension to continuous compact groups. The terminology "discrete Fourier transform" derives from the algorithm having been originally designed to compute the (possibly approximate) Fourier transform of a continuous signal from a discrete collection of sample values.

Under the simplifying assumption of periodicity, a continuous function may be interpreted as a function on the unit circle S^1, a compact abelian group. Any such function f has a *Fourier expansion* defined as

$$f(e^{2\pi i t}) = \sum_{l \in \mathbf{Z}} \hat{f}(l) e^{-2\pi i l t}, \tag{24}$$

where

$$\hat{f}(l) = \int_0^1 f(e^{2\pi i t}) e^{2\pi i l t} dt. \tag{25}$$

If $\hat{f}(l) = 0$ for $|l| \geq N$, then f is *band-limited* with *band-limit* N, and the DFT (1) is in fact a *quadrature rule* or *sampling theorem* for f. That is, the DFT of the function $\frac{1}{2N-1} f(e^{2\pi i t})$ on the group of $(2N-1)$st roots of unity computes exactly the Fourier coefficients of the band-limited function. The FFT then efficiently computes these Fourier coefficients.

The first nonabelian FFT for a compact group was a fast spherical harmonic expansion algorithm discovered by J. Driscoll and D. Healy. Several ingredients were required: (1) a notion of "band-limit" for functions on S^2, (2) a sampling theory for such functions, and (3) a fast algorithm for the computation.

The spherical harmonics are naturally indexed according to their order (the common degree of a set of homogeneous polynomials on S^2). With respect to the usual coordinates of latitude and longitude, the spherical harmonics separate as a product of exponentials and associated Legendre functions, each of which separately has a sampling theory. Finally, using the usual FFT for the exponential part and a new fast algorithm (based on three-term recurrences) for the Legendre part forms an FFT for S^2.

These ideas generalize nicely. Keep in mind that the representation theory of compact groups is much like that of finite groups: there is a countable complete set of irreducible representations, and any square-integrable function (with respect to Haar measure) has an expansion in terms of the corresponding matrix elements. There is a natural definition of band-limited in the compact case, encompassing those functions whose Fourier expansion has only a finite number of terms. The simplest version of the theory is as follows:

Definition. *Let $\mathcal{R}$ denote a complete set of irreducible representations of a compact group G. A* system of band-limits *on G is a decomposition of $\mathcal{R} = \cup_{b\geq 0}\mathcal{R}_b$ such that*

1. $\mathcal{R}_b$ is finite for all $b \geq 0$,
2. $b_1 \leq b_2$ implies that $\mathcal{R}_{b_1} \subseteq \mathcal{R}_{b_2}$,
3. $\mathcal{R}_{b_1} \otimes \mathcal{R}_{b_2} \subseteq \text{span}_{\mathbf{Z}}\mathcal{R}_{b_1+b_2}$.

Suppose $\{\mathcal{R}_b\}_{b\geq 0}$ is a system of band-limits on G and $f \in L^2(G)$. Then f *is band-limited with band-limit* b if the Fourier coefficients are zero for all matrix elements in ρ for all $\rho \notin \mathcal{R}_b$.

The case of $G = S^1$ provides the classical example. If $\mathcal{R}_b = \{\chi_j : |j| \leq b\}$, where $\chi_j(z) = z^j$, then $\chi_j \otimes \chi_k = \chi_{j+k}$, and the notion of band-limited corresponding to the definition coincides with the usual notion.

For a nonabelian example, consider $G = SO(3)$. In this case the irreducible representations of G are indexed by the nonnegative integers, with V_λ the unique irreducible of dimension $2\lambda + 1$. Let $\mathcal{R}_b = \{V_\lambda : \lambda \leq b\}$. The Clebsch-Gordon relations

$$V_{\lambda_1} \otimes V_{\lambda_2} = \sum_{j=|\lambda_1-\lambda_2|}^{\lambda_1+\lambda_2} V_j \tag{26}$$

imply that this is a system of band-limits for $SO(3)$. When restricted to the quotient $S^2 \cong SO(3)/SO(2)$, band-limits are described in terms of the highest order spherical harmonics that appear in a given expansion.

This notion of band-limit permits the construction of a sampling theory [14]. For example, in the case of the classical groups, a system of band-limits $\mathcal{R}_b^n$ is chosen with respect to a particular norm on the dual of the associated Cartan subalgebra. Such a norm $\|\cdot\|$ (assuming that it is invariant under taking duals and that $\|\alpha\| \leq \|\beta\| + \|\gamma\|$ for α occurring in $\beta \otimes \gamma$) defines a notion of band-limit given by all α with norm less than a fixed b. This generalizes the definition above. The associated sampling sets X_b^n are contained in certain one-parameter subgroups. These sampling sets permit a separation of variables analogous to that used in the Driscoll-Healy FFT. Once again the special functions satisfy certain three-term recurrences which admit a similar efficient divide-and-conquer computational approach (see [15] and references therein). One may derive efficient algorithms for all the classical groups $U(n)$, $SU(n)$, and $Sp(n)$.

Theorem 3. *Assume $n \geq 2$.*

(i) For $U(n)$, $T_{X_b^n}(\mathcal{R}_b^n) \leq O(b^{\dim U(n)+3n-3})$,

(ii) for $SU(n)$, $T_{X_b^n}(\mathcal{R}_b^n) \leq O(b^{\dim SU(n)+3n-2})$,

(iii) for $Sp(n)$, $T_{X_b^n}(\mathcal{R}_b^n) \leq O(b^{\dim Sp(n)+6n-6})$,

where $T_{X_b^n}(\mathcal{R}_b^n)$ denotes the number of operations needed for the particular sample set X_b^n and representations $\mathcal{R}_b^n$ for the associated group.

Further and Related Work

Noncompact Groups

Much of modern signal processing relies on the understanding and implementation of Fourier analysis for $L^2(\mathbf{R})$, i.e., the noncompact abelian group $\mathbf{R}$. Nonabelian, noncompact examples have begun to attract much attention.

In this area some of the most exciting work is being done by G. Chirikjian and his collaborators. They have been exploring applications of convolution on the group of rigid motions of Euclidean space to such diverse areas as robotics, polymer modeling, and pattern matching. See [5] for details and pointers to the literature.

To date the techniques used here are approximate in nature, and interesting open problems abound. Possibilities include the formulation of natural sampling, band-limiting, and time-frequency theories. The exploration of other special cases such as semisimple Lie groups (see [1] for a beautifully written, succinct survey of the Harish-Chandra theory) would be one natural place to start. A sampling and band-limiting theory would be the first step towards developing a computational theory, i.e., FFT. "Fast Fourier transforms on semisimple Lie groups" has a nice ring to it!

Approximate Techniques

The techniques in this paper are all exact, in the sense that if computed in exact arithmetic, they yield exactly correct answers. Of course, in any actual implementation, errors are introduced, and the utility of an algorithm will depend highly on its numerical stability.

There are also "approximate methods", approximate in the sense that they guarantee a certain specified approximation to the exact answer that depends on the running time of the algorithm. For computing Fourier transforms at nonequispaced frequencies, as well as spherical harmonic expansions, the fast *multipole method* due to V. Rokhlin and L. Greengard is a recent and very important approximate technique. Multipole-based approaches efficiently compute these quantities approximately in such a way that the running time increases by a factor of $\log(\frac{1}{\epsilon})$, where ϵ denotes the precision of the approximation. M. Mohlenkamp has applied quasi-classical frequency estimates to the approximate computation of various special function transforms.

Quantum Computing

Another related and active area of research involves connections with quantum computing. One of the first great triumphs of the quantum computing model is P. Shor's fast algorithm for integer factorization on a quantum computer [18]. At the heart of Shor's algorithm is a subroutine which computes (on a quantum computer) the DFT of a binary vector representing an integer. The implementation of this transform as a sequence of one- and two-bit quantum gates is the *quantum FFT*, effectively the Cooley-Tukey FFT realized as a particular factorization of the Fourier matrix into a product of matrices composed as tensor products of certain 2×2 unitary matrices, each of which is a "local unitary transform". Extensions of these ideas to the more general group transforms mentioned above are a current important area of research of great interest in computer science.

Final Remarks

So, these are some of the things that go into the computation of the finite Fourier transform. It is a tapestry of mathematics both pure and applied, woven from algebra and analysis, complexity theory, and scientific computing. It is on the one hand a focused problem, but like any good problem, its "solution" does not end a story, but rather initiates an exploration of unexpected connections and new challenges.

References

[1] J. Arthur, Harmonic analysis and group representations, *Notices Amer. Math. Soc.* **47** (2000), 26–34.

[2] L. Auslander, J. R. Johnson, R. W. Johnson, Multidimensional Cooley-Tukey algorithms revisited, *Adv. Appl. Math.* **17** (1996), 477–519.

[3] L. Auslander and R. Tolimieri, Is computing with the finite Fourier transform pure or applied mathematics? *Bull. Amer. Math. Soc. (N.S.)* **1** (1979), 847–897.

[4] T. Beth, *Verfahren der schnellen Fourier-Transformation*, Teubner Studienbücher, Stuttgart, 1984.

[5] G. S. Chirikjian and A. B. Kyatkin, *Engineering Applications of Noncommutative Harmonic Analysis*, CRC Press, Boca Raton, FL, 2000.

[6] J. W. Cooley, The re-discovery of the fast Fourier transform algorithm, *Mikrochimica Acta* **III** (1987), 33–45.

[7] J. W. Cooley and J. W. Tukey, An algorithm for machine calculation of complex Fourier series, *Math. Comp.* **19** (1965), 297–301.

[8] P. Diaconis, *Group Representations in Probability and Statistics*, Inst. Math. Stat., Hayward, CA, 1988.

[9] I. Gel'fand and M. Tsetlin, Finite dimensional representations of the group of unimodular matrices, *Dokl. Akad. Nauk SSSR* **71** (1950), 825–828 (Russian).

[10] M. T. Heideman, D. H. Johnson, and C. S. Burrus, Gauss and the history of the fast Fourier transform, *Arch. Hist. Exact Sci.* **34** (1985), 265–277.

[11] G. James and A. Kerber, *The Representation Theory of the Symmetric Group*, Encyclopedia Math. Appl., vol. 16, Addison-Wesley, Reading, MA, 1981.

[12] T. Y. Lam, Representations of finite groups: A hundred years, I and II. *Notices Amer. Math. Soc.* **45** (1998), 361–372, 465–474.

[13] D. K. Maslen, The efficient computation of Fourier transforms on the symmetric group, *Math. Comp.* **67** (1998), 1121–1147.

[14] ——, Efficient computation of Fourier transforms on compact groups, *J. Fourier Anal. Appl.* **4** (1998), 19–52.

[15] D. K. Maslen and D. N. Rockmore, Generalized FFTs—a Survey of Some Recent Results, *Groups and Computation, II* (New Brunswick, NJ, 1995), DIMACS Ser. Discrete Math. Theoret. Comput. Sci., vol. 28, Amer. Math. Soc., Providence, RI, 1997, pp. 183–237.

[16] C. Rader, Discrete Fourier transforms when the number of data samples is prime, *IEEE Proc.* **56** (1968), 1107–1108.

[17] D. N. Rockmore, Some applications of generalized FFTs (an appendix w/D. Healy), *Groups and Computation, II* (New Brunswick, NJ, 1995), DIMACS Ser. Discrete Math. Theoret. Comput. Sci., vol. 28, Amer. Math. Soc., Providence, RI, 1997, pp. 329–369.

[18] P. W. Shor, Polynomial-time algorithms for prime factorization and discrete logarithms on a quantum computer, *SIAM J. Comput.* **26** (1997), 1484–1509.

[19] `http://www.ece.cmu.edu/~spiral/`.

[20] A. Willsky, On the algebraic structure of certain partially observable finite-state Markov processes, *Inform. Contr.* **38** (1978), 179–212.

Franklin P. Peterson (1930–2000)

E. H. Brown, F. R. Cohen, F. W. Gehring, H. R. Miller, and B. A. Taylor

Haynes Miller

Franklin Paul Peterson was born on August 27, 1930, in Aurora, Illinois. His father, Paul, died when Frank was around seven, and his mother, Mildred, soon married his father's brother, Conrad. Frank had a younger brother, Norman, who after graduating from MIT became a metallurgist at the Argonne National Laboratory.

After attending Northwestern University, Frank began his graduate studies in 1952 under Norman Steenrod at Princeton University, where he completed his Ph.D. in the nominally standard three years. He visited the University of Chicago on an NSF Postdoctoral Fellowship and then returned to Princeton as Higgins Lecturer for the period 1956–58, after which he moved to MIT. On August 8, 1959, Frank was married to Marilyn (née Rutz).

Frank was an inveterate traveler, and he maintained close friendships with the many contacts he made around the world. He participated in the Symposium on Algebraic Topology in 1956 in Mexico City and spent the summer of 1959 there. He spent the academic year 1960–61 at the University of Oxford as a Sloan Research Fellow. He visited Bucharest and Warsaw in 1961, Moscow and Tbilisi in 1967, and Tbilisi again in 1972. He spent the spring and summer of 1967 in Kyoto on a Fulbright Research Fellowship and took the overland route, stopping in Samarkand, Bokara, and Kathmandu. At the invitation of the Academia Sinica, Frank made a historic trip to China in May 1973, together with Donald Spencer, William Browder, and Marilyn. They visited mathematical institutions in Beijing, Shanghai, Suzhou, Hangzhou, and Canton. In 1990 he won the prestigious Humboldt Research Award for Senior U.S. Scientists and spent most of five summers between 1991 and 1998 in Heidelberg, enjoying a long friendship with the academic community there. Frank loved conferences and would usually arrange a gustatory tour with select friends, sometimes traveling considerable distances for the purpose.

A renowned bon vivant, Frank enjoyed fine foods and wines of many descriptions in the company of friends. His taste in wines was quite catholic, and he always kept in mind the ratio of quality to price. He and Marilyn studied cooking at the Cordon Bleu in Paris one summer. He played bridge, tennis, and table tennis with the same rare combination of competitiveness and unfailing fairness and good humor that marked his professional life.

Franklin Peterson suffered a fatal stroke while visiting friends in Washington, DC, on September 1, 2000.

Early Work

Frank Peterson was a prime representative of the dominant method of an era in algebraic topology: namely, the use of cohomology operations to analyze homotopy types, especially ones deriving from bundle theory and bordism. He contributed greatly to both the substance and the style of the period.

When Frank was a graduate student, Steenrod operations were young (first appearing in 1947, with successive clarifications by Cartan and by

Haynes Miller is professor of mathematics at the Massachusetts Institute of Technology. His e-mail address is hrm@math.mit.edu.

Ph.D. Students of Frank Peterson

Peter Anderson (1964)
Vincent Giambalvo (1966)
Gregory Brumfiel (1967)
David Segal (1967)
Carey Mann (1969)
Stephen Williams (1969)
Hans Salomonsen (1971)
E. Bruce Williams (1972)
W. Stephen Wilson (1972)
Henry Walker (1973)
Arthur Goldhammer (1973)
Manuel Moriera (1975)
James Krevitt (1977)
Kenneth Prevot (1977)
David Anick (1980)
Michael Hoffman (1981)
Paul Goerss (1983)
Ethan Devinatz (1985)
Raymond Coley (1985)
Thomas Hunter (1987)
Kathryn Lesh (1988)
Hal Sadofsky (1990)

Steenrod and his student José Adem continuing into the early 1950s). Serre's thesis (1951) extended the scope of methods involving fibrations, and it together with Borel's thesis (published in 1953) and the discovery by William Massey (an earlier student of Steenrod) of exact couples (1952) finally made Leray's theory of spectral sequences accessible. In an early paper Serre also introduced the first theory of localization in topology in the form of his "mod C" calculations.

Frank's thesis exploited these new tools to extend known results about homotopy classes of maps from a complex K into the n-sphere S^n. Hopf had shown that if $\dim K \le n$, then cohomology classifies such classes. The description of $[K, S^n]$ in case $\dim K = n+1$ was the problem that led Steenrod to discover the squares in the first place, and Frank now went further to prove classification results localized at a prime, using the mod C theory. Following a suggestion of John Moore, he also introduced coefficients into the picture by mapping into a "Moore space" $M(G, n)$ (a simply connected space whose only nonzero reduced homology group is $H_n(M(G,n)) = G$) in place of a sphere. (Much later Moore and his collaborators were to use the notation $P^{n+1}(p^r)$ in case G is a cyclic group of order p^r to denote spaces of this type.) Frank used to talk about Steenrod's demanding standards, claiming that he wrote from scratch seven drafts of his thesis before Steenrod was satisfied.

Very early on (1949) Steenrod had defined functional primary operations. Adem (1952) had made a start at defining secondary operations, and Massey had reported on his triple products in Mexico City in 1956, but these things were still very mysterious. Among the objectives Frank set himself was the task of establishing the general properties of higher-order operations. Postnikov's work on k-invariants appeared in Russian in 1955 and gave a context for studying higher-order operations (as well as clarifying the contents of Frank's thesis), and Frank became an expert, perhaps the leading expert, at operating this machinery. Some of his joint work with Norman Stein set out the basic definitions and proved the fundamental "Peterson-Stein formulas". See [6] for a modern perspective on these operations and an indication of their importance today.

Frank was not by nature a machine builder, however. He loved to compute and looked to geometric questions to guide him in his choice of computational project. Characteristic classes of vector bundles provided him with one such area. He applied the same machinery he had employed in his thesis to give simple conditions under which the triviality of characteristic classes implies triviality of the vector bundle. In the opposite direction, as a complement to the construction by Massey of secondary characteristic classes of a bundle with trivial Euler class, Peterson and Stein computed the cohomology of the universal example and showed that Massey's classes are algebraically independent.

These calculations led to collaboration with Bill Massey on a study of the cohomology of fiber spaces. The key idea was to study a fiber bundle $p : E \to B$ by means of a pair (E_T, E), where E_T is the fiberwise cone of E. This idea becomes effective only under rather strong geometric and algebraic hypotheses on the fibration, but ones that are satisfied in many important situations. In modern terms their method amounts to considering the low homological dimension portion of the Eilenberg-Moore spectral sequence, and the hypotheses are designed to guarantee that this portion generates the E^2-term and that the spectral sequence collapses. Their work grew into an AMS Memoir [7].

The Adams spectral sequence (1956) was another foundation stone of the edifice of algebraic topology in the second half of the twentieth century. It provided a mechanical way of studying the implications of higher-order operations and offered an alternative to the Postnikov tower, using homological algebra over the mod p Steenrod algebra $\mathcal{A}_p$ to begin a direct computation of homotopy classes of maps. Adams restricted himself to the stable range, but in their Memoir Massey and Peterson constructed, under appropriate conditions on a space X, an "unstable Adams tower" for X. Massey has written: "My memory is that most of these papers were genuine joint collaborations. Two exceptions: the unstable Adams spectral sequence was almost entirely Frank's work, while the Noetherian property of unstable modules over the mod 2 Steenrod algebra was my contribution."

Although the simplicial methods of Bousfield and Kan have since provided a much more general construction, the Massey-Peterson tower has proved easy to use and of surprising power and versatility. John Harper, Richard Kane, and others have used it to analyze H-spaces, and they are fundamental to Mark Mahowald's perspective on unstable homotopy theory. The category $\mathcal{U}$ of unstable modules over the Steenrod algebra, as explored by Massey and Peterson, turns out to relate intimately to modern objects such as Mac Lane homology and topological Hochschild homology.

The final building block of the edifice of algebraic topology of this era was René Thom's work on cobordism (1954). This opened the way to many geometric applications of homotopy theory, in which Frank was an active participant. He was delighted by Arunas Liulevicius's application of the Hopf algebra methods of Milnor and Moore. Frank's great contributions to our understanding of cobordism frequently occurred in joint work with Ed Brown, who has more to say about this below. This was truly one of the great collaborations in the history of topology.

Frank's perspective on basic homotopy theory is captured by the book *Cohomology Operations and Applications in Homotopy Theory*, by Robert Mosher (whom Frank regarded as his first student, though George Whitehead signed the thesis) and Martin Tangora. Mosher's lectures, upon which this book is based, closely followed lectures by Frank at MIT.

In later years Frank's interest focused increasingly on the algebraic structure imposed by an action of the mod 2 Steenrod algebra. An early manifestation of this interest was his work in the early 1970s with John Moore. They established easily checked conditions on a bounded-below module M over $\mathcal{A}_p$, at an odd prime p, guaranteeing that M is free, in analogy with a theorem of Adams and Margolis at the prime 2. They also gave general algebraic conditions on a graded algebra guaranteeing that among bounded-below modules the properties of being flat, projective, and injective coincide.

Frank was always quick to appreciate the potential of new ideas in the subject. A good example of this is his work with Vince Giambalvo that uses a new basis for the Steenrod algebra recently discovered by Dan Arnon to express the ideal of operations annihilating all elements of $H^*(\mathbb{R}P^\infty)$.

Service

Frank identified deeply with "Tech", as he called MIT. He served as chairman of the omnibus Pure Mathematics Committee for the years 1972–75, 1979–82, and 1984–87. In addition, he served as the graduate admissions chairman a number of times and expressed great pride at how well the students he had chosen turned out.

Franklin P. Peterson

Frank signed the theses of twenty-two Ph.D. students at MIT (see the sidebar). Several of these theses became fundamental to later developments in topology. Frank was a supportive and open-minded advisor. He was the de facto advisor also of Robert Mosher (formally George Whitehead's student) and of Peter Landweber (formally Raoul Bott's).

Frank taught his share of service courses. He would dress for the occasion of a large lecture by donning his legendary bow tie. At some point in the early 1980s Frank decided that his students by and large just did not seem as prepared as they had a decade or so earlier. Rather than leave it at that, with a complaint, Frank agreed the next year to read admission folders. He ranked the group he was assigned, kept a record of his rankings, and then compared his ranking with the choices made by the MIT admissions department. He was outraged to find that the MIT choices were close to the reverse of his own. He let his dissatisfaction be known, and a faculty movement was born, one which ultimately refocused the admissions criteria used by MIT.

One of the first things Frank did on arriving at MIT was to found (in collaboration with Ed Brown) the Monday MIT Topology Seminar, in imitation of Lefschetz's Thursday Topology Seminar at Princeton. This became the central meeting point for topologists of all persuasions in the Cambridge

Peterson with Cathleen Morawetz at his AMS retirement party in February 1999.

area. In the early 1960s he would make taking notes at the seminar and mimeographing them for distribution a part of the paid Research Assistantship duties of a graduate student in topology. An important part of the process for Frank was the choice of restaurant for dinner after the seminar. He liked to discover restaurants that did not yet have a liquor license and arrange with them to bring his own wine, whose price was then tabulated separately. He would try to negotiate an arrangement of arguable legality by which the restaurant would overlook his specially designed wine-bottle carrier, even after obtaining a license. Frank's warmth and inclusiveness was tremendously important to the creation of the topology community around MIT.

Edgar Brown

Frank and I first met in 1956 at the University of Chicago, where he was visiting for the year and I was an instructor. The mathematics department was a very lively place for topology and a great experience for both of us. Ed Spanier ran a topology seminar in which Frank and I gave talks on our Ph.D. theses, René Thom gave a talk on transverse regularity of smooth maps, and Steve Smale spoke about immersions of the circle into the plane. We also had a seminar to learn some Spanish in preparation for the 1956 International Topology Conference in Mexico City, another great experience. At the end of the summer we went our separate ways, rejoining in 1958, Frank at MIT and me at Brandeis. In 1959 Frank and I started a topology seminar, which in a few years became the MIT Monday topology seminar and which is still going. Initially it met each week, alternating between Brandeis and MIT, with participants George Whitehead, Arnold Shapiro, Frank, me, graduate students from MIT and Brandeis, and visitors to the area. George Whitehead gave the first talk on his work on homology theories. Arnold Shapiro spoke on the S-dual of a manifold and the Thom space of its normal bundle. For a good many years Frank would give the first talk of the new academic year.

Sam Gitler visited Brandeis during 1960–61 and in our mathematical discussions explained the "relations among characteristic classes" problem. For example, it was known that for the Stiefel-Whitney characteristic classes of a manifold, $w_1^3 + w_1 w_2 = 0$ on all 5-manifolds. The problem was to find all such relations. The close relationship between Stiefel-Whitney classes (hereafter SWCs) and the Steenrod squaring operations, $\mathrm{Sq}^i : H^q(X) \longrightarrow H^{q+i}(X)$, was well known ($H^q$ denotes cohomology with $\mathbb{Z}/2$ coefficients). Using this, Frank made some low-dimensional calculations, producing some new relations between SWCs. We began meeting from time to time in our homes, discussing how to find relations between SWCs, and drifted into a collaboration which was to last, on and off, for the next thirty years. Our first success was to find a very neat description of the ideal I_m of all polynomials in SWCs that vanish on all m-manifolds (manifold will mean compact, closed, smooth manifold).

We next extended our SWC results to Pontrjagin and Chern classes reduced mod p for odd primes p. Thom's cobordism machinery deals with $\Omega_*(G)$, the cobordism ring of manifolds whose stable tangent bundles have reductions to one of the classical families of Lie groups, $G = O, SO, U, SU, Spin, \ldots$. The general theory gives $\Omega_*(G) \approx \pi_*(MG)$, where MG is, more or less, the one-point compactification of the universal G vector bundle. The serious calculations occur in determining $H^*(MG;\mathbb{Z}/p)$ as a module over $\mathcal{A}_p$. For Pontrjagin and Chern classes one studies $H^*(MSO;\mathbb{Z}/p)$ and $H^*(MU;\mathbb{Z}/p)$, which Milnor had shown are free modules over $\mathcal{A}_p/(Q_0)$, where (Q_0) is the two-sided ideal generated by the Bockstein operation. ($\mathcal{A}_p/(Q_0)$ is the algebra of Steenrod reduced pth powers.) To carry over the I_m methods, we first thought of expressing MSO and MU, at a prime p, as a product of spaces X_r (actually spectra), where $H^*(X_r;\mathbb{Z}/p)$ is a free module over $\mathcal{A}_p/(Q_0)$ on one generator in dimension r. By an elaborate higher-order Bockstein operations–Postnikov tower construction, we succeeded in showing that X_r exists [3]. This spectrum came to be known as BP. Subsequently Quillen's canonical splitting of the localization MU at a prime p into a wedge of suspensions of BP opened the way to the "chromatic" approach to stable homotopy theory, first by Miller, Ravenel, and Wilson, and later by Devinatz, Hopkins, and Smith. Ironically, we did not need the X_r's to figure out $I_m(SO,p)$ and $I_m(U,p)$.

Using the techniques we had acquired in studying "relations", we turned to calculating cobordism groups. It turns out that $H^*(MG;\mathbb{Z}/p)$, G as above, is exceptionally simple as a module over $\mathcal{A}_p$. It gets progressively more complicated as G progresses from O to $Spin$, but remains a sum of cyclic modules over $\mathcal{A}_p$. Don Anderson joined our research efforts, bringing his knowledge of KO characteristic classes, which inspired us to tackle $\Omega_*(SU)$. Using the Adams spectral sequence, we succeeded

Edgar Brown is professor emeritus of mathematics at Brandeis University. His e-mail address is brown@brandeis.edu.

in showing that $[M] \in \Omega_*(SU)$ is zero if and only if all its Stiefel-Whitney numbers and KO numbers are zero (number = characteristic class evaluated on an orientation). Among additional results we gave a basis for the torsion subgroups.

We next turned to $\Omega_*(Spin)$. Here again we used the technique of attempting to split the Thom spectrum into a wedge of simpler factors. By low-dimensional calculations Frank developed a theory of modules over a Hopf algebra which enabled us to say a good deal about $\Omega_*(Spin)$, including a complete determination of its additive structure [1].

In 1963, when we had essentially completed our analysis of I_m, a preprint of *Groups of Homotopy Spheres* by Kervaire and Milnor was in circulation. I thought homotopy theory could resolve a problem left open in this paper, namely, the Arf invariant problem, which asks whether or not a particular easily constructed differentiable structure on a $(4k+1)$-sphere is an exotic structure. Kervaire had shown that it was exotic for dimension 10. For each k he gave necessary and sufficient conditions consisting of the vanishing of the Arf invariant (the mod 2 analog of the signature of a real quadratic form) of a naturally defined quadratic form $\phi : H^{2k+1}(M) \longrightarrow \mathbb{Z}/2$ when M is stably parallelizable. Frank and I began collaborating on the Arf invariant problem, and our first result was to show that for $2k+2 \neq 2^i$, $i > 3$, the decomposition of Sq^{2k+2} gives a secondary cohomology operation on cohomology classes of dimension $2k+1$, yielding a ϕ with the desired properties and providing an $\mathrm{Arf} : \Omega_{8k+2}(Spin) \longrightarrow \mathbb{Z}/2$. Results of Conner and Floyd about $\Omega_*(SU)$ and a product formula for Arf gave an affirmative answer for dimensions $(8k+2)$ [4]. Bill Browder, by similar but considerably more delicate arguments, extended this to all dimensions except $2^i - 2$, which remains open for $i > 5$.

From our perspective on relations between characteristic classes, Frank and I thought about the immersion conjecture: Any m-manifold immerses in $\mathbb{R}^{2m-\alpha(m)}$, where $\alpha(m)$ is the number of ones in the dyadic expansion of m. Our results on I_m show that SWCs will not contradict this conjecture. By work of Smale and Hirsch on immersions, the immersion conjecture is equivalent to the conjecture that for any M the classifying map for the normal bundle of M embedded in a high-dimensional Euclidean space, $M \longrightarrow BO$, lifts to $M \longrightarrow BO_{m-\alpha(m)}$. Using "Brown-Gitler technology", an extension of "relations among SWCs", Frank and I constructed a space BO/I_m over BO such that $H^*(BO) \longrightarrow H^*(BO/I_m)$ is an epimorphism and has kernel I_m. Furthermore, for any m-manifold the classifying map of its normal bundle lifts to BO/I_m. This in turn provided the foundation for Ralph Cohen's work on the immersion conjecture.

All in all, Frank and I had a very enjoyable and productive collaboration in which our talents very successfully complemented each other. With varying regularity we would meet for an hour or two, exchange thoughts about the subject under investigation, usually only mildly comprehensible to each other. After a while this produced some proofs and theorems which, within days, Frank would write up, producing a first draft requiring at most minor changes.

Fred Cohen

On Frank's Later Work, and a Personal Recollection

Frank Peterson's joy in doing mathematics as an individual as well as with other people had a profound positive impact on the lives of many of his friends. I have taken the liberty of describing one such personal experience with Frank which is surely typical. A brief discussion of where a small part of Frank's later mathematics fits is given afterwards.

I was visiting the Institute for Advanced Study during one of the occasions when Frank gave a lecture at Princeton University. Our first conversation occurred that evening during a party at Bill Browder's house and concerned a recipe for caneton à l'orange using Tang, an instant orange juice mix. Frank was unfamiliar with the recipe, but he listened patiently.

A few years later he suggested that we have lunch together during an AMS annual meeting in Atlanta. Friends had regaled me with stories about Frank, one of which concerned his personal bottle of mustard. As predicted, that bottle made an appearance during our lunch in Atlanta. These events had a very settling effect on a somewhat nervous recent Ph.D. and were the beginning of a friendship I have treasured. Frank and I got together many times after that. We proved theorems, sometimes cooked, and had a joyful time.

John Moore had taught a course on classical homotopy theory in which he had proven early global theorems due to Ioan James and Hirosi Toda that addressed bounds for the order of the torsion in the homotopy groups of spheres. That course pointed the way toward subsequent work of Paul Selick and of Frank, as well as joint work of John Moore, Joe Neisendorfer, and me. Paul Selick had proven a beautiful theorem which solved a problem in Moore's course (a conjecture of Michael Barratt's). Paul's theorem states that if p is an odd prime, then p times every element in the p-primary component of any homotopy group of the 3-sphere is zero. His proof used an ingenious choice of map $s : \Omega^2(S^3\langle 3\rangle) \to \mathrm{map}_*(P^2(p), \Omega S^{2p+1})$, which was an H-map. However, the nonexistence of such a

Fred Cohen is professor of mathematics at the University of Rochester. His e-mail address is cohf@math.rochester.edu.

map when spaces are localized at the prime 2 led to the notion of an "atomic" space as follows. I had shown that no hypotheses at all were required for the map above to yield a proof of Paul's theorem as any self-map of $\Omega^2(S^3\langle 3\rangle)$ that induces an isomorphism on the first nonvanishing homotopy group modulo p must be an equivalence (after localization at p). This structure concerning self-maps was subsequently formalized in the notion of an "atomic" space in joint work of John Moore, Joe Neisendorfer, and myself.

Frank became interested in this feature almost at once. During one of Frank's early visits, we considered the "atomicity" of the space of continuous functions from the real projective plane to loop spaces of spheres. Frank, Paul, Eddie Campbell, and I showed that the space of pointed maps from the real projective plane to the loop space of the n-sphere is atomic if $n \neq 2, 4, 5, 8, 9$, or 17. All the other cases admit nontrivial product decompositions given in terms of loop spaces of spheres as well as the classical fibre of the double suspension. These decompositions are extensions to the prime 2 of a decomposition given by Paul Selick for odd primes.

Frank, Paul, and Eddie addressed the atomicity properties of other related spaces [5]. One beautiful result of theirs is as follows. The localization at 2 of the $(n-1)$-st loop space of the n-connected cover of the n-sphere is atomic if n is not 2, 4, or 8. Thus, if $n \neq 2, 4, 8$, then any self-map of $\Omega^{n-1}S^n\langle n\rangle$ that is nontrivial when restricted to the second homotopy group of $\Omega^{n-1}S^n\langle n\rangle$ is a 2-local homotopy equivalence. They also proved an analogous result in case spaces are localized at odd primes p and n is odd.

The spaces in question are huge. That they are atomic is striking. One immediate application is the Kahn-Priddy theorem (which asserts that the stable homotopy groups of $K(\mathbb{Z}/p\mathbb{Z}, 1)$ surjects to the p-torsion of the stable homotopy groups of spheres). Their proof of atomicity of $\Omega^{n-1}S^n\langle n\rangle$ was another beautiful and difficult computation using the classical Dickson algebra, an algebra which would also appear in later work of Frank and his collaborators. One question left open by this work is whether there is an analogue of the Kahn-Priddy theorem for the spaces $\Omega^{2n}(S^{2n+1}\langle 2n+1\rangle)$.

The Dickson algebra D_k is given by the algebra of invariant elements obtained from the natural action of $GL(k, \mathbb{F}_p)$ on the polynomial ring over $\mathbb{F}_p$ with k indeterminates, the tautological representation of $GL(k, \mathbb{F}_p)$), as introduced by L. E. Dickson.

One way in which the Dickson algebra arises in algebraic topology is as the dual of the Araki-Kudo-Dyer-Lashof algebra. The Dickson algebra had played an important role in earlier work of Madsen, Madsen-Milgram, May, Mitchell, Mui, Priddy, and Wilkerson.

Frank's interests in the Dickson algebra and the cohomology of iterated loop spaces fitted closely with another area in which he worked. The mod-p cohomology of a space is an algebra over the mod-p Steenrod algebra $\mathcal{A}_p$. Frank asked for the dimension of a minimal set of generators for the underlying $\mathcal{A}_p$ module in the case of $p = 2$ when the space in question is an n-fold product of infinite-dimensional real projective spaces. He formulated the conjecture that the generators are all in degree d, where $\mu(d) \leq n$ and $\mu(d)$ is defined to be the smallest integer k such that d is the sum of k integers, each of which is one less than a power of 2.

This guess, which became known as the "Peterson Conjecture", attracted many people. For example, the case of $n = 3$ was solved in the thesis of M. Kameko. In addition, D. Anick, M. Boardman, D. Carlisle, M. Crabb, V. Giambalvo, J. Hubbuck, N. H. V. Hung, M. Kameko, D. Pengelley, J. Repka, P. Selick, J. Silverman, W. Singer, G. Walker, F. Williams, and Reg Wood were some of the people who worked on this problem or closely related problems.

The Peterson Conjecture was eventually solved by Reg Wood, whose paper was followed immediately by a paper of Frank's [9] in which he used the solution of the Peterson Conjecture to prove a beautiful theorem concerning the unoriented bordism class of a smooth manifold. Namely, let M denote a closed C^∞ manifold of dimension d, for which n denotes the cup-length for the mod-2 cohomology ring of M. Frank proved that if $\alpha(n) > d$, then the manifold M is an unoriented boundary. This theorem complements work of Harpreet Singh, which had occasioned Frank's conjecture in the first place.

With N. H. V. Hung, Frank pursued an analogous problem to describe a minimal set of $\mathcal{A}_2$-module

Left: Frank Peterson receiving a commemorative chair from AMS Executive Director John Ewing and making remarks, during his retirement party in 1999.

generators for the mod-2 Dickson algebra D_k, $D_k \otimes_{\mathcal{A}_2} \mathbb{F}_2$, and extended Bill Singer's computation for $k = 2$ to cover $k = 3$ and 4. They investigated a construction of Lannes and Zarati and proposed a conjecture, still open, which would imply that the elements in the Hurewicz image for the mod-2 homology of $\Omega_0^\infty S^\infty$ are limited to elements arising in homotopy with either Hopf invariant one or Arf invariant one.

These mathematical directions touched on relationships of topology, homotopy theory, modular representation theory, Lie algebras, and the structure of modules over the Steenrod algebra. This mathematics represents a small but illustrative taste of Frank's interests, together with some of the mathematics which those interests spawned.

D. Pengelley, V. Giambalvo, Frank Williams, and I were working with Frank at the time of his death. These mathematicians are finishing their joint projects in memory of a good friend and colleague.

Fred Gehring and Al Taylor

Franklin Peterson and the AMS

The current healthy and stable financial condition of the American Mathematical Society is due in no small part to the vision and influence of Franklin Peterson throughout his twenty-five years of service as treasurer. We both had the opportunity to work with Frank, the first of us through the late 1970s and 1980s and the second in the 1990s. This period encompassed both good years and lean years for the Society. We were always impressed by Frank's good judgment, his careful stewardship of the Society's assets, and his concern that the Society remain dedicated to its mission of supporting mathematical research and scholarship.

Frank had considerable power as treasurer of the AMS, and he was careful to use it almost exclusively in connection with financial issues facing the Society. One story told us by Steve Armentrout, associate treasurer with Frank for over fifteen years, recalls a legendary incident that illustrates Frank's diplomatic skills.

In the 1980s the Society had two codirectors, the executive director of the Society in Providence and the executive editor of *Mathematical Reviews* in Ann Arbor. At a meeting during this period the codirectors could not reach agreement on a financial issue that affected both units. Frank suggested that the codirectors, the chair of the Board of Trustees, and the associate treasurer meet in a few days and have lunch at Frank's house in Boston to discuss the matter further.

The group met on a beautiful autumn day in Boston, Frank was a genial host, and lunch—with a couple of bottles from Frank's famous wine cellar—was very pleasant. Everyone relaxed and a short discussion after lunch was all that was needed to resolve the matter in question. All went away marveling at Frank's diplomacy.

During the next few years before the dual directorship was abolished, there were a couple of other occasions when the Providence and Ann Arbor units seemed to be at an impasse over some issue. Each time, after a couple of minutes of tense silence, Frank would smile gently and say softly, "Perhaps it's time to have luncheon at my house again." Needless to say, it was never necessary.

Another example of Frank's careful leadership occurred annually when the treasurer, associate treasurer, chair of the Board of Trustees, executive director, and chief financial officer met to discuss salary increases for AMS staff. Frank realized that a great strength of the Society is the dedication of its long-term employees. He also understood the importance of being able to work in pleasant surroundings and to have competitive salary and benefits. On the other hand, he recognized that

Fred Gehring is professor emeritus of mathematics at the University of Michigan. His e-mail address is fgehring@math.lsa.umich.edu.

Al Taylor is professor and chair of the Department of Mathematics at the University of Michigan and associate treasurer of the AMS. His e-mail address is taylor@umich.edu.

personnel costs were the largest single component of the Society's expenses.

Frank's long view and sense of fairness gave a remarkable perspective and balance to these discussions. In lean years when there were great fiscal pressures on the AMS, he made sure that the AMS staff was not carrying an undue share of the budget-balancing burden. In good years he saw to it that the interests of the AMS members were not forgotten.

Frank oversaw tremendous growth in the Society's assets and impact during his years of service from 1973 through 1998. A few numbers illustrate this growth. Over its first eighty-five years of existence, the AMS accumulated a total of $660,000 in assets. During Frank's tenure as treasurer, the operating revenue increased by 500 percent, the total assets by 1400 percent, and the number of staff by 50 percent.

The increase in assets was not a continuous process, but one that involved many ups and downs. The most difficult of these was a three-year period in the early 1980s when large deficits began to threaten the very existence of the Society.

A basic strategy adopted at this time, advocated strongly by Frank and supported by others, was that the Society systematically build up a substantial reserve fund so that it could weather times when income and expenses fell out of balance. This economic stabilization fund has been in existence for almost two decades and has now achieved the goal of its founders.

Frank chaired the Investment Committee, which oversees the Society's endowment and long-term reserve funds. The vigorous investment environment of the 1990s allowed the reserve fund to increase more rapidly than anyone had hoped, and the goal was achieved more than five years ahead of schedule. We view the establishment of this fund as one of Frank's most significant accomplishments, one that will benefit the Society for decades to come.

There are, as one might expect, many personal stories about Frank after so many years as treasurer. One concerns his personal teapot at the AMS building in Providence. It was always present at every committee meeting he attended. In fact, on the occasion of Frank's retirement as treasurer, one AMS staff member playfully estimated that about 1,200 gallons of "Treasurer Tea" had been prepared at AMS meetings during Frank's term.

Another concerns his ever-present bow tie. Frank noticed that Archibald Cox wore bow ties while investigating the 1973 Watergate break-in. Shortly thereafter, President Nixon fired Cox. At that point, Frank said he started to wear bow ties in honor of Cox. He often carried one in his shirt pocket to provide "instant formality" when needed.

Frank was a terrific person to work with because he had such good financial sense and so much devotion to the Society. He was careful and cautious, always ready with a suitable reminder that times were not always good and that preparing for the bad times was everyone's obligation during the good. On the other hand, Frank was thoughtful, forward looking, and ready to support ideas he felt promoted mathematics. Two projects he enthusiastically endorsed were the Centennial Fellowships and the establishment of the Washington office, which has given so much more visibility to mathematics in the past few years.

Franklin Peterson dedicated a large part of his life to the American Mathematical Society. There are countless numbers of grateful members who appreciate all that he did for them, and there are others, yet to come, who will benefit from his caring stewardship of the Society's endowments and reserves.

References

[1] D. W. ANDERSON, E. H. BROWN JR., and F. P. PETERSON, The structure of the spin cobordism ring, *Ann. of Math. (2)* **86** (1967), 271–298. [MR 36:2160]

[2] E. H. BROWN JR. and F. P. PETERSON, Relations among characteristic classes. I, *Topology* **3** (1964), 39–52. [MR 29:629]

[3] ____, A spectrum whose Z_p cohomology is the algebra of reduced p^{th} powers, *Topology* **5** (1966), 149–154. [MR 33:719]

[4] ____, The Kervaire invariant of $(8k+2)$-manifolds, *Amer. J. Math.* **88** (1966), 815–826. [MR 34:6786]

[5] H. E. A. CAMPBELL, F. P. PETERSON, and P. S. SELICK, Self-maps of loop spaces. I, *Trans. Amer. Math. Soc.* **293** (1986), 1–39. [MR 87e:55010a]

[6] J. R. HARPER, *Secondary Cohomology Operations*, to appear.

[7] W. S. MASSEY and F. P. PETERSON, The mod 2 cohomology structure of certain fibre spaces, *Mem. Amer. Math. Soc.* **74** (1967). [MR 37:2226]

[8] R. E. MOSHER and M. C. TANGORA, *Cohomology Operations and Applications in Homotopy Theory*, Harper & Row, Publishers, New York and London, 1968. [MR 37:2223]

[9] F. P. PETERSON, A-generators for certain polynomial algebras, *Math. Proc. Cambridge Philos. Soc.* **105** (1989), 311–312. [MR 90a:55031]

Reflections of a Department Head on Outreach Mathematics

John B. Conway

Several years ago my department committed itself to hiring tenure-track faculty who would be outreach mathematicians, faculty whose scholarly activities would consist of interacting with K-12 mathematics teachers and facilitating the department in its desire to influence the teaching of mathematics in the schools. Last year we hired two such people. In this article I will describe the process by which I and my colleagues brought this about and some of the rewards and difficulties. The companion article contains the reflections of one of our outreach mathematicians.

My purpose in writing this article stems from the same deep-seated belief that led me to advocate hiring outreach mathematicians. The mathematics profession will greatly benefit from having mathematicians involved in K-12 mathematics. I encourage others to join my department in this undertaking.

The University of Tennessee is a land-grant institution, so public service is an integral part of our mission. Our mathematics department has a tradition of involvement with K-12 teachers, starting long before my arrival here as department head in 1990. A point of pride here is that future teachers complete a five-year program, with the first four years spent getting a major in their subject area. So immediately, as a byproduct of our major program, my department is involved in training future teachers. Following a series of NSF (National Science Foundation) grants in the 1960s and 1970s, the department started an MM (Master's of Mathematics) degree program to improve the mathematical knowledge of K-12 teachers. Because of this same tradition, when I arrived there were two professors (since retired) whose main activities were connected with outreach and education. Though the department did not have faculty who did research in mathematics education, the presence of these two colleagues set the stage for recruiting in outreach.

Another pertinent fact is that our College of Arts & Sciences has a long tradition of commitment to academic outreach. Again, that started as the concept—formulated by more than one dean—of the role of a land-grant university. There were staff people who did outreach. There have always been some faculty in the college who have participated in a serious way in outreach either as a modification of or an addition to their research careers. This aided the department when it approached the dean about hiring outreach mathematicians. Still, hiring untenured faculty who do outreach presented some problems at the college level, as I'll discuss later.

This is a good place to emphasize a distinction between outreach mathematics and mathematics education. Educational research involves discovery of how students learn and how to improve that learning. My outreach mathematicians are not directly involved in research in education, though it would not surprise me if, during the course of their careers, they occasionally do become involved. Rather they are committed to interacting with teachers and influencing the content of what is taught in K-12 mathematics. They are also

John B. Conway is professor of mathematics and head of the mathematics department at the University of Tennessee at Knoxville. His e-mail address is conway@math.utk.edu.

involved in the examination of how future teachers are taught. As mathematicians, we know content. Examination of pedagogy is in the realm of the College of Education.

Why Should a Mathematics Department Become Involved in Outreach?

There is so much criticism of mathematics education in this country. In our calculus classes we all see unprepared students, and K–12 mathematics instruction and curriculum seems a ready focus for blame. In my view, I have met the enemy and he is us. Research mathematicians have for many years divorced themselves from what happens in K–12 mathematics. This means that we cede the entirety of the preparation of future college students to people with limited mathematical expertise and experience. If we want to pluck ripe fruit from the tree, we really should spend some time watering the roots. Some research mathematicians are beginning to influence curriculum and standards. But there continues to be a need for individual mathematics departments to work on the local level.[1]

So I believe that the participation of mathematicians in teacher training and deliberations about K–12 education is crucial. Our participation will ultimately result in better teaching and learning throughout the spectrum of American mathematics.

Persuading My Department

Convincing my department to commit to outreach was easier than one might think. I have a small advantage in that my personal research record inclines my colleagues to listen to what I have to say. Perhaps the history of the department was a factor too. In any case, the vast majority of my colleagues supported recruiting outreach mathematicians (OMs). Yes, there were some objections and many questions. It isn't that we have positions to burn; when there is a vacancy, there is as much jockeying by the various research groups to claim the right to fill it as in any department. But in principle they saw the need for and advantages of becoming involved in outreach. They also clearly bought the need for two OMs, since being a solo trailblazer can be a lonely occupation. Also, a single OM would be more like lip service than a commitment.

On the other hand, there was wide disagreement as to exactly what an outreach mathematician should do. Work with students or teachers? High school, community colleges, or middle school? Should we insist on a Ph.D. in mathematics or admit the possibility of hiring someone with a doctorate in mathematics education? There was debate—a very healthy event. The prevailing opinion was to concentrate on K–12, but there was a divergence of opinion as to whether this should be middle or high school. (A focus on elementary school mathematics had few if any proponents.)

Recruiting

Last year (1999–2000) we conducted our third search to find an outreach mathematician. In our first attempt the administration canceled all searches because of budget difficulties. We had already interviewed two candidates, and the department was equally divided between hiring one of the two and hiring neither. Part of the problem was that the search exposed a lack of departmental focus on some crucial points. Some basic questions had not been answered. The total newness of the undertaking meant we had no available road map, but I'll take the load of responsibility for not better vetting the concept of outreach.

Before we started the second search, we decided to open the pool to people with an Ed.D., provided they had a master's in mathematics. We had not done this the first time around and had found the pool of applicants too limited. The ideal way to start such a venture would be to recruit an associate or full professor to do outreach, but budgetary realities precluded this. The rub is that few people get a Ph.D. in mathematics with the intention of doing outreach, so restricting the search to Ph.D.'s in mathematics produced an unusual collection of candidates, few of whom seemed suitable.

In the second search we interviewed several candidates, made an offer, and got our first choice—someone with a Ph.D. in mathematics. He came but, for many reasons, did not work out. Why? Here, like in a divorce, one will get a different perspective depending on whom one talks to. One difficulty was that the OM was alone. Another was that the department's stated expectations lacked focus: even though the first search had revealed weaknesses, we hadn't formulated anything that gave the OM and the faculty a clear idea of the nature of the job. Still another was that the department had not properly laid the foundation with the College of Education. When the OM's desire to do research in mathematics education led him to give a graduate seminar in it, all the difficulties converged, and what had been a wart exploded into an open sore. Giving mathematics credit for a course in education was the realization of the worst fears of many mathematics faculty. Our College of Education colleagues were truly incensed. They became firm believers in the mathematics department's ultimate aim of taking over mathematics education.

The third time worked like a charm. The search produced three good candidates. We hired two

[1] *Two recent instances of a call for increased outreach involvement are: W. E. Kirwan, Mathematics departments in the 21st century: Role, relevance, and responsibility,* Amer. Math. Monthly ***108** (2001), 1–9; Presidential views: Interview with Hyman Bass,* Notices ***48** (2001), 312–315.*

assistant professors, both with Ph.D.'s in mathematics. It is pertinent, however, to underline that neither of our outreach mathematicians is fresh from graduate school. Both have several years' teaching experience. One, who wrote the companion to this piece, had worked as an instructor doing outreach at the University of Colorado. The other had less experience, though he had given some summer workshops funded by Eisenhower grants at the University of Tennessee and had successfully organized our first statewide mathematics contest.

Though several candidates we interviewed in the last two searches had doctorates in education, my faculty did not react positively to them. Many of my colleagues had strong doubts that these candidates could do the range of teaching that was expected. This last point may be a cultural problem, but for me it is essential that any outreach mathematician have the trust and full respect of the rest of the faculty. Someone who teaches only lower-division courses would be viewed as a second-class faculty member. In addition, we have a graduate degree aimed at teachers, and teaching courses in the program calls for some mathematical expertise. I bow to my colleagues' collective wisdom here.

Defining the Position

Defining the duties of an outreach mathematician is a dynamic process. I am a person who likes to have matters and rules and processes tied down, neatly wrapped, and fixed. I don't like dynamic processes in running a department. But in this case it's the best course. I think this is one of those situations where if one waited until one answered all the questions and dotted all the i's, defining the duties of an outreach mathematician would never get done. On the other hand, when we recruit research mathematicians, we specify only in the broadest of terms the kind of research we expect them to do. Nevertheless, the description of the expectations of an outreach mathematician is somewhat more ambiguous. But this ambiguity has a virtue. Let the people define themselves.

The department did adopt a formal statement of expectations for an outreach mathematician, modeled after a similar document we had to formulate in connection with our university entering into a posttenure review procedure. The accompanying sidebar contains the guts of that statement as it differs from what is expected of other mathematics faculty.

Originally there was no requirement of publishing other than what appears in the penultimate paragraph. My dean objected to this. My faculty was not so interested in publishing as in influencing mathematics teaching in the schools. But the dean's point was that the original draft requirements made little distinction between an outreach mathematician and various staff hired by the university and doing outreach; to get tenure one must contribute to knowledge on a broad front. She is right on this point.

I was a bit surprised to discover that many outlets for outreach publishing exist. So the publishing stipulation has not been an onerous requirement for either me or my outreach mathematicians. Many mathematicians have a skepticism about research in mathematics education. All seem to have their favorite example of some nonsensical research in mathematics education. We should realize, however, that this is an unthinking attitude. Certainly we understand the laws of logic sufficiently to know that the existence of examples does not prove a universal truth. Also, I know a few examples of mathematics research papers whose quiet death in a darkened mathematics department would have benefitted the world far more greatly than their publication.

Anything can profit from study. Can anyone possibly believe that all ways of teaching middle school mathematics are equally efficacious? In addition, if the research mathematics community is to become involved with school mathematics, as I think it should, certainly a record of the experiences, successes, and failures of those involved will have value. Outreach publication has merit.

In the mathematics culture it might seem unusual to require the outreach mathematicians to get external funding. In mathematics, unlike the natural sciences, one can indeed do the work without external funding. But being an effective outreach mathematician—one who conducts workshops and reform and who has a wide impact—requires funding. Thus an outreach mathematician is expected to get funding, although a research mathematician is not.

The College of Education and Outreach

Some people in my College of Education (COE) have been enthusiastic supporters. Others have felt, apparently, that there is a threat to their turf. So I, as department head, try to soothe and reassure those who feel a threat by averring that we are interested only in content questions and want to cooperate. I tell them that we are their allies and seek theaters of cooperation.

We had someone from the COE on our search committee for an outreach mathematician, and this was a good bridge. Not surprisingly, that faculty member is one of the enthusiastic supporters of outreach mathematics. So the lesson here is one that reiterates a basic fact of human behavior when one engages in activity that affects people besides one's self: the more informed people are, the higher their comfort level. The more they become involved, the more they become enthusiastic supporters. People in the COE are vital, significant contributors to any conceivable

Excerpt from UT Statement of Expectations

In addition, the OM must satisfy the following in teaching and service to be classified as meeting expectations.

Teaching

• Be an adviser for prospective mathematics teachers and students who are enrolled in the MM program.

Service

• Be an active participant in the work of committees whose responsibilities include the monitoring of the courses associated with teacher training (at present, these committees are the Undergraduate Committee and Mathematics Education Committee).

• Communicate to the mathematics department the issues of mathematics education.

• In lieu of a traditional research program in mathematics, the OM is expected to engage in a full range of activities outside the confines of the Knoxville campus. Such activities will be referred to as outreach scholarship.

The following are the criteria for meeting expectations in outreach scholarship.

An assistant professor must:

• Obtain grants from external sources to support outreach activities.

• Publish in outreach or pedagogical journals and engage in other scholarly activities that are subject to external peer review.

• Offer well-attended, quality workshops to improve K-12 teachers' skills.

• Have contacts with mathematics teachers and students which improve the quality of mathematics learning.

• Participate as a speaker in area mathematics organizations such as SMMEA and TMTA. (These are regional associations of mathematics teachers.)

An associate professor must:

• Continue the activities expected of an assistant professor with additional intensity.

• Become involved as a leader in East Tennessee mathematics organizations.

• Participate as a speaker in national mathematics organizations such as NCTM or MAA.

• Be visible and professionally active as an OM, with recognition beyond the state of Tennessee.

A full professor must:

• Continue the activities expected of an associate professor.

• Be visible and active as an OM, with national recognition for these efforts.

The OM's professional performance will be judged by the quality and impact of the effort; the dissemination of the outreach outcomes to the scholarly community through presentations, publications, and other scholarly products; interaction with the community of scholars in the Department of Mathematics and mathematics educators in the UT College of Education, regional community colleges, and local public schools; as well as an assessment of his/her success in the integration of scholarship, teaching, and public service.

As in the case of traditional research faculty, additional assessment tools include but are not limited to: letters from chairs (and members) of committees, standard assessment techniques for teaching, survey of former students similar to the surveys used for teaching, letters from appropriate faculty and outside reviewers.

project for improving school mathematics. We should not ignore them or try to bypass them; rather, we should incorporate them into our projects.

The Future

I see many encouraging developments connected with our program in outreach mathematics. Our outreach mathematicians are making good contacts, and we are getting good feedback from a variety of sources. They are learning some background in mathematics education and becoming acquainted with people on and off campus who have a role to play in any reform. They have already begun what I feel will be an extremely important part of their job: facilitating the involvement of the rest of the department in K–12 mathematics. There are more demands for the time of our outreach mathematicians than they can accommodate. I constantly worry about them spreading themselves too thinly and I periodically raise a cautionary note.

I will have a more complete picture of the state of outreach in a few years. In the meantime, I invite you to contemplate outreach at your own institution. The road is not smooth, straight, or well posted. There are risks, but the payoff for success is enormous.

Reflections of an Outreach Mathematician

Jerry F. Dwyer

The mathematics department of the University of Tennessee at Knoxville has recognized the benefits of an outreach program and has made a strong commitment to outreach activities by hiring two faculty members whose job title is "outreach mathematician". The exact nature of this post is still being defined by the actions of these new faculty members.

The new outreach position follows the usual model for a tenure-track post: typically 40 percent teaching, 40 percent research, and 20 percent service. However, the research expectations are replaced by the requirement that the outreach mathematician develop a funded outreach program, act as liaison with the College of Education, offer mentoring to teacher trainees, and publish in scholarly outreach journals. Outreach for the University of Tennessee mathematics department is loosely defined as any activity that enhances the teaching and learning of mathematics outside the department, in particular in K–12 education and community colleges. The official description of the expectations is included in the companion article written by my department head.

I was hired in the fall of 2000 for one of the new positions. My colleague Reid Davis was hired at the same time for the other position. I brought extensive experience gained while developing outreach programs at the University of Colorado, Boulder. I had worked in several engineering departments for many years as an applied mathematician and produced related publications in the mechanics literature. However, I maintained a deep interest in quality mathematics teaching and felt more at home when I finally obtained a post in a mathematics department.

The new position at Tennessee offers much freedom within the job parameters, and the opportunity exists to define the role according to the particular strengths and interests of the incumbent. This is one of the first such posts in a research mathematics department in the nation, and it offers much potential for innovation.

Why Outreach?

There are many reasons for mathematics departments to engage in outreach. The state of mathematics education at the K–12 level is important to all college mathematics teachers. It is appropriate that faculty from a major university mathematics department be involved. Outreach to the community is often the source of fruitful collaboration between different departments on campus, and outreach activities lead to greater visibility for a mathematics department. This increased visibility can be part of a valuable recruiting strategy, and outreach plays an important role in attracting new students. Finally, participation by mathematics departments in K–12 and community projects offers valuable opportunities for graduate students to gain beneficial teaching experience.

Challenges

A variety of subtle and interesting challenges have appeared in my new job. In many ways these challenges reflect a clash of cultures. The research mathematician often lives in a specialized culture, while the outreach mathematician must understand and interact with many different cultures. The following paragraphs describe the challenges associated with the education culture, the humanities/liberal arts

Jerry F. Dwyer is assistant professor of mathematics at the University of Tennessee at Knoxville. His e-mail address is `dwyer@math.utk.edu`.

culture, the public school culture, the team research grant culture, the local community culture, and the campus administrative culture.

The kind of outreach work that I do is more common in colleges of education than in colleges of arts and sciences. Because relations between mathematics departments and education schools have often been strained or almost nonexistent, a mathematician feels wary when dealing with mathematics education. Moreover, a mathematician is hesitant to get involved in traditional mathematics education work if departmental colleagues do not value such work and feel that it belongs in the education school.

Outreach work is more of a community-based and sociological endeavor than is mathematics research. Reflecting this difference, scholarly publications in outreach include much description of planning, motivation, outcomes, and reflections on experiences. Faculty from the humanities and liberal arts are well versed in this type of writing. But faculty from mathematics, science, and engineering are a product of a different kind of research culture. We have a different approach to conducting and reporting our research. For example, a mathematician might want to publish in a scholarly journal a report on educational activities. However, the mathematician may lack the background knowledge and be unwilling to spend the time on the literature review required for such a publication.

The main focus of our outreach is in K-12 education, and I am currently paying special attention to elementary and middle schools. Achievement of American middle school students is low, and there are many reasons for this. It is not clear how the problems may be tackled, and the magnitude of the task can be overwhelming. There is a danger of trying to solve all problems at once, which is not possible. Many of the issues are political in nature and are related to school boards and local curriculum on one level and to teacher training and certification on another level. These are all beyond the power of the mathematics faculty member. Furthermore, there is often little enthusiasm within the schools and districts where there is greatest need. Some states have education as a low priority and then try to make up ground by demanding high-stakes testing, which is often opposed to sound pedagogy.

A recent report (TIMMS, 1999) suggests that American schools are often run as businesses which happen to have education as part of their role. My own observation is that education in the school often takes a back seat to school lunches, class photos, flu shots, band practice, etc. Classes are regularly interrupted by public speaker announcements. It is often difficult to arrange class visits because students are going to the zoo or on some other field trip. Mathematics class seems to be a low priority for school administrators. Perhaps the most frustrating of all is when we make a classroom presentation and the teacher decides to use that time to grade homework rather than participate. What message does that send to the students? This environment is foreign to me, for the schools I attended as a child in Ireland were primarily places of learning.

A major challenge in outreach work is the need to obtain funding. We teachers of mathematics like to study mathematics and do mathematics research, but most of us do not want to be entrepreneurs and administrators: we do not want to spend our time writing grant proposals. Dedicated individuals with few resources can accomplish significant mathematical research, but outreach is a different story. Although one may not need grant money to visit schools, sit on committees, and write articles and reports, often effective outreach work requires large teams of participants. The only way to create these teams is to obtain funding for salary support. Moreover, there are costs associated with organizing events such as teacher workshops and meetings for parents, and grant money is needed to cover these costs.

Another subtle challenge that I faced in developing an outreach program was adapting to the local community. Mathematical or scientific work is usually independent of the surroundings and the community. All that is required is some solitude and occasionally some equipment. Outreach work depends essentially on making contacts in the local community and beyond. Thus, it takes much longer to initiate an outreach project than a traditional mathematical research project. Although traditional research is performed at all times of the day or week, active outreach is restricted to the school hours.

A final point about outreach scholarship is worth noting. Because there is already a body of literature and a community of practitioners in outreach, college and university administrators may have preconceived ideas about what an outreach mathematician should do. However, my primary responsibility is to the mathematics department. As my department sees the role of "outreach mathematician", the word "outreach" is only the descriptive adjective. Tension occurs because the outreach mathematician also needs to satisfy the college as a whole in order to achieve tenure. This observation may help other mathematics departments in developing outreach positions while remaining independent of preconceived outside ideas.

Activities

In this section I describe some concrete activities that I have undertaken as an outreach mathematician. One of the most important of these is a series of classroom presentations that have been described as "model" teaching. These presentations include game playing and interactive teaching in a manner that is different from what the students usually encounter. This style of teaching brings enthusiasm and content knowledge to the classroom, which act as motivation for the regular teacher. The feedback from these presentations has been very positive. Two important points have to be made here. First, it is critical that the university mathematician enter the classroom as a collaborator and colleague, not for the purpose of "fixing" the teacher or doing a research study. Second, we must make sure that we provide assistance without becoming immersed in a particular school situation. The outreach mathematician is a university faculty member with a faculty role and must not become a special version of a middle or high school teacher.

"Service learning", a component of some college courses, means that students perform community service, which enhances their own learning in the course (Kraft, 1996). In our lower-level undergraduate courses we offer students the opportunity to assist in local K-12 classrooms. This strengthens our relationship with the teachers and also increases the awareness of outreach among our students. It is hoped that these activities will give us greater visibility in the teaching community and increase our own awareness of K-12 issues. All of this should give us greater credibility if later we wish to speak out on important curricular and pedagogical issues.

Building respect within the department for my role is also important. I have facilitated school visits by my faculty colleagues. The average mathematics faculty member is happy to visit schools occasionally and to reach out with his or her expertise, but not to make the arrangements or to deal with the logistics. The outreach mathematician's role in facilitating these visits is therefore very welcome. Gaining respect for my work throughout the entire campus is equally important, and dialogue across college boundaries is also greatly enhanced by this new position. Especially important is to foster good relations with the College of Education, which is a natural ally in raising the standards of mathematics teaching.

One of the primary ways to make an impact on K-12 mathematics education is to raise the content knowledge of teachers. We have already presented some seminars and are proposing a series of classes and workshops aimed at teachers from first to eighth grade. It is important not only that these classes contain substantial mathematics content but also that enthusiasm for mathematics is conveyed. Our philosophy that there is a beauty in the conceptual understanding of mathematics must be passed on. This is one area where mathematics faculty can have a very positive outreach role.

In collaboration with the College of Education we have submitted a proposal to the National Science Foundation for a Center for Teaching and Learning. We have also begun to identify some foundations and corporations that may be able to fund some of our local projects. The optimum use of funds is in the area of personnel costs, as good teachers and visionary facilitators are the keys to the success of our projects. For this reason we hope that we can hire some postdoctoral workers to assist and develop programs. The personal beliefs, enthusiasm, and energy of the outreach facilitators are crucial to progress in these ventures. There is definitely some sense that this work is personality driven.

One important role of an outreach mathematician is that of representing the views of mathematicians in the world of mathematics education. Very often education committees lack adequate representation from the world of mathematics. We cannot complain when decisions are made that do not reflect our views if we have not bothered to take an interest in these matters. It is my intention to represent the mathematics department in several such roles.

The Way Ahead

I strongly believe in the importance of outreach, and I will continue to pursue the activities described in the previous section. Although for the moment this will mostly be at a local level, I hope that what we do at the University of Tennessee can offer insights to other colleges and universities as they develop their own outreach programs. Recent articles (Holland, 1999; Keener, 1999) address many of the issues facing institutions as they try to develop criteria for recognizing faculty participation in outreach. These challenges are common to many institutions across the nation. Here at the University of Tennessee there is senior support for outreach, and this support has now translated into the creation of tenure-track outreach mathematician positions and formal recognition of outreach as a scholarly activity. I look forward to sharing our experience with colleagues around the nation as other mathematics departments begin to undertake similar ventures in outreach.

References

[1] B. A. Holland, Factors and strategies that influence faculty involvement in public service, *J. Public Service Outreach* **4** (1999), 37–44.

[2] M. S. Keener, Strengthening institutional engagement: Addressing faculty issues to facilitate change, *J. Public Service Outreach* **4** (1999), 29–36.

[3] R. J. Kraft, Service learning: An introduction to its theory, practice, and effects, *Education and Urban Society* **28** (1996), 131–159.

[4] TIMMS, *Facing the Consequences: Using TIMSS for a Closer Look at United States Mathematics and Science Education*, Kluwer, Dordrecht, 1999.

What Do You Want from Your Publisher?

An Annotated Checklist for Mathematical Authors

Wilfrid Hodges

What Do You Want from Your Publisher? An Annotated Checklist for Mathematical Authors

A copyright agreement with your publisher is a signed undertaking that he will do or not do certain things and you will do or not do certain other things. If you are wondering how to get a fair deal in this agreement, you should start by asking what you want your publisher to do for you and what you are prepared to let your publisher ask from you. The checklist below may help you to make sure that you have not missed any important points.

The agreement is a bargain struck between your interests and those of your publisher. For example, both you and your publisher have a common interest in stopping your work from being plagiarised by other people. But if your publisher is expected to take plagiarists to court at his expense, he may well feel entitled to redress the balance by asking you for something else that he wants but you may not.

Changes in the law and technology are continually altering the balance between author and publisher. So you shouldn't feel inhibited about telling your publisher if you feel that some change in the copyright form sent to you by your publisher would make it a fairer deal. (Your publisher is not inhibited about changing his form where he feels it's appropriate.) Because of the costs involved, the publisher is more likely to be willing to discuss the contract for a book than for a journal article, but even for journal articles pressure from authors may lead a publisher to change his standard contract.

So far as possible we have avoided legal terminology in the checklist. This is for two reasons. The first is to make the points clearer and more direct. The second is that there are still enormous differences between one legal system and another, though the differences are gradually narrowing under the pressure of international trade. For example, "copyright" in the USA and its nearest equivalent in France, "droit d'auteur", are really quite different concepts, and the German and British legal systems make different assumptions about who is the initial owner of a work. Different legal systems have different ways of delivering the balance that you want.

We assume you are a mathematician and not a lawyer. So how can you draft a clause that gets the effect you want? You can start with what your publisher proposes, using your common sense. The points in the checklist below all carry notes about things to look out for, and in several cases we point out things that matter in particular countries. We hope these resources will be enough for you; if not, you may need to find a friendly lawyer.

Note: P is publisher (assumed male).

1. Things you might allow P to do

a) Publish your work.

> Make sure that it's clear what the "work" is, especially if it involves electronic items.

Wilfrid Hodges is professor of mathematics at Queen Mary, University of London. His e-mail address is `w.hodges@qmul.ac.uk`.

The copyright checklist was written by Wilfrid Hodges and was approved and is recommended by the Committee on Electronic Information and Communication of the International Mathematical Union (IMU).

There is also a question whether it is "your" work. Of course you will know if you stole it from someone. But even if you wrote the paper entirely on your own, you may not realise that your employer can claim ownership of your mathematical work.

In France and Germany this can't arise. But in any English-speaking country you would be wise to check your contract of employment to see what it says about the copyright in works that you wrote as part of your employment, particularly if you are working for a government agency. Be warned also that your contract of employment need not be the end of the story, because the law in different countries makes different assumptions about copyright ownership if your contract of employment is not specific about it. For example, in Canada the assumption is that your employer holds the copyright unless your contract of employment says otherwise, though as author you have certain rights over the publication of articles written by you. If you are a U.S. public servant and the work was done as part of your official duties, then there is no copyright on it within the U.S., though there may be outside the U.S.; if you are in this position, you probably know where to seek advice on the matter.

In France it is essential that your copyright agreement says explicitly that P is allowed to publish the work.

b) Distribute free copies under certain conditions.

This raises no legal problems.

c) Authorize other people or institutions to publish copies of your work.

For example, you probably want to allow offprint services to distribute offprints of your work and to charge a fee for copies.

d) Authorize other people or institutions to make copies of your work under certain restricted conditions.

This is a very important clause. Students and researchers need to be able to make photocopies of your written papers or parts of your books. If your work is electronic, then nobody can load it onto their computer or bring it up on their screen without copying it (from disk or Internet to RAM, from RAM to screen); so for electronic works this clause is absolutely essential.

Usually P takes responsibility for negotiating licences for colleges and libraries, though P may contract this out to an agency. Your contract must give P permission to do this, though P will notice if you ask him to accept a contract that doesn't. You should try to avoid details at this point, because there are many subtleties that you probably aren't aware of. (For example, should electronic access from the college be controlled by password, IP address, or domain name?) Librarians and publishers both complain bitterly that the other side often makes unreasonable demands; best you keep out of these fights.

e) Authorize other people to make derivative uses of your work, such as reviewing or indexing.

For normal scientific reviewing, fair use or equivalent rules will usually allow the small amount of copying that may be involved. But creating an abstract or quoting more extensively than is required for purposes of scholarly comment may fall outside these rules. If you grant P the right to handle such matters, dealing with requests for uses such as these will generally fall to P's "rights and permissions" department.

2. Things you might require P to do

a) Pay you.

This normally applies only to books. There are some journals and conference proceedings for which you have to pay P.

b) Anything under (1) above.

It's up to P what he will accept along these lines, but he will not usually accept an obligation to publish without a clause that the work must be of acceptable quality. But in any case you and P have a common interest in having people or libraries buy the work.

c) Advertise the publication of your work adequately.

This applies to books rather than journal papers. It is not a thing that publishers will normally accept as an obligation. Nevertheless, one does meet authors who have a grievance about

Executive Summary for Authors of Research Papers in Journals

The number of mathematical papers that are stored or circulated as electronic files is increasing steadily. It is important that copyright agreements should keep in step with this development and not inhibit mathematical authors or their publishers from making the best use of the electronic medium together with more traditional media. While most mathematicians have no desire to learn the subtleties of copyright law, there are some general principles that they should keep in mind when discussing with their publishers copyright for research papers.

1. A copyright agreement with your publisher is a bargain struck between his interests and yours. You are entitled to look out for your interests. Most journal publishers have a standard copyright form and may be unwilling to vary it for individual authors. But nothing prevents you from asking, if you see room for improvement. Pressure from authors may lead publishers to change their standard contracts.
2. Three groups of people have an interest in your paper:
   a) you and your employer (who may in some countries automatically be the original copyright holder and hence a party to the copyright agreement);
   b) the journal publisher;
   c) users of the paper who are not parties to the copyright agreement, including readers and libraries.

One of the main purposes of your copyright agreement is to control how your publisher or you make the paper available to this third group. Publishers will hardly allow individual authors to dictate agreements with libraries. But if you know that a certain journal publisher makes life hard for libraries, you can take this into account when choosing where to submit your paper.

3. There is no ideal copyright agreement for all situations. But in general your agreement should contain the following features:
   a) You allow your publisher to publish the paper, including all required attachments if it is an electronic paper.
   b) You give your publisher rights to authorize other people or institutions to copy your paper under reasonable conditions and to abstract and archive your paper.
   c) Your publisher allows you to make reprints of the paper electronically available in a form that makes it clear where the paper is published.
   d) You promise your publisher that you have taken all reasonable steps to ensure that your paper contains nothing that is libelous or infringes copyright.
   e) Your publisher will authorize reprinting of your paper in collections and will take all reasonable steps to inform you when he does this.
4. Should you grant full copyright to the publisher? In some jurisdictions it is impossible to transfer full copyright from author to publisher; instead, the author gives the publisher an exclusive right to do the things that publishers need to do, and these things need to be spelt out in the agreement. This way of proceeding is possible in all jurisdictions, and it has the merit of being clear and honest about what is allowed or required.

The executive summary was endorsed by the Executive Committee of the IMU in its 68th session in Princeton, NJ, May 14–15, 2001.

the way their work was advertised. There is nothing to prevent your asking for such a clause, particularly if P is one of those charming publishers who threaten to give your book less favourable treatment if you don't go along with their other requests on the copyright form.

d) Let you know when other people ask for or are given permission to republish the work.

You can reasonably ask to be informed if a chapter of your book is going to appear in someone's collection; you can't reasonably ask to be informed every time an offprint is issued.

Also, P will be a fool to give you a cast iron guarantee in this clause. By the time P needs to send you the information, you may have left the country and be impossible to trace. Any clause of this kind should require P only to use "best endeavours" (or some similar phrase) to get the information to you.

e) Update the electronic format of electronic material as the advance of technology requires.

You are in uncharted territory here. It is more sensible to require this for electronic material in a standard text format than it is for graphics files that may need some particular software application to run them. P may reasonably insist on a "best endeavours" clause in any case.

Some publishers say explicitly that they will not patch up your files if these are incompetently written. This is a very reasonable requirement, and you should assume too that P will not sort out the mess if you have used an outdated format (for example, an obsolete version of TeX).

f) Take legal proceedings against plagiarists.

P would be stupid to accept this obligation without very severe restrictions. Legal proceedings are expensive, and sometimes the chance of conviction is low. Also, as it stands this is an obligation into the indefinite future (or at least until the copyright lapses, which in North America is normally seventy years after the death of the author). Why should P lumber himself with this? You should rest in the knowledge that plagiarism is a threat to P as well as to you.

Note that in most countries P will not be in any position to take plagiarists to court if P doesn't have a legal interest in the work. But the details vary from country to country.

3. Things you might require P not to do

a) Alter your work.

By international agreement you as author have a moral right to claim authorship of your work and to object to any distortion, mutilation, or other modification of it which would be prejudicial to your honour or reputation. Like all moral rights, this right stays with you forever and doesn't need to be stated in the copyright agreement, but different countries have taken different steps to safeguard this right.

In any event, the moral right is rather vague. You may want to demand something stricter, for example, that no change is made in the text of your paper. Don't be surprised if P puts restrictions on this. For example, P has to protect himself against possible libel or plagiarism by you; he may insist on being able to make alterations that are necessary for legal reasons, and he won't want to be delayed by having to check with you first. (This arises particularly with electronic files that P keeps on his website. He can hardly alter journals already delivered to libraries.) In return, you can reasonably insist that any such emergency alteration is approved by an academic editor.

Don't be surprised either if P insists on being able to make purely electronic or formatting adjustments; this is reasonable.

4. Things P might want you to do

a) Guarantee that the work has not previously been published and that you are not simultaneously offering it to another publisher.

As it stands, this prevents P from publishing a work of yours which has already been published, even when the person who holds the necessary authority has authorised P to republish. But if P knows that this is the situation and still wants to publish, P will presumably withdraw the clause.

There can be a tricky scenario when the previous publication was on paper, very likely before electronic publication was invented, and the proposed new publication is electronic. Both you and P need to be sure that the previous publisher can't stop you making the new publication. This may depend not only on the text of the earlier copyright agreement but also on the legal system of the country in question. Unless you are extremely sure of your situation, find the copyright agreement with the previous publisher and show it to a reliable lawyer.

b) Guarantee that you are legally entitled to give P the rights that you are claiming to give him.

Caution here. Unless you are *very* sure of the full facts, you should never do more than guarantee that you have taken all reasonable steps to make sure you are entitled.

For example, an electronic paper may contain software that some company issued as freeware, but later the company

Call to All Mathematicians

Endorsed by the IMU Executive Committee on May 15, 2001, in its 68th session in Princeton, NJ.

Open access to the mathematical literature is an important goal. Each of us can contribute to that goal by making available electronically as much of our own work as feasible.

Our recent work is likely already in computer readable form and should be made available variously in TeX source, dvi, pdf (Adobe Acrobat), or PostScript form. Publications from the pre-TeX era can be scanned and/or digitally photographed. Retyping in TeX is not as unthinkable as first appears.

Our action will have greatly enlarged the reservoir of freely available primary mathematical material, particularly helping scientists working without adequate library access.

This statement was written and recommended by the Committee on Electronic Information and Communication (CEIC) of the International Mathematical Union (IMU).

changed its mind and demanded that users of the software should pay for a licence. You (and hence P) may still be legally liable, though you may be able to plead in mitigation that you didn't know about the change. This is very uncommon, but the fact that it can happen at all should warn you to take care with a clause like (b).

c) Guarantee that the work contains no libel or other material that shouldn't be published.

You can agree to this more safely than (b), but you should still be careful, particularly in Britain where the libel laws are stiff.

d) Include a confidentiality clause, or ask for part of the agreement to be by a verbal understanding rather than a written contract.

There *might* be a good reason for these, but common sense suggests you should be extremely suspicious. If you do have grounds for suspicion, you might ask for a clause saying that no oral statement should be taken into account apart from the text, which should be taken to constitute the entire agreement.

5. Things P might want you not to do

a) Publish the work yourself.

This includes keeping the work on a public website after P has published it. If you have given somebody else an *explicit* licence to include it in their website, then in general you can't prevent them keeping the work on their site. Usually in such cases the licence is implicit, so that you can write to the owner withdrawing the licence, and the owner is then obliged to remove the work from the site.

The legal terminology of most countries allows three possibilities.

i) If you have given an "exclusive licence" to P, then this prevents you from publishing the work yourself or authorising anyone else to publish it. P on the other hand can do with your work what you license him to do and nothing more.

ii) If you give P a "nonexclusive licence", this entitles you to publish the work yourself and authorise other people to publish it, but in this case P may very well ask you to promise not to authorise third parties to publish the work except under strict conditions (see (c) below). Again, P can do whatever you license him to do. (Don't be bullied by publishers who warn you that if you opt for this kind of agreement, they will be inhibited in disseminating your book. With their agreement, you can license them to do whatever you want them to do.)

iii) If you have "assigned copyright" to P, then all authority over the work passes to P. This prevents you from publishing the work yourself or authorising anyone else to publish it, except that P may give you in return a (nonexclusive) licence to publish under certain conditions. Recently many publishers have been moving toward this arrangement—that you assign copyright but receive a carefully circumscribed exclusive licence—as a way of heading off demands from authors that they should retain copyright. A typical clause of this kind might allow you to (1) make copies for classroom teaching, (2) make copies for distribution to colleagues in your own institution, (3) use the work in later publications of your own (including lectures), (4) keep the work on your own website.

In Germany (iii) is technically impossible, but German publishers sometimes refer to (i) as "transfer of copyright".

In the U.S. (where the terminology of (i)–(iii) does apply), your legal rights and those of P don't depend on copyright being registered with the Copyright Office. But if you are a U.S. resident and want to use your copyright as a basis for suing someone, you must have registered. Moreover, if you want to sue for statutory damages and attorney's fees, you must have registered either before the plagiarism occurred or within three months of first publication. In cases (i) and (ii) you hold the copyright, and you will need to register it yourself. In case (iii) P holds the copyright and may ask you to state in the contract that you allow P to register it.

b) Authorize someone else to publish or copy the work.

This has become a real problem, where a publisher holds the copyright on a book that is out of print and is unwilling to republish it (or to republish it with changes that you want to make), though other publishers are willing. So in case (a) (iii) you should consider insisting on a clause that P will agree to grant a licence to another publisher on reasonable terms if the book goes out of print.

If you insist on being able to authorise further publication or copying yourself, bear in mind that for people who want to publish or copy, P may be much easier to find than you, particularly if P is a famous publishing house. You can make yourself a little easier to reach by entering into a collective licensing scheme such as those run by the UK Copyright Licensing Agency or the U.S. Copyright Clearance Center or any similar collection society. Some publishers specifically exclude registration with a licensing agency even if you retain copyright; this is a bit of cheek, and you might want to press them on it.

c) Publish a revised or upgraded version of the work yourself.

This possibility arises very easily if the work is published electronically; you are bound to be tempted to correct false theorems and maybe to attach relevant programs when they become available. But it can also arise with printed work: for example, if you retain copyright and then later allow another publisher to include some of the work in a published collection and you update the work for this new publication.

If you do retain copyright and P is asking for a restriction of this kind, you will need to agree with P on a way of drawing a line between the kinds of revised publications that will devalue P's version unacceptably and those that won't. You are on your own here; there are no standard agreed formulations. (But some may emerge as it becomes commoner for authors to retain copyright.)

d) Publish (or authorise someone else to publish) the work without its including an acknowledgment that the first publication was by P, with a full reference to that publication.

This is a common clause in contracts that allow you to publish the work yourself. It seems very reasonable. Sometimes P will require that the acknowledgment be in a suitably prominent place, for example, on the first page.

e) Revoke the contract.

It's normal to make copyright agreements irrevocable by either party. But if you and the publisher agree, there is nothing in the law to prevent your granting copyright or licence for a limited period or in a restricted area of the world, or simply leaving it open for either party to revoke the contract after first publication.

6. Other considerations

a) Which country's laws apply?

A copyright contract should contain a "jurisdiction clause" saying what jurisdiction applies; sometimes it does this by saying where the parties can sue. If both publisher and author are in the same country (or the same legal jurisdiction, e.g., Scotland or a state of the U.S.), the law makes the default assumption that the laws of that country or jurisdiction apply. The legal situation is very complicated if publisher and author are in different countries and the contract contains no jurisdiction clause.

b) Define your terms. There are any number of anecdotes about authors getting caught out by not realising how a word in the contract might be interpreted. For example, your contract should probably define what it counts as "publication" or avoid the word altogether; otherwise you may find in U.S. law that a free distribution doesn't count as publication. Your definitions don't have to agree with some standard legal definition; they do their job if they make clear what the parties to the contract had in mind.

Acknowledgements. My thanks to Eva Bayer-Fluckiger, John Ewing, Susan Hezlet, Gary Lea, Ulf Rehmann, Laurent Siebenmann, and Bernd Wegner for their comments on an earlier version, though they are not responsible for any mistakes of fact or judgement.

Where Mathematics Comes From: How the Embodied Mind Brings Mathematics into Being

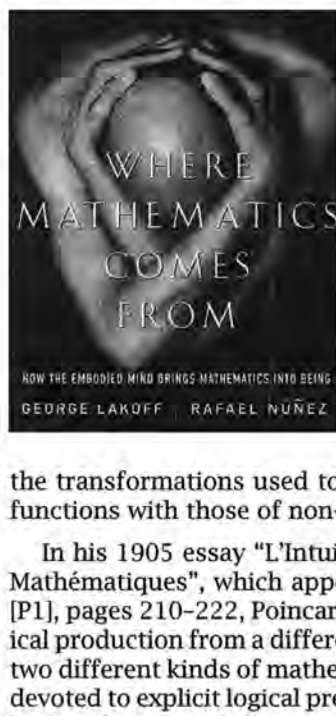
Reviewed by James J. Madden

Where Mathematics Comes From: How the Embodied Mind Brings Mathematics into Being
George Lakoff and Rafael E. Núñez
Basic Books, 2000
ISBN 0-465-03770-4
$30.00, hardcover/$20.00, softcover

> *A metaphor is an alteration of a woorde from the proper and naturall meanynge, to that which is not proper, and yet agreeth thereunto, by some lykenes that appeareth to be in it.*
>
> —*Thomas Wilson,* The Arte of Rhetorique (1553) [Wi], *page 345*

> *Conceptual metaphor is a cognitive mechanism for allowing us to reason about one kind of thing as if it were another. ...It is a grounded, inference-preserving cross-domain mapping—a neural mechanism that allows us to use the inferential structure of one conceptual domain (say, geometry) to reason about another (say, arithmetic).*
>
> —Where Mathematics Comes From, *page 6*

In his philosophical writings, Poincaré reflected on the origins of mathematical knowledge. His best-known remarks, translated as the essay "Mathematical Creation" in [P1], include speculations about the unconscious processes that precede discovery. This is where we read the famous story of how, while boarding a bus in Coutances, Poincaré suddenly realized the identity of the transformations used to define the Fuchsian functions with those of non-Euclidean geometry.



In his 1905 essay "L'Intuition et la Logique en Mathématiques", which appears in translation in [P1], pages 210–222, Poincaré looks at mathematical production from a different angle. He pictures two different kinds of mathematician. One kind is devoted to explicit logical precision. Ideas must be broken down into definitions and deductions. Even conceptions that seem clear and obvious must be subjected to analysis, cut apart, and examined under the microscope of logic. The other kind of mathematician is guided by geometric intuition, physical analogies, and images derived from experience. This mathematician is like Klein, who proved a theorem in complex function theory by imagining a Riemann surface made of metal and considering how electricity must flow through it.

James J. Madden is professor of mathematics at Louisiana State University. His e-mail address is madden@math.lsu.edu.

Poincaré goes on to argue that logic and intuition play complementary roles in mathematics. Logic provides rigor and certainty by substituting precise notions for vague and ambiguous ones and by moving in sure, syllogistic steps. Logic, however, does not perceive goals and does not grasp that which motivates and organizes our mathematical activity. We may follow the logical trail through an argument yet fail to "see" the idea in it. For this we need intuition, which provides insight, purpose, and direction. But intuition is sometimes ambiguous, and sometimes it even deceives. So ultimately it is only by the combination of logic and intuition that mathematics advances.

Poincaré set his ideas down at a time when revolutionary advances in mathematical logic were just beginning. He could not have foreseen what the next century would achieve in foundational studies. Today, we cannot claim to have the final word, but we clearly understand much more about logic and the role it plays in mathematics than we did one hundred years ago.

How about intuition? What more do we know about this? A few references come to mind: Hilbert and Cohn-Vossen's book [HC], Hadamard's essay [H], and perhaps a couple of more recent items, particularly S. Dehaene's work on the number sense [Dh] and Devlin's book [De]. I find noteworthy the essay [T], written by a young Oxford mathematics student who went on to become a neuroscientist of high repute at the University of California Los Angeles. Overall, however, it seems that intuition has remained largely unanalyzed and poorly understood.

A good way to approach the book of Lakoff and Núñez is to see it, as the authors suggest in the preface, as an empirical study of the precise nature of clear mathematical intuitions (page xv). Lakoff and Núñez promise in the introduction to give an account of how normal human cognitive mechanisms rooted in the brain are used to formulate mathematical concepts, reason mathematically, and create and understand mathematical ideas. Logic and formal rigor do not figure prominently in this account. Rather, the book is about the intuitive side; the focus is on certain "conceptual metaphors" which, the authors hypothesize, are the basic building blocks of mathematical intuition. Moving beyond cognitive science into philosophy, the authors even suggest that metaphors account for the meaning of mathematical concepts and are the basis of mathematical truth. "Metaphor" is the key word in this book.

How do metaphors function in the mathematical activities of actual people? On this, Lakoff and Núñez are not very clear.

Much of the book is devoted to the examination of prominent topics in standard mathematics curricula. These topics include grade school arithmetic, algebraic structures and their models, logic, set theory, limits, real numbers, and a little bit of nonstandard analysis. Chapters 13 and 14 have a historical orientation, discussing the contributions of Dedekind and Weierstrass to the foundations of analysis. Chapters 15 and 16 treat philosophical issues. The book ends with an extended discussion of the equation $e^{\pi i} + 1 = 0$ intended to illustrate "mathematical idea analysis", a technique that was invented by the authors and that they use to uncover the metaphorical elements in mathematical ideas.

The arguments do not follow a direct path. The book builds on many fronts, elaborates subgoals, and spins off subsidiary projects. While reading the book, I sometimes found it difficult to keep track of what the authors were aiming at. For this review, therefore, I shall simplify things by picking out three major strands and commenting on them separately. I have mentioned them already. They are:

- a hypothesis about the role of metaphors in mathematical cognition,
- a philosophical position about mathematical truth, and
- the technique of mathematical idea analysis.

In many ways the three strands are interdependent—a point to be remembered, even though my discussion is divided into three parts. I find the metaphor hypothesis the most interesting, and accordingly I devote more space to this than to the other two items.

Let me state the metaphor hypothesis as I interpret it. When people think about mathematics—even very deep, advanced mathematics—they somehow activate links to mundane experiences that occur in everyday functioning in the world and links to other mathematical experiences as well. These links are not logical or deductive—often, they are not even conscious. They involve very complex pattern-matching, by means of which people transfer abilities and concepts that are relevant or adaptive in familiar, natural settings to new settings that are less familiar and more abstract. The lifting or "retooling" of cognitive categories and abilities in this fashion is what the authors call *conceptual* *metaphor*. The second quote at the beginning of this review is as close to a definition of this as anything that the authors give.

Lakoff and Núñez present the metaphor hypothesis within the framework of a general theory of human cognition that Lakoff himself played an important role in creating; see [LJ]. In addition to the idea that most abstract concepts are metaphorical, this theory has two other basic tenets. One is that thought is mostly unconscious and mostly "involves automatic, immediate, implicit rather than explicit understanding" (page 28). Conceptual metaphors may be unconscious; they support and influence our thinking without our necessarily being aware of them. The other tenet is that human conceptual structures are deeply influenced by the particulars of our concrete, physical being. We reason with the same equipment we use to observe our immediate surroundings, move about in them, and interact with people and things. Even the most abstract concepts, if analyzed properly, show the marks of their origin in, and dependence on, basic perceptual and motor schemata. In summary, all concepts—mathematical concepts in particular—are metaphorical and rest upon unconscious understandings that originate in bodily experience.

Let us look at some examples. There are various kinds of conceptual metaphors. *Grounding metaphors* transfer conceptual abilities acquired in concrete experiences (like putting things in piles or traveling) to abstract domains like arithmetic. *Linking metaphors* make connections between different abstract domains. What struck Poincaré as he stepped aboard the bus, for example, was a linking metaphor at a very high level that had somehow evolved in his unconscious and then made its way to the surface.

Basic arithmetic has several grounding metaphors, all discussed in Chapter 3. One of these metaphors connects experiences with collections of objects on the one hand and the basic arithmetic operations on the other. Joining two collections, for example, corresponds to addition, while splitting a collection into many subcollections of equal size corresponds to division. The commutative law of addition corresponds to the fact that when two collections are thrown together, it does not matter which goes first. Understanding the commutative law presumably involves some sort of reference back to this property of collections and thus the activation of this metaphor. Other aspects of arithmetic are associated with other grounding metaphors. Adding positive and negative numbers may be understood metaphorically by referring to forward and backward trips along a linear path.

One might react to this with the feeling that it is all pretty trivial. Of course, once the arithmetic metaphors are internalized, using them is as easy as riding a bike. But the skills involved in using arithmetic, or in riding a bike, are cognitively quite complex. This is most obvious in the fact that *learning* them is not at all trivial. I would even suggest that evidence in favor of the metaphor hypothesis can be found in the fact that exposure to different metaphors influences the learning process. In the appendix of [MC], Robert Moses discusses a strategy he developed for teaching arithmetic with signed numbers. Moses does not mention metaphors explicitly, but in the terminology of Lakoff and Núñez, what he did was hypothesize that certain children were failing to progress because they were inappropriately bound by the collection metaphor. So Moses developed a teaching strategy intended to strengthen the trip metaphor, and this strategy succeeded quite well.

Here is another example of a grounding metaphor. In Chapter 8 Lakoff and Núñez introduce what is the single most important metaphor in the book, the "Basic Metaphor of Infinity" (BMI), and illustrate its occurrence in several mathematical contexts. Like all conceptual metaphors, the BMI involves a correspondence between a "source domain", which is familiar and often concrete, and a "target domain", which is less familiar and usually more abstract. In the BMI, the source is the general idea of an iterative process that reaches a completion. Examples would be walking to a destination or picking all the berries off a bush. The target is any iterative process that potentially goes on and on, like counting "One, two, three... ." The BMI simply shifts the idea of a completed process from its natural context into a new context, like counting, in which the idea does not exactly fit but to which it bears a likeness or analogy. Thus, we can reason about the collection of all natural numbers by extending or generalizing the patterns by which we reason about things like the set of all steps taken on a walk somewhere. It is not claimed that the use of this metaphor is conscious, but just that there is a common pattern. We are prepared to think about infinite processes by experiencing finite ones, and the descriptive categories we apply in the finite case have analogues in the infinite. Of course, there are vast differences between the logic of finite and infinite processes, but the authors do not seem very concerned about such differences. I suppose that the authors consider such details to be peripheral to the cognitive science, despite their mathematical importance.

How do metaphors function in the mathematical activities of actual people? On this, Lakoff and Núñez are not very clear. When they do talk about the mathematical activities of real people, they describe them in generic terms: people entertain ideas or "use cognitive mechanisms" of one sort or another to "conceptualize" this or that. Presumably, when an individual is engaged in mathematical work, that person is guided by metaphors that are somehow represented in his or her own brain. The details would depend on the specific task or problem. Unfortunately, Lakoff and Núñez do not provide any illustrations of what they suppose goes on in "real time", so this is about as much as I can say.

This brings me to my first main criticism concerning the metaphor hypothesis: What is the quality of the evidence for it? If, as the authors say on page 1, their goal is to determine "what mechanisms of the human brain and mind allow human beings to formulate mathematical ideas and reason mathematically," then one would expect some data about the actual thoughts and actions of people in the process of doing mathematics. Such data do exist; the work of Robert Moses provides one example. However, essentially the only kind of evidence Lakoff and Núñez provide comes from the examination of the contents of texts and curricula. How much can we infer about the "basic cognitive mechanisms" used in mathematics from what we find in texts and curricula? A study of navigation based on the standard manuals would tell us very little indeed about how the task was actually accomplished on the bridge of a large ship. How exactly do people use metaphors when they are learning new material, solving problems, proving theorems, and communicating with one another? I would like to have seen direct support for the metaphor hypothesis from the observation of mathematical behaviors. After a demonstration that metaphors are indeed as common as the authors believe, I would want a detailed examination of the *ways* metaphors are used in a wide variety of settings. The authors report no such information, and in fact they acknowledge the lack of direct empirical support for their hypotheses in many places. Carefully designed studies might lead to very different ideas about how metaphors function in mathematics or mathematics learning. For example, at the AMS meeting in New Orleans in January 2001, Eric Hsu and Michael Oehrtman, mathematics education research postdocs at the Dana Center at the University of Texas at Austin, spoke about their study of calculus learners. They found students making up their own, often dysfunctional, metaphors, and they raised the fascinating question of how it is that some learners shed the idiosyncratic metaphors they initially build and acquire the ones that are standard.

Mathematics is constantly absorbing what it learns about itself by gazing at itself.

My second main criticism concerns lack of precision in the concept of metaphor. By rough page count, more than half the text is devoted to displaying mathematical metaphors of one sort or another. After a while, the notion of metaphor seems to become a catchall. In the discussion beginning on page 384, for example, "metaphor" is used to refer to the following: the algebra/geometry dictionary in analytic geometry; the definition of function addition, $(f+g)(x) := f(x)+g(x)$; the "Unit Circle Blend", which involves various things one might attend to in a diagram showing the unit circle at the origin in a Cartesian coordinate system, together with a central angle; the "Trigonometry Metaphor", i.e., thinking of the cosine and sine of θ as the x- and y-coordinates of the point reached after moving counterclockwise from $(1,0)$ along the unit circle through an angle of θ; the "Recurrence Is Circularity Metaphor", which refers to connections between mathematical concepts and the language of recurrence used in nonmathematical settings to describe things like the seasons; and, finally, polar coordinates. Other parts of the book add yet more variety. In abstract algebra the relationship of an abstract structure (e.g., a group) to a model of that structure (a group of rotations) is an example of a metaphor. Cauchy, Dedekind, and Weierstrass contributed to the foundations of analysis by creating the "Arithmetic Cut Metaphor", the "Spaces Are Sets of Points Metaphor", and many others. When mathematicians write axioms, they are using the "Essence Metaphor". Set-theoretic foundations give us an instance of the "Formal Reduction Metaphor". With examples of so many differing kinds serving such diverse functions, the notion of metaphor begins to lose its meaning. If I had been given the original definition and a couple of examples and then had gone looking for conceptual metaphors in mathematics, I would never have come back with many of the things listed in this paragraph. The idea that metaphors play a role in mathematical thinking is quite attractive, but what is needed is a notion specific and precise enough so that people working independently and without consulting one another can discover the same metaphors and agree on the functions they perform. I do not think we have this yet.

Let me turn now to the philosophical parts of the book. The authors devote many pages to portraying a sort of philosophy/ideology that they call the "Romance of Mathematics", which they contrast with their own philosophy. This is a good rhetorical strategy, since the so-called "romance" would probably be disliked by all readers except some superficial and self-congratulatory mathematicians. For the sake of brevity, I will not comment on the "romance" but just go directly to the authors' philosophical ideas.

According to my reading, Lakoff and Núñez want us to view mathematics as a natural human activity, about which their cognitive theory informs us. They would like us to use words like "meaning", "existence", and "truth" to describe aspects of this activity. In particular, they say that mathematical entities are "metaphorical entities" that exist "conceptually" only "in the minds of beings with [appropriate] metaphorical ideas" (pages 368–9). They also say that when we speak of the truth of a mathematical statement, we must speak only relative to a particular person, and we may mean no more than this: that person's understanding of the statement accords with his or her understanding of the subject matter and the situation at hand; see page 366. Such a view of mathematical truth appears to be at odds with the reality of how mathematicians communicate. If *my* mathematics depends on the metaphors that happen to be in my head, and *your* mathematics depends on the metaphors in yours, then how is it that we can share mathematical ideas? And why is it that we agree on so much?

Lakoff and Núñez make a couple of hypotheses that might address these objections. First, they claim that the metaphors on which mathematics is based are not arbitrary. Many grounding metaphors, in particular, are forced on us by our physical nature. Second, they claim that natural metaphors have a very elaborate and precise structure; see page 375. These, of course, are empirical hypotheses. Some day we might acquire good evidence for or against them. If they are borne out, they might support the kind of naturalistic approach to the philosophy of mathematics that the authors have begun to sketch. In my opinion, though, a naturalistic approach should certainly not dismiss the way mathematicians share definitions with one another, understand and criticize one another's reasoning, and use a precise, if artificial, logical language to put their ideas in writing so that those ideas can be judged by the world. Surely we can acknowledge a role for intuition without ignoring the ways that logic and conventional rigor support the kind of knowledge that mathematicians build and share.

Let me move now to the third and last of the three major strands on which I promised to comment. The authors argue that mathematical ideas occur within elaborate networks of interconnected metaphors. "Mathematical idea analysis" is the technique of teasing apart the network to reveal the metaphorical parts. The reason for doing this is to "characterize in precise cognitive terms the mathematical ideas in the cognitive unconscious that go unformalized and undescribed when a formalization of conscious mathematical ideas is done" (page 375).

The appendix contains an extended discussion of the equation $e^{\pi i} + 1 = 0$ that is intended to illustrate the method. The authors say that they want to characterize the meaning of the equation and provide an understanding of it (page 384). What a mathematician will find here is a detailed description of the geometric interpretation of complex exponentiation. Building from basic high-school-level ideas up to college-level complex analysis, the treatment is, at different times, insightful, entertaining, opaque, interesting, breezy, ponderous, and muddled.[1] Mathematicians will find the images and metaphors discussed here to be very familiar, scarcely unconscious. Many come directly from the pages of calculus books and are things most of us describe over and over to our calculus classes. To me, these mental images are certainly very helpful in understanding. The mystery has always been how difficult it is for students to absorb them and use them productively.

Lakoff and Núñez seem to want to open up that whatever-it-is that makes mathematics into a coherent, meaningful whole and expose it for all to see and appreciate. If only there were a way! Poincaré himself speculated about how best to teach mathematics, concluding finally that understanding means different things to different people at different times and for different purposes; see

[1] *See the website* `http://www.unifr.ch/perso/nunezr/errata.html` *for a list of errata. One error in the first printing (pages 416–8) was fairly serious. The "correction" that I found at the website and that appears in the recently distributed softcover edition of the book is a kind of mathematical red herring—a passage that appears to answer a question but in fact misleads. The authors preface this passage by criticizing other texts for failing to answer "the most basic of questions: Why* should *this particular limit,* $\lim_{n\to\infty}(1+\frac{1}{n})^n$, *be the base of the exponential function that is its own derivative?" (pages 415–6). In the revised explanation (errata 416–8), the unacknowledged assumption that* $\lim_{n\to\infty}(1+\frac{1}{n})^n$ exists *is used in an essential way. (There are situations that are analogous in all explicit details but in which the pattern of explanation that the authors use would "explain" a falsehood.) When the authors complete their proffered explanation, they make a point of saying that, once the meanings and metaphors are combined with some "simple algebraic manipulations," there is "nothing mysterious" (errata, page 419) about the result. I would retort that what is really the most basic question is: How do we know that there is any number at all to which the values of* $(1+\frac{1}{n})^n$ *tend as n increases? The authors create the appearance of simplicity only by suppressing this issue, and in fact they create a path that can lead to error. The book* [Do], *on the other hand, contains a nice self-contained treatment of this limit, beginning, appropriately, with a non-mysterious demonstration of its existence; see page 45. The central claims of the book under review, which are in cognitive science and philosophy, may not be threatened by such mathematical infelicities, but perhaps they serve as useful reminders of the importance of logical discipline in mathematics.*

[P1], page 432. Surely there will always be good reasons to experiment with new formats for mathematical exposition, and Lakoff and Núñez are not alone in exploring. Zalman Usiskin, for example, has proposed something he calls "concept analysis", intended for people who are learning to teach mathematics; see [U]. Concept analysis examines various methods of representing and defining mathematical ideas, as well as how those methods evolved over time, how they are used, the problems people have understanding them, and strategies that are useful in explaining them.

This concludes my comments on the three strands I identified earlier. If I think about the portrayal of mathematics in the book as a whole, I find myself disappointed by the pale picture the authors have drawn. In the book, people formulate ideas and reason mathematically, realize things, extend ideas, infer, understand, symbolize, calculate, and, most frequently of all, *conceptualize*. These plain vanilla words scarcely exhaust the kinds of things that go on when people do mathematics. They explore, search for patterns, organize data, keep track of information, make and refine conjectures, monitor their own thinking, develop and execute strategies (or modify or abandon them), check their reasoning, write and rewrite proofs, look for and recognize errors, seek alternate descriptions, look for analogies, consult one another, share ideas, encourage one another, change points of view, learn new theories, translate problems from one language into another, become obsessed, bang their heads against walls, despair, and find light. Any one of these activities is itself enormously complex cognitively—and in social, cultural, and historical dimensions as well. In all this, what role do metaphors play?

Moving to a different perspective, I want to note that there are areas not even hinted at in the book where cognitive science is prepared to contribute to our understanding of mathematical thought. Consider this: Metaphorical ideas are frequently misleading, sometimes just plain wrong. Zariski spent most of his career creating a precise language and theory capable of holding the truths that the Italian geometers had glimpsed intuitively while avoiding the errors into which they fell. What cognitive mechanisms enable people to recognize that a metaphor is not doing the job it is supposed to do and to respond by fashioning better conceptual tools?

From early childhood people comment on their own thinking or on the things they create in order to represent their thinking, and they use this commentary to adjust and correct themselves. In a fascinating article about her own first-grade classroom, Kristine Reed Woleck describes how children talk to themselves and to one another while drawing and revising pictures to depict mathematical ideas, in the process coming to "question, debate, defend, clarify, and refine their mathematical understandings" ([W], page 224). Isn't this a miniature version of what a group of research mathematicians might be found doing in front of a tentative proof sketched on a blackboard? Or what you do alone when you draft a proof and then read, correct, and redraft it?

If mathematical thinking is like other kinds of thinking in its use of metaphors, what distinguishes mathematical thinking may be the exquisite, conscious control that mathematicians exercise over how intuitive structures are used and interpreted. We can step back from our own thinking and critically examine our attempts at meaning-making. This, I would venture, is as fundamental a cognitive mechanism as any mentioned by Lakoff and Núñez. Mathematics is constantly absorbing what it learns about itself by gazing at itself. In Al Cuoco's memorable phrase, "mathematics is its own mirror on the very thinking that creates it" ([CC], page x). In a similar vein, Schoenfeld's classic study [S] showed how important self-observation is in solving mathematical problems. Today we can associate the ability to observe and control our own thought processes with certain clearly demarcated regions of the brain, and we understand much about how these regions function in normal brains and how they fail in certain diseased brains; see [M].

Where does mathematics come from? Poincaré viewed mathematical intuition as that which invents and logic as that which proves. Perhaps in this sense mathematics starts with intuition. But Poincaré also said that without proof there is no understanding, no communication, no meaning ([P2], page 95–6). Most mathematicians would probably agree that mathematics is both invention *and* proof and that it comes from the cooperation of intuition *and* logic.

What about the question I asked earlier: what do we know today about mathematical intuition that we did not know one hundred years ago? Lakoff and Núñez have suggested that intuition is not as formless and elusive as perhaps we had thought. To the contrary, or so they claim, it works on the basic mechanism of metaphor, and it has a profound structure that is dictated by human nature. These are interesting and appealing ideas, or perhaps *intuitions*, about the nature of mathematical intuition.

Among the sciences, mathematics is not alone in building on intuition. Nor is it alone in requiring more. Every science also needs concepts that are precise enough to frame testable hypotheses, and every scientific *theory* needs proof—not in the mathematical sense, but at least in the sense that the theory has been subjected to the most rigorous trials we can devise and has survived. Lakoff and Núñez have shared with us their intuitions about the way the mathematical mind operates. More work remains to be done. We do not know what scientists may some day build upon these intuitions.

Acknowledgments. I would like to thank Roger Howe for sharing with me his reactions to this book and for reading and commenting on an earlier version of this review. I would also like to thank Allyn Jackson and two unknown referees for useful comments. Most of this review was written while I was visiting Wesleyan University, where I received partial support from the mathematics department. I would like to thank the university and the department for their excellent hospitality.

References

[CC] Albert A. Cuoco and Frances R. Curcio, eds., *The Roles of Representation in School Mathematics*, Yearbook, National Council of Teachers of Mathematics, 2001.

[De] Keith Devlin, *The Math Gene: How Mathematical Thinking Evolved and Why Numbers Are Like Gossip*, Basic Books, 2000.

[Dh] Stanislas Dehaene, *The Number Sense: How the Mind Creates Mathematics*, Oxford University Press, 1997.

[Do] Heinrich Dörre, *100 Great Problems of Elementary Mathematics: Their History and Solutions*, translated by David Antin, Dover, New York, 1965.

[H] Jacques Hadamard, *The Psychology of Invention in the Mathematical Field*, Princeton University Press, 1945.

[HC] David Hilbert and S. Cohn-Vossen, *Anschauliche Geometrie*, Julius Springer, Berlin, 1932; translated as *Geometry and the Imagination*, Chelsea, New York, 1952.

[LJ] George Lakoff and Mark Johnson, *Philosophy in the Flesh: The Embodied Mind and Its Challenge to Western Thought*, Basic Books, 1999.

[M] Earl K. Miller, The prefrontal cortex and cognitive control, *Nature Reviews in Neuroscience* **1** (2000), 59–65.

[MC] Robert P. Moses and Charles E. Cobb Jr., *Radical Equations: Math Literacy and Civil Rights*, Beacon Press, Boston, 2001.

[P1] Henri Poincaré, *The Foundations of Science*, authorized translation by G. B. Halsted, The Science Press, New York, 1913.

[P2] ____, *Dernières Pensées*, Flammarion, Paris, 1913; reprint 1963.

[S] Alan Schoenfeld, *Mathematical Problem Solving*, Academic Press, Orlando, FL, 1985.

[T] Paul Thompson, The nature and role of intuition in mathematical epistemology, *Philosophia: Philos. Quart. Israel* **26** (1998), 279–319.

[U] Zalman Usiskin, Teachers' mathematics: A collection of content deserving to be a field, *UCSMP Newsletter*, No. 28, Winter 2000-01, 5–10.

[Wi] Thomas Wilson, *Arte of Rhetorique* (Thomas J. Derrick, ed.), Garland Publishing, Inc., New York and London, 1982.

[W] Kristine Reed Woleck, Listen to their pictures: An investigation of children's mathematical drawings, in [CC].

Mathematics People

Hopfield Awarded Dirac Medal

JOHN J. HOPFIELD of Princeton University has been awarded the 2001 Dirac Medal of the Abdus Salam International Centre for Theoretical Physics (ICTP). The award citation reads: "J. J. Hopfield has made important contributions in an impressively broad spectra of scientific subjects. His special and rare gift is his ability to cross the interdisciplinary boundary to discover new questions and propose answers that uncover the conceptual structure behind the experimental facts. His early research on the light emitting diodes has been recognised with the Buckley Prize. In biology he understood the need for and proposed the principle 'proofreading', by which the replication mechanism manages to achieve accuracy far beyond the possible in equilibrium processes. The famous Hopfield model of neural processing demonstrated by construction how qualitatively different computation in a computer and in the brain could be. More recently, he has found an entirely different organizing principle in olfaction and demonstrated a new principle in which neural function can take advantage of the temporal structure of the 'spiking' interneural communication."

The ICTP awarded its first Dirac Medal in 1985. Given in honor of P. A. M. Dirac, the medal is awarded annually on Dirac's birthday, August 8, to an individual who has made significant contributions to theoretical physics and mathematics. The medalists also receive a prize of US$5,000.

An international committee of distinguished scientists selects the winners from a list of nominated candidates. The Dirac Medal is not awarded to Nobel Laureates or Wolf Foundation Prize winners.

—From an ICTP announcement

B. H. Neumann Awards Given

The B. H. Neumann Awards for 2001 have been awarded by the Board of the Australian Mathematics Trust to ANDY EDWARDS of Ormiston College, Brisbane; MICHAEL EVANS of Scotch College; and ALICE THOMAS of Meriden College, Sydney.

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

American Mathematical Society Centennial Fellowships

Invitation for Applications for Awards for 2002–2003
Deadline December 1, 2001

The AMS Centennial Research Fellowship Program makes awards annually to outstanding mathematicians to help further their careers in research. From 1997–2001 the fellowship program was aimed at recent Ph.D.'s. Recently the AMS Council approved changes in the rules for the fellowships. The eligibility rules are as follows.

The primary selection criterion for the Centennial Fellowship is the excellence of the candidate's research. Preference will be given to candidates who have not had extensive fellowship support in the past. Recipients may not hold the Centennial Fellowship concurrently with another research fellowship such as a Sloan or NSF Postdoctoral Fellowship. Under normal circumstances the fellowship cannot be deferred. A recipient of the fellowship shall have held his or her doctoral degree for at least three years and not more than twelve years at the inception of the award. Applications will be accepted from those currently holding a tenured, tenure-track, postdoctoral, or comparable (at the discretion of the selection committee) position at an institution in North America.

The stipend for fellowships awarded for 2002–03 is expected to be approximately $55,000, with an additional expense allowance of about $1,650. Acceptance of the fellowship cannot be postponed.

The number of fellowships to be awarded is small and depends on the amount of money contributed to the program. The Trustees have arranged a matching program from general funds in such a way that funds for at least one fellowship are guaranteed. Due to a change in eligibility criteria and an increase in the stipend beginning in 2002–03, it is expected that three fellowships will be awarded. A list of previous fellowship winners can be found at `http://www.ams.org/secretary/prizes.html`.

Applications should include a cogent plan indicating how the fellowship will be used. The plan should include travel to at least one other institution and should demonstrate that the fellowship will be used for more than reduction of teaching at the candidate's home institution. The selection committee will consider the plan in addition to the quality of the candidate's research and will try to award the fellowship to those for whom the award would make a real difference in the development of their research careers. Work in all areas of mathematics, including interdisciplinary work, is eligible.

The deadline for receipt of applications is **December 1, 2001**. Awards will be announced in February 2002 or earlier if possible.

For application forms write to the Executive Director, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294; or send electronic mail to `ams@ams.org`; or call 401-455-4106. Application forms are also available via the Internet at `http://www.ams.org/employment/centflyer.html`.

Please note that completed application and reference forms should not be sent to the AMS, but to the address given on the forms.

—AMS announcement

Research Opportunities in Japan, Korea, and Taiwan for U.S. Graduate Students

The National Science Foundation (NSF), the National Institutes of Health/Fogarty International Center (NIH/FIC), and the U.S. Department of Agriculture/Agricultural Research Service (USDA/ARS) are cosponsoring a summer research program in 2002 for U.S. graduate students in Japan, Korea, and Taiwan.

The Summer Institute in Japan, the Monbusho Summer Program, the Summer Institute in Korea, and the Summer Institute in Taiwan provide graduate students in science and engineering with firsthand experience in Japanese, Korean, and Taiwanese research environments, an introduction to the science and science policy infrastructure of the respective countries, and language and cultural training. The primary goals of the programs are to introduce students to Japanese, Korean, and Taiwanese science and engineering in the context of a research laboratory and to initiate personal relationships that will better enable them to collaborate with their counterparts in other countries in the future. The programs will last approximately eight weeks, from mid-June to August. Students may study and work at one of a variety of government, corporate, and university research laboratories, depending on the specific program.

Applicants must be U.S. citizens or permanent residents. They must be enrolled at a U.S. institution in a science or engineering Ph.D. program, in an M.D. program with an interest in biomedical research, or in a master's degree program with at least one full academic year completed at the end of the calendar year of application. They must be pursuing studies in fields of science or engineering that are supported by the NSF, the NIH, or the USDA and that also are represented among the potential host institutions.

International travel costs to and from Japan, Korea, or Taiwan; in-country living costs (accommodations, food, and professional travel); and an allowance of $2,500 for each participant will be provided.

The deadline for application materials to be postmarked is **December 1** each year. All application materials (including forms from the applicant and from those recommending him or her) should be sent to the NSF East Asia and Pacific Program (NSF/EAP), Room 935, Division of International Programs, National Science Foundation, 4201 Wilson Boulevard, Arlington, VA 22230.

Further information and a full description of the summer programs, including a list of potential host institutions and application instructions, are available at the NSF/Tokyo website `http://www.twics.com/~nsftokyo/` (select "Summer Programs" from the opening screen menu bar), or from Larry H. Weber, NSF/EAP; telephone 703-292-8704; e-mail: `lweber@nsf.gov`.

—From an NSF announcement

AAUW Educational Foundation Fellowships and Grants

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

Applications are now available for Master's and First Professional Awards, which carry cash awards of between $5,000 and $12,000. The deadline for applications to be postmarked is **January 10, 2002**. The fellowship year runs from July 1, 2002, to June 30, 2003. For more information, see the AAUW's website at `http://www.aauw.org/3000/fdnfelgra/selectprofbd.html` or contact the AAUW Educational Foundation, Department 60, 2201 North Dodge Street, Iowa City, IA 52243-4030; telephone 319-337-1716, extension 60.

—From an AAUW announcement

AWM Workshop for Women Graduate Students and Postdocs

The Association for Women in Mathematics (AWM) has announced that a workshop for women in mathematics will be held July 8–10, 2002, in conjunction with the meeting of the Society for Industrial and Applied Mathematics (SIAM) in Philadelphia, Pennsylvania, July 8–12, 2002. The workshop will feature minisymposia on research areas selected from mathematical biology, modeling, control, optimization, scientific computing, and partial differential equations and applications. The deadline for receipt of applications is **January 21, 2002**.

The AWM holds a series of workshops for women graduate students and recent Ph.D.'s in conjunction with major mathematics meetings. The workshops are also supported by the Office of Naval Research and the Air Force Office of Scientific Research. For further information see the AWM website at `http://www.awm-math.org/`.

—AWM announcement

News from Institut Mittag-Leffler

The academic year 2002–03 at the Institut Mittag-Leffler, Djursholm, Sweden, will consist of two terms. The fall term (2002) will be devoted to Partial Differential Equations and Spectral Theory. The organizing committee consists of Victor Guillemin of MIT, Bernhard Helffer of the Université Paris XI (Orsay), and Ari Laptev of KTH. The spring term (2003) will be devoted to Mathematical Control and Systems Theory. The organizing committee consists of Christopher Byrnes of Washington University, Anders Lindquist of KTH, Clyde Martin of Texas Tech University, and Anders Rantzer of the University of Lund.

The application deadline for postdoctoral fellowships is **January 31, 2002**. Applications should be sent to Marie-Louise Koskull, Institut Mittag-Leffler, Auravägen 17, SE-182 60 Djursholm, Sweden. For further information consult the institute's home page, `http://www.ml.kva.se/`.

—Institut Mittag-Leffler announcement

For Your Information

Everett Pitcher Lectures

The next series of Everett Pitcher Lectures will be held November 13, 14, and 16, 2001, on the campus of Lehigh University in Bethlehem, Pennsylvania. The speaker will be Peter Shor of AT&T. The title of his lecture series is "Quantum Information and Computation".

The lectures, which are open to the public, are held in honor of Everett Pitcher, who was secretary of the AMS from 1967 until 1988. Pitcher served in the mathematics department at Lehigh from 1938 until 1978, when he retired as Distinguished Professor of Mathematics.

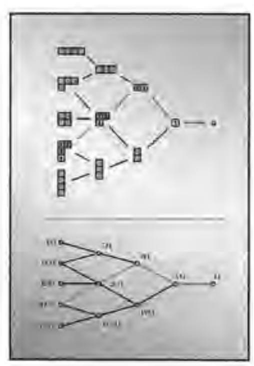
Further information can be obtained by writing to Everett Pitcher Lecture Series, Department of Mathematics, Lehigh University, Bethlehem, PA 18015; by calling 610-758-3745; or by visiting the website `http://www.lehigh.edu/~math/pitcher.html`.

—Department of Mathematics, Lehigh University

About the Cover

The cover of this issue was suggested by the article of Maslen and Rockmore in this issue (see pages 1151-1160). The nodes in Young's lattice are Young diagrams, or equivalently partitions of non-negative integers. The cover illustrates that Young's lattice is the same as the Bratteli diagram exhibited in Maslen and Rockmore's article. Partitions of n parametrize irreducible representations of S_n, and the cover also illustrates that paths in the lattice correspond to Young tableaux, a commonly used way to index basis elements of representations of the symmetric groups.

—Bill Casselman (`covers@ams.org`)



Inside the AMS

AMS Congressional Briefing

A standing-room-only crowd of about eighty packed the latest AMS lunch briefing for members of Congress and their staff on Capitol Hill, July 26, 2001. Cosponsored by long-time mathematics supporter Congressman Vernon J. Ehlers (R-MI), the topic, a briefing on the National Research Council Report *Adding It Up: Helping Children Learn Mathematics*, was a timely one, given President Bush's Mathematics and Science Partnerships initiative and Ehlers' plans to reintroduce his mathematics and science education bills, which narrowly missed passage in the previous session of Congress.

Pictured at the AMS congressional briefing, left to right: Deborah Loewenberg Ball, Congressman Vernon Ehlers, AMS President Hyman Bass, and Roger Howe, chair of the AMS Committee on Education.

The speakers were Deborah Loewenberg Ball (University of Michigan), Hyman Bass (University of Michigan and current AMS president), and Roger Howe (Yale University and current chair of the AMS Committee on Education), who presented a dynamic and fast-paced overview of the findings and recommendations of the just-released report, addressing three questions: What are the core problems of mathematics education? What are the roots of these problems? What needs to be done to address these problems and attain new goals?

The audience included congressional science and education staffers and also representatives from the National Science Foundation, the U.S. Department of Education, and other mathematics and science professional organizations. The speakers chose mathematical examples that were interesting, understandable, and involved audience participation. Appreciative comments were received from their nonmathematical audience about the thoughtful preparation the speakers put into this briefing.

A prepublication version of the report is available at the National Academy Press website, `http://www.nap.edu/catalog/9822.html`.

—Monica Foulkes, AMS Washington Office

Excellence in Undergraduate Mathematics: Confronting Diverse Student Interests

The AMS and the Mathematicians and Education Reform (MER) Forum are jointly launching a project entitled Excellence in Undergraduate Mathematics: Confronting Diverse Student Interests. With three-year funding from the

National Science Foundation, planning for the project is now under way.

The project has two main goals. The first is to stimulate mathematics and mathematical sciences departments to look carefully at the diverse undergraduate student populations in their classes and to assess how well current courses meet the students' mathematical needs. The second is to facilitate departmental efforts to revise existing courses and develop or adapt new courses to afford all students a meaningful mathematical experience.

Most mathematics students fall into three general groups: students taking calculus but not continuing in mathematics, students fulfilling a mathematics requirement that does not require calculus, and students majoring in mathematically intensive fields who take advanced undergraduate courses. The AMS-MER project focuses on the second and third groups of students.

The project is intended to build on the awareness and expertise gained by departments involved in the calculus reform movement that has taken place over the past decade. This experience can be adapted and applied to other areas of the undergraduate curriculum. The project will also seek the involvement of other groups in the mathematical community, such as the Conference Board of the Mathematical Sciences and the pertinent committees of the Mathematical Association of America.

The heart of the project is an integrated set of six national workshops held on college and university campuses. Each participating department will be represented by a faculty team of two to four members. Two workshops will be held each academic year, one in the fall and the other in the spring. The first workshop will be held December 6–9, 2001, at Arizona State University, Tempe. The spring 2002 workshop will be at Washington University in St. Louis. In addition, the project will build networks of mathematical sciences departments, arrange programs at national meetings, and issue publications. While highlighting the needs of particular student groups, the project will also focus on critical issues that cut across all institutions.

The Excellence in Undergraduate Mathematics project is an opportunity for faculty to interact with others who are striving to excel in undergraduate instruction, to learn from one another, and to showcase their progress. For further information contact the project director, Naomi Fisher, `ndfisher@uic.edu`.

—*Allyn Jackson*

AMS E-mail Support for Frequently Asked Questions

A number of non-user-specific electronic addresses have been established for contacting the AMS staff. The following is an updated list of those addresses together with a description of the types of inquiries that may be made through each address. This list is also available on the AMS's website at `http://www.ams.org/ams/email.html`.

abs-info@ams.org
for questions regarding a particular abstract.

abs-submit@ams.org
for information on how to submit abstracts for AMS meetings and MAA sessions at January Joint Mathematics Meetings. Type HELP as the subject line.

acquisitions@ams.org
to contact the AMS Acquisitions Department.

ams@ams.org
to contact the Society's headquarters in Providence, Rhode Island.

amsdc@ams.org
to contact the Society's office in Washington, DC.

amsmem@ams.org
to request information about membership in the AMS or about dues payments, or to ask any general membership questions; may also be used to submit address changes.

bookstore@ams.org
for inquiries related to the online AMS Bookstore.

classads@ams.org
to submit classified advertising for the *Notices*.

cust-serv@ams.org
for general information about AMS products (including electronic products); to send address changes, place credit card orders for AMS products, or conduct any general correspondence with the Society's Customer Services Department.

development@ams.org
for information about giving to the AMS, including the Epsilon Fund.

eims-info@ams.org
to request general information about deadlines and rates for *Employment Information in the Mathematical Sciences* (EIMS). Type HELP as the subject line.

ejour-submit@ams.org
to submit papers to *Representation Theory* and *Conformal Geometry and Dynamics*, electronic journals of the AMS. Each submission must be accompanied by the journal template. A copy of the template is available by sending e-mail to `ejour-submit@ams.org`. Put the word TEMPLATE in the subject field of the e-mail message. To get additional help, put the word HELP in the subject field in a separate mail message.

emp-info@ams.org
for information on AMS employment and career services.

eprod-support@ams.org
for technical questions regarding AMS electronic products and services.

era-submit@ams.org
for authors to submit research announcements to *Electronic Research Announcements of the AMS*.

mathcal@ams.org
to send information to be included in the "Mathematics Calendar" section of the *Notices*.

mathrev@ams.org
to submit reviews to *Mathematical Reviews* and to send related correspondence.

meet@ams.org
to request general information about Society meetings and conferences.

meetreg-request@ams.org
to request e-mail meeting registration forms.

meetreg-submit@ams.org
to submit completed e-mail registration forms.

mmsb@ams.org
for meeting registration and housing information.

msn-support@ams.org
for technical questions regarding MathSciNet.

notices@ams.org
to send correspondence to the managing editor of the *Notices*, including items for the news columns, "Reference & Book List", or the "Mathematics Calendar". The editor (notices@math.tamu.edu) is the person to whom to send articles and letters. Requests for permission to reprint from the *Notices* should be sent to reprint-permission@ams.org (see below).

notices-ads@ams.org
to submit display ads electronically to the *Notices*.

paoffice@ams.org
to contact the AMS Public Awareness Office.

president@ams.org
to contact the president of the American Mathematical Society.

prof-serv@ams.org
to send correspondence about AMS professional programs and services.

pub@ams.org
to send correspondence to the AMS Publication Division.

pub-submit@ams.org
to submit accepted electronic manuscripts to AMS publications (other than *Abstracts*).

reprint-permission@ams.org
to request permission to reprint material from Society publications.

sales@ams.org
to inquire about reselling or distributing AMS publications, or to send correspondence to the AMS sales department.

secretary@ams.org
to contact the secretary of the American Mathematical Society.

sos@ams.org
for information about AMS services to publishers.

statements@ams.org
to correspond regarding a balance due shown on a monthly statement.

survey@ams.org
for information or questions about the *Annual Survey of the Mathematical Sciences* or to request reprints of *Survey* reports.

tech-support@ams.org
to contact the Society's typesetting Technical Support group.

textbooks@ams.org
to request examination copies or to inquire about using AMS publications as course texts.

webmaster@ams.org
for general information or for assistance in accessing and using the AMS website.

Deaths of AMS Members

MOHAMED ALI AL-BASSAM, of the University of Baghdad and Kuwait University, died on August 23, 2001. Born on December 18, 1923, he was a member of the Society for 52 years.

IRVINE N. BAKER, Imperial College of Science and Technology, London, England, died on May 21, 2001. Born on August 10, 1932, he was a member of the Society for 12 years.

JOHN SCHUMAKER, professor emeritus, Rockford College, IL, died on November 15, 2000. Born on July 24, 1925, he was a member of the Society for 35 years.

BRUCE G. SLOSS, King Saud University, Saudi Arabia, died on August 16, 2001. Born on March 7, 1960, he was a member of the Society for 9 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.tamu.edu` in the case of the editor and `notices@ams.org` in the case of the managing editor. The fax numbers are 979-845-6028 for the editor and 401-331-3842 for the managing editor. Postal addresses may be found in the masthead.

Upcoming Deadlines

October 15, 2001: Applications for NSA Mathematical Sciences Program. See `http://www.nsa.gov/programs/msp/grants.html`, or write to: NSA Mathematical Sciences Program, National Security Agency, ATTN: R51A, Ft. George G. Meade, MD 20755-6000.

October 17, 2001: Applications for NSF Postdoctoral Research Fellowships. See `http://www.fastlane.nsf.gov/`.

October 22, 2001: Applications for NSF International Research Fellow Awards. See `http://www.nsf.gov/sbe/int/fellows/start.htm/` or contact program officer Susan Parris, 703-292-8711, `sparris@nsf.gov`.

October 31, 2001: Applications for AMS Travel Grants for ICM 2002. See `http://www.ams.org/careers-edu/icmapp.html`; e-mail: `ICM02@ams.org`; telephone 800-321-4267, ext. 4105, or 401-455-4105.

November 1, 2001: Proposals for ONR Young Investigator Program. See

Where to Find It

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

http://www.onr.navy.mil/sci-tech/special/complete.htm, or contact Andre M. Van Tilborg, Director, Mathematical, Computer, and Informations Sciences Division, Office of Naval Research; telephone 703-696-4312; e-mail vantila@onr.navy.mil.

November 1, 2001: Applications for Fulbright Scholar international education and academic administrator seminars. Contact the Council for International Exchange of Scholars (CIES), 3007 Tilden Street, NW, Suite 5L, Washington, DC 20008-3009; telephone 202-686-7877; World Wide Web http://www.cies.org/cies/pr_competit_02.htm.

November 16, 2001: Applications for MSRI postdoctoral fellowships and general memberships. See http://www.msri.org/, or write to MSRI, 1000 Centennial Drive, Berkeley, CA 94720-5070.

December 1, 2001: Applications for NSF, NIH/FIC, USDA/ARS summer research program in 2002 for U.S. graduate students in Japan, Korea, and Taiwan. See "Mathematics Opportunities" in this issue.

December 1, 2001: Applications for AMS Centennial Fellowships. See "Mathematics Opportunities" in this issue.

December 15, 2001: Applications for AMS Epsilon Fund. Application materials are available at http://www.ams.org/careers-edu/epsilon.html or by mail: Professional Services Department, AMS, 201 Charles Street, Providence, RI 02904; telephone 800-321-4267, ext. 4105; e-mail: prof-serv@ams.org.

December 31, 2001: Nominations for NSF Alan T. Waterman Award. Contact Susan E. Fannoney, telephone: 703-292-8096, or e-mail: sfannone@nsf.gov.

December 31, 2001: Submissions for undergraduate paper contest in *Cryptologia*. See http://www.dean.usma.edu/math/resource/pubs/crypto/index.htm.

January 1, 2002: Applications for grants for ICM 2002 from the Chinese Mathematical Society and the ICM 2002 Organizing Committee. Information and application forms can be found at http://www.icm2002.org.cn/. Or write to: Shanzhen Lu, Department of Mathematics, Beijing Normal University, 100875 Beijing, China; e-mail: icm@bnu.edu.cn.

January 10, 2002: Applications for AAUW Master's and First Professional Awards. See "Mathematics Opportunities" in this issue.

January 21, 2002: Applications for AWM workshop for women graduate students and postdocs. See "Mathematics Opportunities" in this issue.

January 31, 2002: Applications for IMU travel grants for ICM 2002. See http://elib.zib.de/IMU/.

February 1, May 1, October 1, 2002: Applications for NSF/AWM Travel Grants for Women. See http://www.awm-math.org/travelgrants.html; telephone 301-405-7892; e-mail: awm@math.umd.edu.

February 1, 2002: Applications for NSF/AWM Mentoring Travel Grants. See http://www.awm-math.org/travelgrants.html; telephone 301-405-7892; e-mail: awm@math.umd.edu.

March 1, 2002: Nominations for Third World Academy of Sciences (TWAS) Awards in Basic Sciences. Information is available at http://www.ictp.trieste.it/~twas/Awards_Info.html.

NSF Division of Mathematical Sciences

Listed below are names, e-mail addresses, and telephone numbers for the program directors for the coming academic year in the Division of Mathematical Sciences of the National Science Foundation.

Algebra, Number Theory, and Combinatorics
Helen Grundman
703-292-4876
hgrundma@nsf.gov

Brent Gordon
703-292-4877
bgordon@nsf.gov

Lynne Walling
703-292-4878
lwalling@nsf.gov

Analysis
Joe Jenkins
703-292-4870
jjenkins@nsf.gov

Juan Manfredi
703-292-4871
jmanfred@nsf.gov

Roger Lewis
703-292-4872
rlewis@nsf.gov

Applied Mathematics/Computational Mathematics
Thomas Fogwell
703-292-8104
tfogwell@nsf.gov

Hans Kaper
703-292-4879
hkaper@nsf.gov

Deborah Lockhart
703-292-4858
dlockhar@nsf.gov

Catherine Mavriplis
703-292-4859
cmavripl@nsf.gov

Michael Steuerwalt
703-292-4860
msteuerw@nsf.gov

Paul Saylor
703-292-8870
psaylor@nsf.gov

Henry Warchall
703-292-4861
hwarchal@nsf.gov

Infrastructure
Lloyd Douglas
703-292-4862
ldouglas@nsf.gov

Statistics and Probability
Keith Crank
703-292-4880
kcrank@nsf.gov

Marianthi Markatou
703-292-4882
mmarkato@nsf.gov

John Stufken
703-292-4881
jstufken@nsf.gov

Geometric Analysis, Topology, and Foundations
M. Helena Noronha

703-292-4868
mnoronha@nsf.gov

Yongwu Rong
703-292-4885
yrong@nsf.gov

Benjamin Mann
703-292-4867
bmann@nsf.gov

Christopher Stark
703-292-4869
cstark@nsf.gov

The administrative staff includes:

Division Director
Philippe Tondeur
703-292-8870
ptondeur@nsf.gov

Executive Officer
Bernard McDonald
703-292-4851
bmcdonal@nsf.gov

Administrative Officer
Tyzcer Henson
703-292-4852
thenson@nsf.gov

The postal address is: Division of Mathematical Sciences, National Science Foundation, Room 1025, 4201 Wilson Boulevard, Arlington, VA 22230; telephone 703-292-8870; fax 703-292-9032. The address for the Division's World Wide Web server is http://www.nsf.gov/mps/dms/.

NSF Mathematics Education Staff

The Directorate for Education and Human Resources (EHR) of the National Science Foundation (NSF) sponsors a range of programs that support educational projects in mathematics, science, and engineering. Listed below are the names, telephone numbers, and e-mail addresses of those EHR program officers whose field is in the mathematical sciences or mathematics education. These individuals can provide information about the programs they oversee, as well as information about other EHR programs of interest to mathematicians. The postal address is: Directorate for Education and Human Resources, National Science Foundation, 4201 Wilson Boulevard, Arlington, VA 22230. The World Wide Web address is http://www.nsf.gov/ehr/.

Division of Elementary, Secondary, and Informal Education

Teacher Enhancement Program
Kathryn Chval
703-292-8620
kchval@nsf.gov

Monica Neagoy
703-292-8620
mneagoy@nsf.gov

Diane Spresser
703-292-8620
dspresse@nsf.gov

Instructional Materials Development Program
John (Spud) Bradley, Section Head
703-292-8620
jbradley@nsf.gov

Mary Ann Huntley
703-292-8620
mhuntley@nsf.gov

Division of Research, Evaluation, and Communication

Eric Hamilton, Division Director
703-292-8650
ehamilto@nsf.gov

Finbarr Sloane
703-292-8650
fsloane@nsf.gov

Larry Suter
703-292-8650
lsuter@nsf.gov

Division of Undergraduate Education

James Lightbourne
703-292-8670
jhlightb@nsf.gov

Dennis Davenport
703-292-8670
ddavenpo@nsf.gov

Elizabeth Teles
703-292-8670
eteles@nsf.gov

Lee Zia
703-292-8670
lzia@nsf.gov

Division of Educational Systemic Reform

Robert Mena
703-292-8690
rmena@nsf.gov

Book List

*The **Book List** highlights books that have mathematical themes and hold appeal for a wide audience, including mathematicians, students, and a significant portion of 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 the managing editor, e-mail:* notices@ams.org.

Angles of Reflection: Logic and a Mother's Love, by Joan L. Richards. W. H. Freeman, May 2000. ISBN 0-716-73831-7.

Battle of Wits: The Complete Story of Codebreaking in World War II, by Stephen Budiansky. Free Press, October 2000. ISBN 0-684-85932-7.

The Bit and the Pendulum: How the New Physics of Information Is Revolutionizing Science, by Tom Siegfried. John Wiley & Sons, February 2000. ISBN 0-47132-174-5.

The Book of Nothing: Vacuums, Voids, and the Latest Ideas about the Origins of the Universe, by John D. Barrow. Pantheon Books, April 2001. ISBN 0-375-42099-1.

The Brain: Unraveling the Mystery of How It Works (The Neural Network Process), by Thomas L. Saaty. RWS Publications, 2000. ISBN 1-888603-02-X.

* *Calculated Bets: Computers, Gambling, and Mathematical Modeling to Win*, by Steven S. Skiena. Cambridge University Press, September 2001. ISBN 0-521-00962-6.

Chaotic Elections! A Mathematician Looks at Voting, by Donald G. Saari. AMS, April 2001. ISBN 0-8218-2847-9.

The Colossal Book of Mathematics: Classic Puzzles, Paradoxes, and Problems, by Martin Gardner. W.W. Norton & Company, August 2001. ISBN 0-393-02023-1.

Computers Ltd.: What They Really Can't Do, by David Harel. Oxford University Press, November 2000. ISBN 0-198-50555-8.

A Concise History of Mathematics, by Dirk J. Struik. Dover Publications, 1987. ISBN 0-486-60255-9. (Reviewed June/July 2001.)

Conned Again, Watson! Cautionary Tales of Logic, Math, and Probability, by Colin Bruce. Perseus Publishing, January 2001. ISBN 0-7382-0345-9.

Creators of Mathematics: The Irish Connection, by Ken Houston. University College Dublin Press, September 2000. ISBN 1-900-62149-5.

The Crest of the Peacock: The Non-European Roots of Mathematics, by George Gheverghese Joseph. Princeton University Press, October 2000 (new edition). ISBN 0-691-00659-8.

Crypto: How the Code Rebels Beat the Government—Saving Privacy in the Digital Age, by Steven Levy. Viking Press, January 2001. ISBN 0-67085-950-8.

Damned Lies and Statistics: Untangling Numbers from the Media, Politicians, and Activists, by Joel Best. University of California Press, May 2001. ISBN 0-520-21978-3.

* *The Difference Engine: Charles Babbage and the Quest to Build the First Computer*, by Doron Swade. Viking, September 2001. ISBN 0-670-91020-1.

Divine Harmony: The Life and Teachings of Pythagoras, by John Strohmeier and Peter Westbrook. Berkeley Hills Books, November 1999. ISBN 0-965-37745-8.

The Dots and Boxes Game, by Elwyn Berlekamp. A K Peters, July 2000. ISBN 1-568-81129-2.

Duelling Idiots and Other Probability Puzzlers, by Paul J. Nahin. Princeton University Press, October 2000. ISBN 0-691-00979-1.

Education of a Mathematician, by Philip J. Davis. A K Peters, August 2000. ISBN 1-568-81116-0. (Reviewed January 2001.)

Einstein in Love: A Scientific Romance, by Dennis Overbye. Viking Press, October 2000. ISBN 0-670-89430-3.

Euclid's Window: The Story of Geometry from Parallel Lines to Hyperspace, by Leonard Mlodinow. Free Press, April 2001. ISBN 0-684-86523-8.

Exploring Randomness, by Gregory J. Chaitin. Springer, December 2000. ISBN 1-852-33-417-7. (Reviewed October 2001.)

Finite vs. Infinite, Contributions to an Eternal Dilemma, Cristian S. Calude and Gheorghe Paun, editors. Springer, March 2000. ISBN 1-852-33251-4.

Flatterland: Like Flatland, Only More So, by Ian Stewart. Perseus Publishing, May 2001. ISBN 0-7382-0442-0.

The Fractal Murders, by Mark Cohen. E-book published by Southern Cross Review, 2001. World Wide Web: www.southerncrossreview.org.

Geometry from Africa: Mathematical and Educational Explorations, by Paulus Gerdes. Mathematical Association of America, April 1999. ISBN 0-88385-715-4.

Gödel: A Life of Logic, by John L. Casti and Werner DePauli. Perseus, August 2000. ISBN 0-7382-0274-6. (Reviewed September 2001.)

Gödel Meets Einstein: Time Travel in the Gödel Universe, by Palle Yourgrau. Open Court, November 1999. ISBN 0-812-69408-2.

Hex Strategy: Making the Right Connections, by Cameron Browne. A K Peters, May 2000. ISBN 1-568-81117-9.

The Hilbert Challenge, by Jeremy J. Gray. Oxford University Press, 2000. ISBN 0-198-50651-1.

The Hole in the Universe: How Scientists Peered over the Edge of Emptiness and Found Everything, by K. C. Cole. Harcourt Brace, January 2001. ISBN 0-151-00398-X.

How the Other Half Thinks: Adventures in Mathematical Reasoning, by Sherman Stein. McGraw-Hill, July 2001. ISBN 0-071-37339-X.

How to Solve It: Modern Heuristics, by Zbigniew Michalewicz and David B. Fogel. Springer, December 1999. ISBN 3-540-66061-5.

* *In Code: A Mathematical Journey*, by Sarah Flannery and David Flannery. Workman Publishing, May 2001. ISBN 0-761-12384-9.

Logical Dilemmas: The Life and Work of Kurt Gödel, by John Dawson. A K Peters, December 1997. ISBN 1-56881-025-3. (Reviewed September 2001.)

The Math Gene: How Mathematical Thinking Evolved and Why Numbers Are Like Gossip, by Keith Devlin. Basic Books, August 2000. ISBN 0-465-01618-9. (Reviewed February 2001.)

Mathematics As Sign: Writing, Imagining, Counting, by Brian Rotman. Stanford University Press, September 2000. ISBN 0-804-73684-7.

Mathematics: Frontiers and Perspectives, V. Arnold, M. Atiyah, P. Lax, and B. Mazur, editors. AMS, December 1999. ISBN 0-8218-2697-2.

Mathematics Galore: Masterclasses, Workshops, and Team Projects in Mathematics and Its Applications, by C. J. Budd and C. J. Sangwin. Oxford University Press, June 2001. ISBN 0-198-50769-0 (hardcover), 0-198-50770-4 (paperback).

Newton's Gift: How Sir Isaac Newton Unlocked the System of the World, by David Berlinski. Free Press, October 2000. ISBN 0-684-84392-7.

Newton's Tyranny: The Suppressed Scientific Discoveries of John Flamsteed and Stephen Gray, by David H. Clark and Stephen P. H. Clark. W. H. Freeman, October 2000. ISBN 0-716-74215-2.

Niels Hendrik Abel and His Times: Called Too Soon by Flames Afar, by Arild Stubhaug, translated by R. Daly. Springer, May 2000. ISBN 3-540-66834-9.

Number: From Ahmes to Cantor, by Midhat Gazalé. Princeton University Press, March 2000. ISBN 0-691-00515-X. (Reviewed August 2001.)

The Parrot's Theorem, by Denis Guedj. St. Martin's Press, September 2001. ISBN 0-312-28055-6. (Reviewed March 2001.)

Proofs from THE BOOK, by M. Aigner and G. M. Ziegler. Revised and expanded second edition, Springer, January 2001. ISBN 3-540-67865-4. (First edition reviewed August 1999.)

Ptolemy's Geography, translated by J. Lennart Berggren and Alexander Jones. Princeton University Press, November 2000. ISBN 0-691-01042-0.

The Pursuit of Perfect Packing, by Tomaso Aste and Denis Weaire. Institute of Physics Publishing, July 2000. ISBN 0-750-30648-3.

Radical Equations: Math Literacy and Civil Rights, by Robert P. Moses and Charles E. Cobb Jr. Beacon Press, February 2001. ISBN 0-807-03126-7.

Sacred Geometry, by Miranda Lundy. Walker & Company, April 2001. ISBN 0-802-71382-3.

The Search for Mathematical Roots, 1870-1940: Logics, Set Theories, and the Foundations of Mathematics from Cantor through Russell to Gödel, by I. Grattan-Guinness. Princeton University Press, February 2001. ISBN 0-691-0587-1.

The Story of Mathematics, by Richard Mankiewicz. Princeton University Press, February 2001. ISBN 0-691-08808-X.

Surfing through Hyperspace: Understanding Higher Universes in Six Easy Lessons, by Clifford A. Pickover. Oxford University Press, September 1999. ISBN 0-195-13006-5.

Triangle of Thoughts, by Alain Connes, André Lichnerowicz, and Marcel Paul Schützenberger. AMS, July 2001. ISBN 0-8218-2614-X.

The Universal Computer: The Road from Leibniz to Turing, by Martin Davis. W.W. Norton & Company, October 2000. ISBN 0-393-04785-7. (Reviewed May 2001.)

The Universal History of Computing: From the Abacus to the Quantum Computer, by Georges Ifrah; translated from the French and with notes by E. F. Harding, assisted by Sophie Wood, Ian Monk, Elizabeth Clegg, and Guido Waldman. John Wiley & Sons, November 2000. ISBN 0-471-39671-0.

The Universal History of Numbers: From Prehistory to the Invention of the Computer, by Georges Ifrah; translated from the French by David Bellos, E. F. Harding, Sophie Wood, and Ian Monk. John Wiley & Sons, December 1999. ISBN 0-471-37568-3.

The Unknowable, by Gregory J. Chaitin. Springer, August 1999. ISBN 9-814-02172-5. (Reviewed October 2001.)

What Is Mathematics? An Elementary Approach to Ideas and Methods, by Richard Courant and Herbert Robbins; second edition, revised by Ian Stewart. Oxford University Press, August 1996. ISBN 0-195-10519-2.

Where Mathematics Comes From: How the Embodied Mind Brings Mathematics into Being, by George Lakoff and Rafael Núñez. Basic Books, October 2000. ISBN 0-465-03770-4. (Reviewed in this issue.)

White Light, by Rudy Rucker. Four Walls Eight Windows, April 2001. ISBN 1-56858-198-X.

Women Becoming Mathematicians: Creating a Professional Identity in Post-World War II America, by Margaret A. M. Murray. MIT Press, September 2000. ISBN 0-262-13369-5. (Reviewed August 2001.)

Wonders of Numbers: Adventures in Math, Mind, and Meaning, by Clifford A. Pickover. Oxford University Press, September 2000. ISBN 0-195-13342-0.

**Added to "Book List" since the list's last appearance.*

Honorary Members of the AMS

Listed below are the Honorary Members of the American Mathematical Society, those who have been members for fifty years or more.

The American Mathematical Society offers congratulations to all its Honorary Members on their longstanding affiliation with the AMS and extends appreciation for their continued commitment to the mathematics profession.

Abbott, James C
Ablow, Clarence M
Adamson, Iain T A C
Adney, Joseph E Jr
Agmon, Shmuel
Aissen, Michael I
Al-Dhahir, M W
Alder, H L
Alt, Franz L
Ancochea, German
Anderson, Florence R
Anderson, Richard D
Anderson, Theodore W
Apostol, Tom M
Arenson, Donald L
Arnold, Bradford H
Artzy, Rafael
Asprey, Winifred A
Aurora, Silvio
Axt, Paul
Ayoub, Christine W
Ayoub, Raymond G
Babbitt, Albert E Jr
Backus, George E
Bade, William G
Baer, Robert M
Baker, Edward G
Baker, George A Sr
Ballard, William R
Ballou, Donald H
Balser, Arienne S
Barber, S F
Barr, William J
Barrar, Richard B
Barrett, Lida K
Bartels, Robert C F
Bartle, Robert G
Bateman, Paul T
Bayo, Enrique
Bazer, Jack
Beard, Helen P
Beaty, Marjorie Heckel
Beckman, Frank S
Bell, Earl L
Bell, Janie L
Bell, Philip O
Benson, Dean C
Benson, Donald C
Berger, Agnes
Bergmann, Peter G
Berkovitz, Leonard D
Berkowitz, Jerome
Bernardi, Salvatore D
Blackall, Clair J
Blackett, Donald W
Blackman, Jerome
Blackwell, David
Blanc, Charles
Blank, Albert A
Block, I Edward
Blum, Edward K
Blum, Joseph
Bonsall, Frank F
Boothby, William M
Borovik, Alexandre V
Bott, Raoul H
Botts, Truman A
Bower, Julia W
Boyle, Evelyn Hull
Brace, John W
Brady, Wray G
Breves Filho, J A
Brigham, Nelson A
Bromberg, Eleazer
Browder, Felix E
Brown, Arthur A
Brown, Beverley M
Brown, Howard H
Brown, Richard H
Brown, Richard K
Brown, Robert Goodell
Brownell, Frank H III
Brunk, Hugh D
Brunschwig, Mildred C
Brunswick, Natascha A
Buchsbaum, David A
Buck, Ellen F
Buehler, Royce E
Burgess, C Edmund
Butchart, John H
Butler, John B Jr
Calabi, Eugenio
Calloway, Jean M
Carlson, Bengt G
Cartan, Henri
Caywood, Thomas E
Chandrasekharan, K
Charpentier, Marie R J
Chen, Y W
Chern, Shiing S
Chernoff, Herman
Choquet, Gustave
Chover, Joshua
Chow, Tseng Yeh
Chowla, Sarvadaman
Chung, Kai Lai
Civin, Paul
Clark, Charles L
Clark, F Eugene
Clark, Robert A
Clement, Mary Dean
Cohen, Haskell
Cohen, Herman J
Cohn, Harvey
Cohn, Richard M
Cole, Charles A
Coleman, A John
Coler, Myron A
Conrad, Paul F
Cook, E Allen Jr
Cooke, Kenneth L
Copeland, Arthur H Jr
Cotlar, Mischa
Coxeter, H S MacDonald
Crandall, Stephen H
Creese, Franklyn G
Criscenti, Jacqueline P
Critchlow, Florence G
Crow, Edwin L
Cullen, Helen F
Cunningham, Frederic Jr
Curtis, Charles W
Curtis, Herbert J
Cuthill, Elizabeth H
Danskin, John M
Dantzig, George B
Darling, Donald A
Davis, Chandler
Davis, Martin D
Dawson, David F
Dean, Richard A
Defrancesco, Henry F
Dekker, Jacob C E
Delange, Hubert
Derr, Leroy J
Devinatz, Allen
Diamond, Ainsley H
Dickson, Robert J
Dimsdale, Bernard
Dinneen, Gerald P
Divinsky, Nathan J
Donoghue, William F Jr
Doob, Joseph L
Douglas, Jim Jr
Dubisch, Roy
Dunn, D W
Duren, William L Jr
Durst, Lincoln K
Dutka, Jacques
Dwork, Julius S
Dye, Leaman A
Dyer-Bennet, John
Eachus, J J
Eckmann, Beno
Eddy, Robert P
Eells, James
Ehrenpreis, Leon
Eisenstadt, B J
Elliott, H Margaret
Elliott, Joanne
Ellis, Robert
Emerson, Marion P
Epstein, Benjamin
Epstein, Bernard
Ericksen, Wilhelm S
Evans, W Buell
Ewy, Daniel J
Fadell, Edward R
Fan, Ky
Farley, Belmont G
Faulkner, Frank D
Federer, Herbert
Feferman, Solomon
Feldman, Chester
Fell, James M G
Fialkow, Aaron D
Firey, William
Fishback, William T

Flanders, Harley
Flatto, Leopold
Fleming, Wendell H
Forman, William
Fowler, Franklin H
Franck, Abraham
Free, Norman S
Freeman, Robert S
Freier, Jerome B
Freilich, Gerald
Freundlich, Marianne Smith
Friberg, Martin S
Friedman, Joyce B
Fry, Cleota G
Fuller, F Brock
Fuller, William R
Gaal, Lisl Novak
Gaalswyk, Arie
Gabriel, Richard F
Gaffney, Matthew P
Gale, David
Garabedian, Paul R
Garcia, Mariano Jr
Garding, Lars
Garfin, Louis
Garrett, James R
Gaskill, Irving E
Geckler, Richard D
Gelbaum, Bernard R
Gerst, Irving
Gerstenhaber, Murray
Ghaffari, Abolghassem
Ghent, K S
Gilbarg, David
Gillman, Leonard
Glauz, Robert D
Gleason, Andrew M
Glusman, Sidney
Goffman, Casper
Goldberg, Samuel
Goldhaber, J K
Goldman, Lawrence
Goldstine, Herman H
Golomb, Michael
Good, Richard A
Goodman, A W
Gottschalk, Walter H
Graves, Robert L
Green, Leon W
Greenspan, Bernard
Grey, Louis D
Griffin, E L Jr
Gulden, S L
Gurney, Margaret
Haag, Vincent H
Haefeli, Hans G
Hailperin, Theodore
Haimo, Deborah Tepper
Halmos, Paul R
Hammer, Carl
Hamstrom, Mary-Elizabeth
Hancock, V Ray
Handelman, George H
Hanisch, Herman
Hannan, James F
Harary, Frank
Hardy, John W Jr
Harrington, Walter J
Harris, Theodore E
Hartman, Philip
Harvey, A Raymond
Hasenfus, Harold J
Hausner, Melvin
Hay, George E
Hayden, Seymour
Hayes, Charles A
Heins, Maurice H
Heller, Alex
Helms, Lester L
Helson, Henry
Hemmingsen, Erik
Henderson, Emma M
Henkin, Leon A
Henriksen, Melvin
Henriques, Anna S
Herriot, John G
Hershner, Ivan R Jr
Herwitz, Paul S
Herzog, Fritz
Hildebrand, F B
Hildebrandt, Theodore W
Hillman, Abraham P
Hirsch, W M
Hirschfelder, Elizabeth S
Hochschild, Gerhard P
Hocking, J G
Hoffman, William C
Honig, Chaim Samuel
Horn, Alfred
Hornback, Joseph H
Howard, Bernard E
Howard, William A
Hsiung, Chuan C
Huber-Dyson, Verena
Huck, Raymond
Hufford, George A
Humphreys, M Gweneth
Hunte, Beryl E
Hunter, Louise S
Hurwitz, Solomon
Huskey, Harry D
Isaacson, Eugene
Jackson, Lloyd K
Jaco, William H
Jacob, Henry G
Jacobson, Florence D
James, Robert C
Jenkins, James A
Johanson, Ralph N
Johnson, L Wayne
Jones, Phillip S
Jonsson, Bjarni
Joshi, Padmini T
Kadison, Richard V
Kakutani, Shizuo
Kaplan, Edward L
Kaplan, Samuel
Kaplan, Wilfred
Kaplansky, Irving
Kasriel, Robert H
Kelly, John B
Kennedy, Edward S
Kent, J T
Keown, R
Kincaid, Wilfred M
Kirk, David B
Kirmser, Philip G
Klamkin, Murray S
Klee, Victor
Kleinfeld, Erwin
Koch, Robert J
Koehler, C Frederick
Komm, Horace
Konijn, H S
Korevaar, J
Koss, Walter E
Kossack, Carl F
Krabill, David M
Kruskal, Martin D
Kuhn, Harold W
LaBudde, Christian D
Langebartel, Ray G
Langenhop, Carl E
Laning, J Halcombe
Larney, Violet Hachmeister
Lashof, Richard K
Lauer, Robert M
Lauritzen, Steffen L
Laush, George
Lax, Peter D
LeVeque, William J
Leavitt, William G
Lebel, Jean E
Leehey, Patrick
Leger, George F
Lehner, Joseph
Leibler, Richard A
Leipnik, Roy B
Lelong, P J
Lengyel, Bela A
Lepson, Benjamin
Lesieur, Leonce
Levene, Howard
Levi, Howard
Levine, Jack
Levinger, Bernard W
Levit, Robert J
Lewis, D J
Light, F W Jr
Lindsay, John W
Lipschutz-Yevick, Miriam A
Lipsich, H David
Lister, William G
Livingood, J N B
Lorch, Lee
Lorell, Jack
Lorentz, George G
Loud, Warren S
Luce, R Duncan
Luchins, Edith H
Mac Lane, Saunders
Mackey, G W
Macon, Nathaniel
Macphail, Moray S
Madow, William G
Mann, W Robert
Mansfield, Ralph
Marchand, Margaret O
Marcou, R J
Mark, J C
Markis, Louise Leon
Marr, John M
Martin, M H
Martin, Norman M
Martin, William T
Massey, William S
Mattuck, Arthur P
Mayberry, John P
McBrien, Vincent O
McCarthy, John
McCoy, Dorothy
McCoy, N H
McDonald, Janet
McLaughlin, Jack E
McMillan, Audrey W
McMillan, Brockway
Meacham, Robert C
Meder, Albert E Jr
Meier, Paul
Mendelsohn, N S
Mendenhall, Robert V
Merkes, Edward P
Merriell, David M
Meserve, Bruce E
Meyer, Burnett C
Meyer, Herman
Meyer, Jean-Pierre G
Michael, Ernest A
Mielke, Paul T
Miller, D D
Miller, Jack M
Miller, Kenneth S
Mills, William H
Miloslavsky, G C
Mitchell, Benjamin E
Moller, Raymond W
Molloy, Charles T
Moore, Edward F
Moore, John C
Moore, Marvin G
Moore, Richard A
Moore, W Keith
Morawetz, Cathleen S
Morduchow, Morris
Morgan, George W
Morgan, Kathryn A
Morrison, Donald R
Morse, Burt J
Moser, William O J
Mostow, George Daniel
Moyls, Benjamin N

Muller, George M
Naef, Walter
Nelson, David
Nesbitt, Cecil J
Neumann, Bernhard H
Neustadter, Siegfried F
Newlander, August Jr
Newman, Morris
Nirenberg, Louis
Noble, Andrewa R
Nomizu, Katsumi
Nordhaus, Edward A
Norman, Robert Z
Novikoff, Albert B
O'Meara, O Timothy
O'Neill, Anne F
O'Neill, Barrett
Oliver, Henry W
Olshen, A C
Orloff, Daniel
Orr, Martin
Osborn, Howard A
Osserman, Robert
Ostrom, T G
Otter, Richard R
Oursler, C C
Paige, Lowell J
Pardee, Otway O M
Parker, Francis D
Payne, Lawrence E
Pedrick, George B
Peeples, William D Jr
Peixoto, Mauricio Matos
Penico, Anthony J
Pepper, Paul M
Percus, Jerome K
Perlis, Sam
Pinney, Edmund
Piranian, George
Pitcher, Everett
Podmele, Theresa L
Polachek, Harry
Pollak, H O
Posey, Eldon E
Potts, Donald H
Price, G Baley
Prim, Robert C III
Protter, Murray H
Pursell, Lyle E
Putnam, Alfred L
Putnam, Calvin R
Quarles, D A Jr
Raney, George N
Rapoport, Anatol
Rauch, Lawrence L
Rausen, John
Reade, Maxwell O
Rechard, Ottis W
Redheffer, Raymond M
Reeves, Roy F
Reich, Edgar
Reingold, Haim
Reisel, Robert B
Reynolds, Robert R
Ribenboim, Paulo
Rice, Henry G
Rickart, Charles E
Riess, Karlem
Robertson, Malcolm S
Robinson, Robin
Rohde, F Virginia
Rooney, Paul G
Root, William L
Rose, Gene F
Rose, Israel H
Rose, Nicholas J
Rosenbaum, Robert A
Rosenblatt, Murray
Rosenbloom, J H
Ross, Arnold E
Rotter, Paul T
Rubin, Herman
Rubin, Jean E
Rudin, Mary E
Rudin, Walter
Rust, Charles H
Salkind, William
Saltzer, Charles
Salzer, Herbert E
Samelson, Hans
Sampson, M H
Samuel, Pierre
Sanderson, Donald E
Sangren, Ward C
Sario, Leo
Scalora, Frank S
Scanlon, Jane Cronin
Schaerf, Henry M
Schafer, Alice T
Schafer, Richard D
Schatz, Joseph A
Schechter, Samuel
Schild, Albert
Schlesinger, Ernest C
Schoenfeld, Lowell
Schurrer, Augusta L
Schwartz, Benjamin L
Schwartz, Jacob T
Schwartz, Laurent
Scott, Leland L
Seiden, Esther
Seifert, George
Serrin, James B
Shaffer, Dorothy B
Shaftman, David H
Shapiro, Harold S
Shapley, Lloyd S
Shenitzer, Abe
Sherman, Bernard
Shniad, Harold
Sholander, Marlow C
Silverman, Robert J
Sinclair, Annette
Singer, Isadore M
Sion, Maurice
Slaby, Harold T
Smith, Edgar C Jr
Smith, Spurgeon E
Smith, William K
Smithies, Frank
Snapper, Ernst
Snell, J Laurie
Snover, James E
Solomon, Louis
Sopka, John J
Specht, Edward J
Spencer, Domina E
Spencer, Guilford L II
Spitzbart, Abraham
Spragens, William H Jr
Springer, George
Stalley, Robert D
Stamey, William L
Standish, Charles J
Starr, David W
Steen, F H
Stegun, Irene A
Stein, Sherman K
Steinberg, Maria W
Steinberg, Robert
Stephens, Clarence F
Strange, William J
Strohl, G Ralph Jr
Sturley, Eric A
Sullivan, Joseph A
Sunseri, Mary V
Supnick, Fred
Szekeres, George
Taam, Choy-Tak
Talmadge, Richard B
Tamari, Dov
Tate, John T
Terzuoli, Andrew J
Thickstun, W R Jr
Thomas, Garth H M
Thomas, George B Jr
Thompson, Layton O
Thomsen, D L Jr
Thorne, Charles J
Thrall, Robert M
Thron, Wolfgang J
Tierney, John A
Todd, John
Toole, John W
Transue, William R
Tuckerman, Bryant
Turquette, Atwell R
Turyn, Richard J
Tutte, W T
Utz, W Roy Jr
Valentine, F A
van Alstyne, John P
Van Tuyl, A H
Vance, Elbridge P
Vaught, Robert L
Vinograde, Bernard
Waldinger, Hermann V
Waltcher, Azelle B
Walters, Eleanor B
Wantland, Evelyn K
Ward, Lewis E
Warner, William H
Wasserman, Robert H
Waterman, Daniel
Wechsler, Martin T
Wedel, Arnold M
Wehausen, John V
Weinberger, Hans F
Weiner, Jerome H
Wellinger, David
Welmers, Everett T
Wend, David V V
Wendel, James G
Wermer, John
Wernick, William
Western, D W
Wetzel, Marion D
White, Myron E
Whitehead, George W
Whitehead, Kathleen B
Whitney, D Ransom
Whittaker, James V
Wicke, Howard H
Widom, Harold
Wightman, Arthur S
Wild, Roy E
Wilkins, J Ernest Jr
Willcox, Alfred B
Williams, Robert F
Willmore, Thomas J
Wilson, Robert L
Wing, G Milton
Winter, Eva P
Wolfson, Kenneth G
Wolinsky, Albert
Wolk, Elliot S
Wong, Yung-Chow
Wood, Rhoda M
Woodbury, Max A
Wouk, Arthur
Wrench, John W Jr
Wurster, Marie A
Wyler, Oswald
Yagi, Fumio
Yood, Bertram
Young, David M Jr
Young, Gail S
Young, Paul M
Zarantonello, Eduardo H
Zelinsky, Daniel
Ziebur, Allen D
Zierler, Neal
Zilber, Joseph A
Zilmer, Delbert E
Zimmerberg, Hyman J

From the AMS Secretary

Bylaws of the American Mathematical Society

Article I

Officers

Section 1. There shall be a president, a president elect (during the even-numbered years only), an immediate past president (during the odd-numbered years only), three vice presidents, a secretary, four associate secretaries, a treasurer, and an associate treasurer.

Section 2. It shall be a duty of the president to deliver an address before the Society at the close of the term of office or within one year thereafter.

Article II

Board of Trustees

Section 1. There shall be a Board of Trustees consisting of eight trustees, five trustees elected by the Society in accordance with Article VII, together with the president, the treasurer, and the associate treasurer of the Society *ex officio.* The Board of Trustees shall designate its own presiding officer and secretary.

Section 2. The function of the Board of Trustees shall be to receive and administer the funds of the Society, to have full legal control of its investments and properties, to make contracts, and, in general, to conduct all business affairs of the Society.

Section 3. The Board of Trustees shall have the power to appoint such assistants and agents as may be necessary or convenient to facilitate the conduct of the affairs of the Society and to fix the terms and conditions of their employment. The Board may delegate to the officers of the Society duties and powers normally inhering in their respective corporative offices, subject to supervision by the Board. The Board of Trustees may appoint committees to facilitate the conduct of the financial business of the Society and delegate to such committees such powers as may be necessary or convenient for the proper exercise of those powers. Agents appointed, or members of committees designated, by the Board of Trustees need not be members of the Board.

Nothing herein contained shall be construed to empower the Board of Trustees to divest itself of responsibility for, or legal control of, the investments, properties, and contracts of the Society.

Article III

Committees

Section 1. There shall be eight editorial committees as follows: committees for the *Bulletin*, for the *Proceedings*, for the *Colloquium Publications*, for the *Journal*, for *Mathematical Surveys and Monographs*, for *Mathematical Reviews*; a joint committee for the *Transactions* and the *Memoirs*; and a committee for *Mathematics of Computation*.

Section 2. The size of each committee shall be determined by the Council.

Article IV

Council

Section 1. The Council shall consist of fifteen members at large and the following *ex officio* members: the officers of the Society specified in Article I, except that it shall include only one associate secretary, the chairman of each of the editorial committees specified in Article III, any former secretary for a period of two years following the terms of office, and members of the Executive Committee (Article V) who remain on the Council by the operation of Article VII, Section 4.

The chairman of any committee designated as a Council member may name a deputy from the committee as substitute. The associate secretary shall be the one charged with the scientific program of the meeting at which the Council meets except that at a meeting associated with no scientific meeting of the Society the secretary may designate the associate secretary.

Section 2. The Council shall formulate and administer the scientific policies of the Society and shall act in an advisory capacity to the Board of Trustees.

Section 3. In the absence of the secretary from any meeting of the Council, a member may be designated as acting secretary for the meeting, either by written authorization of the secretary, or, failing that, by the presiding officer.

Section 4. All members of the Council shall be voting members. Each member, including deputies and the designated associate secretary, shall have one vote. The method for settling matters before the Council at any meeting shall be by majority vote of the members present. If the result of a vote is challenged, it shall be the duty of the presiding officer to determine the true vote by a roll call. In a roll call vote, each Council member shall vote only once (although possibly a member of the Council in several capacities).

Section 5. Any five members of the Council shall constitute a quorum for the transaction of business at any meeting of the Council.

Section 6. Between meetings of the Council, business may be transacted by a mail vote. Votes shall be counted as specified in Section 4 of this Article, "members present" being replaced by "members voting". An affirmative vote by mail on any proposal shall be declared if, and only if, (a) more than half of the total number of possible votes is received by the time announced for the closing of the polls, and (b) at least three-quarters of the votes received by then are affirmative. If five or more members request postponement at the time of voting, action on the matter at issue shall be postponed until the next meeting of the Council, unless either (1) at the discretion of the secretary, the question is made the subject of a second vote by mail, in connection with which brief statements of reason, for and against, are circulated; or (2) the Council places the matter at issue before the Executive Committee for action.

Section 7. The Council may delegate to the Executive Committee certain of its duties and powers. Between meetings of the Council, the Executive Committee shall act for the Council on such matters and in such ways as the Council may specify. Nothing herein contained shall be construed as empowering the Council to divest itself of responsibility for formulating and administering the scientific policies of the Society.

Section 8. The Council shall also have power to speak in the name of the Society with respect to matters affecting the status of mathematics or mathematicians, such as proposed or enacted federal or state legislation; conditions of employment in universities, colleges, or business, research or industrial organizations; regulations, policies, or acts of governmental agencies or instrumentalities; and other items which tend to affect the dignity and effective position of mathematics.

With the exception noted in the next paragraph, a favorable vote of two-thirds of the entire membership of the Council shall be necessary to authorize any statement in the name of the Society with respect to such matters. With the exception noted in the next paragraph, such a vote may be taken only if written notice shall have been given to the secretary by the proposer of any such resolution not later than one month prior to the Council meeting at which the matter is to be presented, and the vote shall be taken not earlier than one month after the resolution has been discussed by the Council.

If, at a meeting of the Council, there are present twelve members, then the prior notification to the secretary may be waived by unanimous consent. In such a case, a unanimous favorable vote by those present shall empower the Council to speak in the name of the Society.

The Council may also refer the matter to a referendum by mail of the entire membership of the Society and shall make such reference if a referendum is requested, prior to final action by the Council, by two hundred or more members. The taking of a referendum shall act as a stay upon Council action until the votes have been canvassed, and thereafter no action may be taken by the Council except in accordance with a plurality of the votes cast in the referendum.

Article V

Executive Committee

Section 1. There shall be an Executive Committee of the Council, consisting of four elected members and the following *ex officio* members: the president, the secretary, the president elect (during even-numbered years), and the immediate past president (during odd-numbered years).

Section 2. The Executive Committee of the Council shall be empowered to act for the Council on matters which have been delegated to the Executive Committee by the Council. If three members of the Executive Committee request that any matter be referred to the Council, the matter shall be so referred. The Executive Committee shall be responsible to the Council and shall report its actions to the Council. It may consider the agenda for meetings of the Council and may make recommendations to the Council.

Section 3. Each member of the Executive Committee shall have one vote. An affirmative vote on any proposal before the Executive Committee shall be declared if, and only if, at least four affirmative votes are cast for the proposal. A vote on any proposal may be determined at a meeting of the Executive Committee, but it shall not be necessary to hold a meeting to determine a vote.

Article VI

Executive Director

Section 1. There shall be an Executive Director who shall be a paid employee of the Society. The Executive Director shall have charge of the offices of the Society, except for the office of the secretary, and shall be responsible for the general administration of the affairs of the Society in accordance with the policies that are set by the Board of Trustees and by the Council.

Section 2. The Executive Director shall be appointed by the Board of Trustees with the consent of the Council. The terms and conditions of employment shall be fixed by the Board of Trustees, and the performance of the Executive Director will be reviewed regularly by the Board of Trustees.

Section 3. The Executive Director shall be responsible to and shall consult regularly with a liaison committee consisting of the president as chair, the secretary, the treasurer, and the chair of the Board of Trustees.

Section 4. The Executive Director shall attend meetings of the Board of Trustees, the Council, and the Executive Committee, but shall not be a member of any of these bodies.

Article VII

Election of Officers and Terms of Office

Section 1. The term of office shall be one year in the case of the president elect and the immediate past president; two years in the case of the president, the secretary, the associate secretaries, the treasurer, and the associate treasurer; three years in the case of vice presidents and members at large of the Council, one vice president and five members at large retiring annually; and five years in the case of the trustees. In the case of members of the editorial committees and appointed members of the communications committees, the term of office shall be determined by the Council. The term of office for elected members of the Executive Committee shall be four years, one of the elected members retiring annually. All terms of office shall begin on February 1 and terminate on January 31, with the exception that the officials specified in Articles I, II, III, IV, and V (excepting the president elect and immediate past president) shall continue to serve until their successors have been duly elected or appointed and qualified.

Section 2. The president elect, the vice presidents, the trustees, and the members at large of the Council shall be elected by written ballot. An official ballot shall be sent to each member of the Society by the secretary on or before October 10, and such ballots, if returned to the secretary in envelopes bearing the name of the voter and received within thirty days, shall be counted. Each ballot shall contain one or more names proposed by the Council for each office to be filled, with blank spaces in which the voter may substitute other names. A plurality of all votes cast shall be necessary for election. In case of failure to secure a plurality for any office, the Council shall choose by written ballot among the members having the highest number of votes. The secretary, the associate secretaries, the treasurer, and the associate treasurer shall be appointed by the Council in a manner designated by the Council. Each committee named in Article III shall be appointed by the Council in a manner designated by the Council. Each such committee shall elect one of its members as chairman in a manner designated by the Council.

Section 3. The president becomes immediate past president at the end of the term of office and the president elect becomes president.

Section 4. On or before February 15, the secretary shall send to all members of the Council for a mail vote a ballot containing two names for each place to be filled on the Executive Committee. The nominees shall be chosen by a committee appointed by the president. Members of the Council may vote for persons not nominated. Any member of the Council who is not an *ex officio* member of the Executive Committee (see Article V, Section 1) shall be eligible for election to the Executive Committee. In case a member is elected to the Executive Committee for a term extending beyond the regular term on the Council, that person shall automatically continue as a member of the Council during the remainder of that term on the Executive Committee.

Section 5. The president and vice presidents shall not be eligible for immediate re-election to their respective offices. A member at large or an *ex officio* member of the Council shall not be eligible for immediate election (or re-election) as a member at large of the Council.

Section 6. If the president of the Society should die or resign while a president elect is in office, the president elect shall serve as president for the remainder of the year and thereafter shall serve the regular two-year term. If the president of the Society should die or resign when no president elect is in office, the Council, with the approval of the Board of Trustees, shall designate one of the vice presidents to serve as president for the balance of the regular presidential term. If the president elect of the Society should die or resign before becoming president, the office shall remain vacant until the next regular election of a president elect, and the Society shall, at the next annual meeting, elect a president for a two-year term. If the immediate past president should die or resign before expiration of the term of office, the Council, with the approval of the Board of Trustees, shall designate a former president of the Society to serve as immediate past president during the remainder of the regular term of the immediate past president. Such vacancies as may occur at any time in the group consisting of the vice presidents, the secretary, the associate secretaries, the treasurer, and the associate treasurer shall be filled by the Council with the approval of the Board of Trustees. If a member of an editorial or communications committee should take temporary leave from duties, the Council shall then appoint a substitute. The Council shall fill from its own membership any vacancy in the elected membership of the Executive Committee.

Section 7. If any elected trustee should die while in office or resign, the vacancy thus created shall be filled for the unexpired term by the Board of Trustees.

Section 8. If any member at large of the Council should die or resign more than one year before the expiration of the term, the vacancy for the unexpired term shall be filled by the Society at the next annual meeting.

Section 9. In case any officer should die or decline to serve between the time of election and the time to assume office, the vacancy shall be filled in the same manner as if that officer had served one day of the term.

Article VIII

Members and Their Election

Section 1. Election of members shall be by vote of the Council or of its Executive Committee.

Section 2. There shall be four classes of members, namely, ordinary, contributing, corporate, and institutional.

Section 3. Application for admission to ordinary membership shall be made by the applicant on a blank provided by the secretary. Such applications shall not be acted upon until at least thirty days after their presentation to the Council (at a meeting or by mail), except in the case of members of other societies entering under special action of the Council approved by the Board of Trustees.

Section 4. An ordinary member may become a contributing member by paying the dues for such membership. (See Article IX, Section 3.)

Section 5. A university or college, or a firm, corporation, or association interested in the support of mathematics may be elected a corporate or an institutional member.

Article IX

Dues and Privileges of Members

Section 1. Any applicant shall be admitted to ordinary membership immediately upon election by the Council (Article VIII) and the discharge within sixty days of election of the first annual dues. Dues may be discharged by payment or by remission when the provision of Section 7 of this Article is applicable. The first annual dues shall apply to the year of election, except that any applicant elected after August 15 of any year may elect to have the first annual dues apply to the following year.

Section 2. The annual dues of an ordinary member of the Society shall be established by the Council with the approval of the Trustees. The Council, with the approval of the Trustees, may establish special rates in exceptional cases and for members of an organization with which the Society has a reciprocity agreement.

Section 3. The minimum dues for a contributing member shall be three-halves of the dues of an ordinary member per year. Members may, upon their own initiative, pay larger dues.

Section 4. The minimum dues of an institutional member shall depend on the scholarly activity of that member. The formula for computing these dues shall be established from time to time by the Council, subject to approval by the Board of Trustees. Institutions may pay larger dues than the computed minimum.

Section 5. The privileges of an institutional member shall depend on its dues in a manner to be determined by the Council, subject to approval by the Board of Trustees. These privileges shall be in terms of Society publications to be received by the institution and of the number of persons it may nominate for ordinary membership in the Society.

Section 6. Dues and privileges of corporate members of the Society shall be established by the Council subject to approval by the Board of Trustees.

Section 7. The dues of an ordinary member of the Society shall be remitted for any years during which that member is the nominee of an institutional member.

Section 8. After retirement from active service on account of age or on account of long-term disability, any ordinary or contributing member who is not in arrears of dues and with membership extending over at least twenty years may, by giving proper notification to the secretary, have dues remitted. Such a member shall receive the *Notices* and may request to receive *Bulletin* as privileges of membership during each year until membership ends.

Section 9. An ordinary or contributing member shall receive the *Notices* and *Bulletin* as privileges of membership during each year for which dues have been discharged.

Section 10. The annual dues of ordinary, contributing, and corporate members shall be due by January 1 of the year to which they apply. The Society shall submit bills for dues. If the annual dues of any member remain undischarged beyond what the Board of Trustees deems to be a reasonable time, the name of that member shall be removed from the list of members after due notice. A member wishing to discontinue membership at any time shall submit a resignation in writing to the Society.

Section 11. Any person who has attained the age of 62 and has been a member for at least twenty years may become a life member by making a single payment equal to five times the dues of an ordinary member for the coming year. Insofar as there is more than one level of dues for ordinary membership, it is the highest such dues that shall be used in the calculation, with the exception for members by reciprocity noted in the following paragraph. A life member is subsequently relieved of the obligation of paying dues. The status and privileges are those of ordinary members.

A member of the Society by reciprocity who has reached the age of 62, has been a member for at least 20 years, has been a member by reciprocity for at least 15 of those 20 years and asserts the intention of continuing to be a member by reciprocity may purchase a life membership by a one-time payment of a special rate established by the Council, with the approval of the Trustees.

Article X

Meetings

Section 1. The annual meeting of the Society shall be held between the fifteenth of December and the tenth of February next following. Notice of the time and place of this meeting shall be mailed by the secretary or an associate secretary to the last known post office address of each member of the Society. The times and places of the annual and other meetings of the Society shall be designated by the Council.

Section 2. There shall be a business meeting of the Society only at the annual meeting. The agenda for the business meeting shall be determined by the Council. A business meeting of the Society can take action only on items notified to the full membership of the Society in the call for the meeting. A business meeting can act on items recommended to it jointly by the Council and the Board of Trustees; a majority of members present and voting is required for passage of such an item. A business meeting of the Society can place action items on the agenda for a future business meeting. Final action on an item proposed by a previous business meeting can be taken only provided there is a quorum of 400 members, a majority of members at a business meeting with a quorum being required for passage of such an item.

Section 3. Meetings of the Executive Committee may be called by the president. The president shall call a meeting at any time upon the written request of two of its members.

Section 4. The Council shall meet at the annual meeting of the Society. Special meetings of the Council may be called by the president. The president shall call a special meeting at any time upon the written request of five of its members. No special meeting of the Council shall be held unless written notice of it shall have been sent to all members of the Council at least ten days before the day set for the meeting.

Section 5. The Board of Trustees shall hold at least one meeting in each calendar year. Meetings of the Board of Trustees may be called by the president, the treasurer, or the secretary of the Society upon three days' notice of such meetings mailed to the last known post office address of each trustee. The secretary of the Society shall call a meeting upon the receipt of a written request of two of the trustees. Meetings may also be held by common consent of all the trustees.

Section 6. Papers intended for presentation at any meeting of the Society shall be passed upon in advance by a program committee appointed by or under the authority of the Council, and only such papers shall be presented as shall have been approved by such committee. Papers in form unsuitable for publication, if accepted for presentation, shall be referred to on the program as preliminary communications or reports.

Article XI

Publications

Section 1. The Society shall publish an official organ called the *Bulletin of the American Mathematical Society.* It shall publish four journals, known as the *Journal of the American Mathematical Society*, the *Transactions of the American Mathematical Society*, the *Proceedings of the American Mathematical Society*, and *Mathematics of Computation.* It shall publish a series of mathematical papers known as the *Memoirs of the American Mathematical Society.* The object of the *Journal, Transactions, Proceedings, Memoirs,* and *Mathematics of Computation* is to make known important mathematical researches. It shall publish a periodical called *Mathematical Reviews*, containing abstracts or reviews of current mathematical literature. It shall publish a series of volumes called *Colloquium Publications* which shall embody in book form new mathematical developments. It shall publish a series of monographs called *Mathematical Surveys and Monographs* which shall furnish expositions of the principal methods and results of particular fields of mathematical research. It shall publish a news periodical known as the *Notices of the American Mathematical Society*, containing programs of meetings, items of news of particular interest to mathematicians, and such other materials as the Council may direct.

Section 2. The editorial management of the publications of the Society listed in Section 1 of this article, with the exception of the *Notices*, shall be in the charge of the respective editorial committees as provided in Article III, Section 1. The editorial management of the *Notices* shall be in the hands of a committee chosen in a manner established by the Council.

Article XII

Indemnification

Any person who at any time serves or has served as a trustee or officer of the Society, or as a member of the Council, or, at the request of the Society, as a director or officer of another corporation, whether for profit or not for profit, shall be indemnified by the Society and be reimbursed against and for expenses actually and necessarily incurred in connection with the defense or reasonable settlement of any action, suit, legal or administrative proceeding, whether civil, criminal, administrative or investigative, threatened, pending or completed, to which that person is made a party by reason of being or having been such trustee, officer or director or Council member, except in relation to matters as to which the person shall be adjudged in such action, suit, or proceeding to be liable for negligence or misconduct in the performance of official duties. Such right of indemnification and reimbursement shall also extend to the personal representatives of any such person and shall be in addition to and not in substitution for any other rights to which such person or personal representatives may now or hereafter be entitled by virtue of the provisions of applicable law or of any other agreement or vote of the Board of Trustees, or otherwise.

Article XIII

Amendments

These bylaws may be amended or suspended on recommendation of the Council and with the approval of the membership of the Society, the approval consisting of an affirmative vote by two-thirds of the members present at a business meeting or of two-thirds of the members voting in a mail ballot in which at least ten percent of the members vote, whichever alternative shall have been designated by the Council, and provided notice of the proposed action and of its general nature shall have been given in the call for the meeting or accompanies the ballot in full.

As amended December 1998

AMS Lecturers, Officers, Prizes, and Funds

Colloquium Lecturers

James Pierpont, 1896
Maxime Bôcher, 1896
W. F. Osgood, 1898
A. G. Webster, 1898
Oskar Bolza, 1901
E. W. Brown, 1901
H. S. White, 1903
F. S. Woods, 1903
E. B. Van Vleck, 1903
E. H. Moore, 1906
E. J. Wilczynski, 1906
Max Mason, 1906
G. A. Bliss, 1909
Edward Kasner, 1909
L. E. Dickson, 1913
W. F. Osgood, 1913
G. C. Evans, 1916
Oswald Veblen, 1916
G. D. Birkhoff, 1920
F. R. Moulton, 1920
L. P. Eisenhart, 1925
Dunham Jackson, 1925
E. T. Bell, 1927
Anna Pell-Wheeler, 1927
A. B. Coble, 1928
R. L. Moore, 1929
Solomon Lefschetz, 1930
Marston Morse, 1931
J. F. Ritt, 1932
R. E. A. C. Paley, 1934
Norbert Wiener, 1934
H. S. Vandiver, 1935
E. W. Chittenden, 1936
John von Neumann, 1937
A. A. Albert, 1939
M. H. Stone, 1939
G. T. Whyburn, 1940
Oystein Ore, 1941
R. L. Wilder, 1942
E. J. McShane, 1943
Einar Hille, 1944
Tibor Radó, 1945
Hassler Whitney, 1946
Oscar Zariski, 1947
Richard Brauer, 1948
G. A. Hedlund, 1949
Deane Montgomery, 1951
Alfred Tarski, 1952
Antoni Zygmund, 1953
Nathan Jacobson, 1955
Salomon Bochner, 1956
N. E. Steenrod, 1957
J. L. Doob, 1959
S. S. Chern, 1960
G. W. Mackey, 1961
Saunders Mac Lane, 1963
C. B. Morrey Jr., 1964
A. P. Calderón, 1965
Samuel Eilenberg, 1967
D. C. Spencer, 1968
J. W. Milnor, 1968
Raoul H. Bott, 1969
Harish-Chandra, 1969
R. H. Bing, 1970
Lipman Bers, 1971
Armand Borel, 1971
Stephen Smale, 1972
John T. Tate, 1972
M. F. Atiyah, 1973
E. A. Bishop, 1973
F. E. Browder, 1973
Louis Nirenberg, 1974
John G. Thompson, 1974
H. Jerome Keisler, 1975
Ellis R. Kolchin, 1975
Elias M. Stein, 1975
I. M. Singer, 1976
Jürgen K. Moser, 1976
William Browder, 1977
Herbert Federer, 1977
Hyman Bass, 1978
Philip A. Griffiths, 1979
George D. Mostow, 1979
Julia B. Robinson, 1980
Wolfgang M. Schmidt, 1980
Mark Kac, 1981
Serge Lang, 1981
Dennis Sullivan, 1982
Morris W. Hirsch, 1982
Charles L. Fefferman, 1983
Bertram Kostant, 1983
Barry Mazur, 1984
Paul H. Rabinowitz, 1984
Daniel Gorenstein, 1985
Karen K. Uhlenbeck, 1985
Shing-Tung Yau, 1986
Peter D. Lax, 1987
Edward Witten, 1987
Victor W. Guillemin, 1988
Nicholas Katz, 1989
William P. Thurston, 1989
Shlomo Sternberg, 1990
Robert D. MacPherson, 1991
Robert P. Langlands, 1992
Luis A. Caffarelli, 1993
Sergiu Klainerman, 1993
Jean Bourgain, 1994
Clifford H. Taubes, 1995
Andrew J. Wiles, 1996
Daniel W. Stroock, 1997
Gian-Carlo Rota, 1998
Helmut H. Hofer, 1999
Curtis T. McMullen, 2000
Janos Kollar, 2001

Gibbs Lecturers

M. I. Pupin, 1923
Robert Henderson, 1924
James Pierpont, 1925
H. B. Williams, 1926
E. W. Brown, 1927
G. H. Hardy, 1928
Irving Fisher, 1929
E. B. Wilson, 1930
P. W. Bridgman, 1931
R. C. Tolman, 1932
Albert Einstein, 1934
Vannevar Bush, 1935
H. N. Russell, 1936
C. A. Kraus, 1937
Theodore von Kármán, 1939
Sewall Wright, 1941
Harry Bateman, 1943
John von Neumann, 1944
J. C. Slater, 1945
S. Chandrasekhar, 1946
P. M. Morse, 1947
Hermann Weyl, 1948
Norbert Wiener, 1949
G. E. Uhlenbeck, 1950
Kurt Gödel, 1951
Marston Morse, 1952
Wassily Leontief, 1953
K. O. Friedrichs, 1954
J. E. Mayer, 1955
M. H. Stone, 1956
H. J. Muller, 1958
J. M. Burgers, 1959
Julian Schwinger, 1960
J. J. Stoker, 1961
C. N. Yang, 1962
C. E. Shannon, 1963
Lars Onsager, 1964
D. H. Lehmer, 1965
Martin Schwarzschild, 1966
Mark Kac, 1967
E. P. Wigner, 1968
R. L. Wilder, 1969
W. H. Munk, 1970
E. F. F. Hopf, 1971
F. J. Dyson, 1972
J. K. Moser, 1973
Paul A. Samuelson, 1974
Fritz John, 1975
Arthur S. Wightman, 1976
Joseph B. Keller, 1977
Donald E. Knuth, 1978
Martin D. Kruskal, 1979
Kenneth G. Wilson, 1980
Cathleen Synge Morawetz, 1981
Elliott W. Montroll, 1982
Samuel Karlin, 1983
Herbert A. Simon, 1984
Michael O. Rabin, 1985
L. E. Scriven, 1986
Thomas C. Spencer, 1987
David P. Ruelle, 1988
Elliott H. Lieb, 1989
George B. Dantzig, 1990
Michael F. Atiyah, 1991
Michael E. Fisher, 1992
Charles S. Peskin, 1993

Robert M. May, 1994
Andrew J. Majda, 1995
Steven Weinberg, 1996
Persi Diaconis, 1997
Edward Witten, 1998
Nancy Kopell, 1999
Roger Penrose, 2000
Ronald L. Graham, 2001

Presidents

J. H. Van Amringe, 1889, 1890
J. E. McClintock, 1891–1894
G. W. Hill, 1895, 1896
Simon Newcomb, 1897, 1898
R. S. Woodward, 1899, 1900
E. H. Moore, 1901, 1902
T. S. Fiske, 1903, 1904
W. F. Osgood, 1905, 1906
H. S. White, 1907, 1908
Maxime Bôcher, 1909, 1910
H. B. Fine, 1911, 1912
E. B. Van Vleck, 1913, 1914
E. W. Brown, 1915, 1916
L. E. Dickson, 1917, 1918
Frank Morley, 1919, 1920
G. A. Bliss, 1921, 1922
Oswald Veblen, 1923, 1924
G. D. Birkhoff, 1925, 1926
Virgil Snyder, 1927, 1928
E. R. Hedrick, 1929, 1930
L. P. Eisenhart, 1931, 1932
A. B. Coble, 1933, 1934
Solomon Lefschetz, 1935, 1936
R. L. Moore, 1937, 1938
G. C. Evans, 1939, 1940
Marston Morse, 1941, 1942
M. H. Stone, 1943, 1944
T. H. Hildebrandt, 1945, 1946
Einar Hille, 1947, 1948
J. L. Walsh, 1949, 1950
John von Neumann, 1951, 1952
G. T. Whyburn, 1953, 1954
R. L. Wilder, 1955, 1956
Richard Brauer, 1957, 1958
E. J. McShane, 1959, 1960
Deane Montgomery, 1961, 1962
J. L. Doob, 1963, 1964
A. A. Albert, 1965, 1966
C. B. Morrey, Jr., 1967, 1968
Oscar Zariski, 1969, 1970
Nathan Jacobson, 1971, 1972
Saunders Mac Lane, 1973, 1974
Lipman Bers, 1975, 1976
R. H. Bing, 1977, 1978
Peter D. Lax, 1979, 1980
Andrew M. Gleason, 1981, 1982
Julia B. Robinson, 1983, 1984
Irving Kaplansky, 1985, 1986
George Daniel Mostow, 1987, 1988
William Browder, 1989, 1990
Michael Artin, 1991, 1992
Ronald L. Graham, 1993, 1994
Cathleen Synge Morawetz, 1995, 1996
Arthur M. Jaffe, 1997, 1998
Felix E. Browder, 1999, 2000
Hyman Bass, 2001, 2002

Secretaries

T. S. Fiske, 1888–1895
F. N. Cole, 1896–1920
R. G. D. Richardson, 1921–1940
J. R. Kline, 1941–1950
E. G. Begle, 1951–1956
J. W. Green, 1957–1966
Everett Pitcher, 1967–1988
Robert M. Fossum, 1989–1998
Robert J. Daverman, 1999–

Treasurers

T. S. Fiske, 1890, 1891
Harold Jacoby, 1892–1894
R. S. Woodward, 1895, 1896
Harold Jacoby, 1897–1899
W. S. Dennett, 1900–1907
J. H. Tanner, 1908–1920
W. B. Fite, 1921–1929
G. W. Mullins, 1930–1936
P. A. Smith, 1937
B. P. Gill, 1938–1948
A. E. Meder, Jr., 1949–1964
W. T. Martin, 1965–1973
Franklin P. Peterson, 1973–1998
John M. Franks, 1999–

Prizes

The George David Birkhoff Prize in Applied Mathematics

This prize was established in 1967 in honor of Professor George David Birkhoff. The initial endowment of $2,066 was contributed by the Birkhoff family and there have been subsequent additions by others. It is awarded for an outstanding contribution to "applied mathematics in the highest and broadest sense." From 1968-1998, the prize was normally awarded every five years. Beginning in 2003, the prize will be awarded every three years. The award is made jointly by the American Mathematical Society and the Society for Industrial and Applied Mathematics. The recipient must be a member of one of these societies and a resident of the United States, Canada, or Mexico.

First award, 1968: To Jürgen K. Moser for his contributions to the theory of Hamiltonian dynamical systems, especially his proof of the stability of periodic solutions of Hamiltonian systems having two degrees of freedom and his specific applications of the ideas in connection with this work.

Second award, 1973: To Fritz John for his outstanding work in partial differential equations, in numerical analysis, and, particularly, in nonlinear elasticity theory; the latter work has led to his study of quasi-isometric mappings as well as functions of bounded mean oscillation, which have had impact in other areas of analysis.

Third award, 1973: To James B. Serrin for his fundamental contributions to the theory of nonlinear partial differential equations, especially his work on existence and regularity theory for nonlinear elliptic equations, and applications of his work to the theory of minimal surfaces in higher dimensions.

Fourth award, 1978: To Garrett Birkhoff for bringing the methods of algebra and the highest standards of mathematics to scientific applications.

Fifth award, 1978: To Mark Kac for his important contributions to statistical mechanics and to probability theory and its applications.

Sixth award, 1978: To Clifford A. Truesdell for his outstanding contributions to our understanding of the subjects of rational mechanics and nonlinear materials, for his efforts to give precise mathematical formulation to these classical subjects, for his many contributions to applied mathematics in the fields of acoustic theory, kinetic theory, and nonlinear elastic theory, and the thermodynamics of mixtures, and for his major work in the history of mechanics.

Seventh award, 1983: To Paul R. Garabedian for his important contributions to partial differential equations, to the mathematical analysis of problems of transonic flow and airfoil design by the method of complexification, and to the development and application of scientific computing to problems of fluid dynamics and plasma physics.

Eighth award, 1988: To Elliott H. Lieb for his profound analysis of problems arising in mathematical physics.

Ninth award, 1994: To Ivo Babuška for important contributions to the reliability of finite element methods, the development of a general framework for finite element error estimation, and the development of p and $h-p$ finite element methods; and to S. R. S. Varadhan for important contributions to the martingale characterization of diffusion processes, to the theory of large deviations for functionals of occupation times of Markov processes, and to the study of random media.

Tenth award, 1998: To Paul H. Rabinowitz for his deep influence on the field of nonlinear analysis.

The Bôcher Memorial Prize

This prize was founded in memory of Professor Maxime Bôcher with an original endowment of $1,450. It is awarded for a notable research memoir in analysis that has appeared during the past five years in a recognized North American journal. This provision, introduced in 1971 and modified in 1993, is a liberalization of the terms of the award. From 1923-1999, the prize was usually awarded every five years. Beginning in 2002, it will be awarded every three years.

First (preliminary) award, 1923: To G. D. Birkhoff for his memoir, *Dynamical systems with two degrees of freedom.* Transactions of the American Mathematical Society, volume 18 (1917), pp. 199–300.

Second award, 1924: To E. T. Bell for his memoir, *Arithmetical paraphrases.* I, II, Transactions of the American Mathematical Society, volume 22 (1921), pp. 1–30, 198–219; and to Solomon Lefschetz for his memoir, *On certain numerical invariants with applications to Abelian varieties,* Transactions of the American Mathematical Society, volume 22 (1921), pp. 407–482.

Third award, 1928: To J. W. Alexander for his memoir, *Combinatorial analysis situs,* Transactions of the American Mathematical Society, volume 28 (1926), pp. 301–329.

Fourth award, 1933: To Marston Morse for his memoir, *The foundations of a theory of the calculus of variations in the large in m-space,* Transactions of the American Mathematical Society, volume 31 (1929), pp. 379–404; and to Norbert Wiener for his memoir, *Tauberian theorems,* Annals of Mathematics, Series 2, volume 33 (1932), pp. 1–100.

Fifth award, 1938: To John von Neumann for his memoir, *Almost periodic functions and groups.* I, II, Transactions of the American Mathematical Society, volume 36 (1934), pp. 445–492, and volume 37 (1935), pp. 21–50.

Sixth award, 1943: To Jesse Douglas for his memoirs, *Green's function and the problem of Plateau,* American Journal of Mathematics, volume 61 (1939), pp. 545–589; *The most general form of the problem of Plateau,* American Journal of Mathematics, volume 61(1939), pp. 590–608; and *Solution of the inverse problem of the calculus of variations,* Proceedings of the National Academy of Sciences, volume 25 (1939), pp. 631–637.

Seventh award, 1948: To A. C. Schaeffer and D. C. Spencer for their memoir, *Coefficients of schlicht functions.* I, II, III, IV, Duke Mathematical Journal, volume 10 (1943), pp. 611–635, volume 12 (1945), pp. 107–125, and the Proceedings of the National Academy of Sciences, volume 32 (1946), pp. 111–116, volume 35 (1949), pp. 143–150.

Eighth award, 1953: To Norman Levinson for his contributions to the theory of linear, nonlinear, ordinary, and partial differential equations contained in his papers of recent years.

Ninth award, 1959: To Louis Nirenberg for his work in partial differential equations.

Tenth award, 1964: To Paul J. Cohen for his paper, *On a conjecture of Littlewood and idempotent measures,* American Journal of Mathematics, volume 82 (1960), pp. 191–212.

Eleventh award, 1969: To I. M. Singer in recognition of his work on the index problem, especially his share in two joint papers with Michael F. Atiyah, *The index of elliptic operators.* I, III, Annals of Mathematics, Series 2, volume 87 (1968), pp. 484–530, 546–604.

Twelfth award, 1974: To Donald S. Ornstein in recognition of his paper, *Bernoulli shifts with the same entropy are isomorphic,* Advances in Mathematics, volume 4 (1970), pp. 337–352.

Thirteenth award, 1979: To Alberto P. Calderon in recognition of his fundamental work on the theory of singular integrals and partial differential equations, and in particular for his paper *Cauchy integrals on Lipschitz curves and related operators,* Proceedings of the National Academy of Sciences, USA, volume 74 (1977), pp. 1324–1327.

Fourteenth award, 1984: To Luis A. Caffarelli for his deep and fundamental work in nonlinear partial differential equations, in particular his work on free boundary problems, vortex theory and regularity theory.

Fifteenth award, 1984: To Richard B. Melrose for his solution of several outstanding problems in diffraction theory and scattering theory and for developing the analytical tools needed for their resolution.

Sixteenth award, 1989: To Richard M. Schoen for his work on the application of partial differential equations to differential geometry, in particular his completion of the solution to the Yamabe Problem in *Conformal deformation of a Riemannian metric to constant scalar curvature,* Journal of Differential Geometry, volume 20 (1984), pp. 479–495.

Seventeenth award, 1994: To Leon Simon for his profound contributions toward understanding the structure of singular sets for solutions of variational problems.

Eighteenth award, 1999: To Demetrios Christodoulou for his contributions to the mathematical theory of general relativity, and to Sergiu Klainerman for his contributions to nonlinear hyperbolic equations, and to Thomas Wolff for his work in harmonic analysis.

The Frank Nelson Cole Prize in Algebra
The Frank Nelson Cole Prize in Number Theory

These prizes were founded in honor of Professor Frank Nelson Cole on the occasion of his retirement as secretary of the American Mathematical Society after twenty-five years of service and as editor-in-chief of the *Bulletin* for twenty-one years. The original fund was donated by Professor Cole from moneys presented to him on his retirement, was augmented by contributions from members of the Society, and was later doubled by his son, Charles A. Cole. The present endowment is $2,250. From 1928-2000, the prizes were awarded at two different five-year intervals for contributions to algebra and the theory of numbers, respectively, under restrictions similar to the Bôcher Prize. Beginning in 2002 (number theory) and 2003 (algebra), the prizes will be awarded at three-year intervals.

First award, 1928: To L. E. Dickson for his book *Algebren und ihre Zahlentheorie*, Orell Füssli, Zürich and Leipzig, 1927.

Second award, 1931: To H. S. Vandiver for his several papers on Fermat's last theorem published in the Transactions of the American Mathematical Society and in the Annals of Mathematics during the preceding five years, with special reference to a paper entitled *On Fermat's last theorem*, Transactions of the American Mathematical Society, volume 31 (1929), pp. 613–642.

Third award, 1939: To A. Adrian Albert for his papers on the construction of Riemann matrices published in the Annals of Mathematics, Series 2, volume 35 (1934) and volume 36 (1935).

Fourth award, 1941: To Claude Chevalley for his paper, *La théorie du corps de classes*, Annals of Mathematics, Series 2, volume 41 (1940), pp. 394–418.

Fifth award, 1944: To Oscar Zariski for four papers on algebraic varieties published in the American Journal of Mathematics, volumes 61 (1939) and 62 (1940), and in the Annals of Mathematics, Series 2, volumes 40 (1939) and 41 (1940).

Sixth award, 1946: To H. B. Mann for his paper, *A proof of the fundamental theorem on the density of sums of sets of positive integers*, Annals of Mathematics, Series 2, volume 43 (1942), pp. 523–527.

Seventh award, 1949: To Richard Brauer for his paper, *On Artin's L-series with general group characters*, Annals of Mathematics, Series 2, volume 48 (1947), pp. 502–514.

Eighth award, 1951: To Paul Erdös for his many papers in the theory of numbers, and in particular for his paper, *On a new method in elementary number theory which leads to an elementary proof of the prime number theorem*, Proceedings of the National Academy of Sciences, volume 35 (1949), pp. 374–385.

Ninth award, 1954: To Harish-Chandra for his papers on representations of semisimple Lie algebras and groups, and particularly for his paper, *On some applications of the universal enveloping algebra of a semisimple Lie algebra*, Transactions of the American Mathematical Society, volume 70 (1951), pp. 28–96.

Tenth award, 1956: To John T. Tate for his paper, *The higher dimensional cohomology groups of class field theory*, Annals of Mathematics, Series 2, volume 56 (1952), pp. 294–297.

Eleventh award, 1960: To Serge Lang for his paper, *Unramified class field theory over function fields in several variables*, Annals of Mathematics, Series 2, volume 64 (1956), pp. 285–325; and to Maxwell A. Rosenlicht for his papers, *Generalized Jacobian varieties*, Annals of Mathematics, Series 2, volume 59 (1954), pp. 505–530, and *A universal mapping property of generalized Jacobians*, Annals of Mathematics, Series 2, volume 66 (1957), pp. 80–88.

Twelfth award, 1962: To Kenkichi Iwasawa for his paper, *Gamma extensions of number fields*, Bulletin of the American Mathematical Society, volume 65 (1959), pp. 183–226; and to Bernard M. Dwork for his paper, *On the rationality of the zeta function of an algebraic variety*, American Journal of Mathematics, volume 82 (1960), pp. 631–648.

Thirteenth award, 1965: To Walter Feit and John G. Thompson for their joint paper, *Solvability of groups of odd order*, Pacific Journal of Mathematics, volume 13 (1963), pp. 775–1029.

Fourteenth award, 1967: To James B. Ax and Simon B. Kochen for a series of three joint papers, *Diophantine problems over local fields*. I, II, III, American Journal of Mathematics, volume 87 (1965), pp. 605–630, 631–648, and Annals of Mathematics, Series 2, volume 83 (1966), pp. 437–456.

Fifteenth award, 1970: To John R. Stallings for his paper, *On torsion-free groups with infinitely many ends*, Annals of Mathematics, Series 2, volume 88 (1968), pp. 312–334; and to Richard G. Swan for his paper, *Groups of cohomological dimension one*, Journal of Algebra, volume 12 (1969), pp. 585–610.

Sixteenth award, 1972: To Wolfgang M. Schmidt for the following papers: *On simultaneous approximation of two algebraic numbers by rationals*, Acta Mathematica (Uppsala), volume 119 (1967), pp. 27–50; *T-numbers do exist*, Symposia Mathematica, volume IV, Academic Press, 1970, pp. 1–26; *Simultaneous approximation to algebraic numbers by rationals*, Acta Mathematica (Uppsala), volume 125 (1970), pp. 189–201; *On Mahler's T-numbers*, Proceedings of Symposia in Pure Mathematics, volume 20, American Mathematical Society, 1971, pp. 275–286.

Seventeenth award, 1975: To Hyman Bass for his paper, *Unitary algebraic K-theory*, Springer Lecture Notes in Mathematics, volume 343, 1973; and to Daniel G. Quillen for his paper, *Higher algebraic K-theories*, Springer Lecture Notes in Mathematics, volume 341, 1973.

Eighteenth award, 1977: To Goro Shimura for his two papers, *Class fields over real quadratic fields and Heche operators*, Annals of Mathematics, Series 2, volume 95 (1972), pp. 130–190; and *On modular forms of half integral weight*, Annals of Mathematics, Series 2, volume 97 (1973), pp. 440–481.

Nineteenth award, 1980: To Michael Aschbacher for his paper, *A characterization of Chevalley groups over fields of odd order*, Annals of Mathematics, Series 2, volume 106 (1977), pp. 353–398; and to Melvin Hochster for his paper *Topics in the homological theory of commutative rings*, CBMS Regional Conference Series in Mathematics, Number 24, American Mathematical Society, 1975.

Twentieth award, 1982: To Robert P. Langlands for pioneering work on automorphic forms, Eisenstein series and product formulas, particularly for his paper *Base change for GL*(2), Annals of Mathematics Studies, volume 96, Princeton University Press, 1980; and to Barry Mazur for outstanding work on elliptic curves and Abelian varieties, especially on rational points of finite order, and his paper *Modular curves and the Eisenstein ideal*, Publications Mathematiques de l'Institut des Hautes Etudes Scientifiques, volume 47 (1977), pp. 33–186.

Twenty-First award, 1985: To George Lusztig for his fundamental work on the representation theory of finite groups of Lie type. In particular for his contributions to the classification of the irreducible representations in characteristic zero of the groups of rational points of reductive groups over finite fields, appearing in *Characters of reductive groups over finite fields*, Annals of Mathematics Studies, volume 107, Princeton University Press, 1984.

Twenty-Second award, 1987: To Dorian M. Goldfeld for his paper, *Gauss's class number problem for imaginary quadratic fields*, Bulletin of the American Mathematical Society, volume 13, (1985), pp. 23-37; and to Benedict H. Gross and Don B. Zagier for their paper, *Heegner points and derivatives of L-Series*, Inventiones Mathematicae, volume 84 (1986), pp. 225-320.

Twenty-Third award, 1990: To Shigefumi Mori for his outstanding work on the classification of algebraic varieties and, in particular, for his paper *Flip theorem and the existence of minimal models for 3-folds*, Journal of the American Mathematical Society, volume 1 (1988), pp. 117-253.

Twenty-Fourth award, 1992: To Karl Rubin for his work in the area of elliptic curves and Iwasawa Theory with particular reference to his papers *Tate-Shafarevich groups and L-functions of elliptic curves with complex multiplication* and *The "main conjectures" of Iwasawa theory for imaginary quadratic fields* and to Paul Vojta for his work on Diophantine problems with particular reference to his paper *Siegel's theorem in the compact case*.

Twenty-Fifth award, 1995: To Michel Raynaud and David Harbater for their solution of Abhyankar's conjecture. This work appeared in the papers *Revêtements de la droite affine en caractéristique* $p > 0$, Invent. Math. **116** (1994) 425-462 (Raynaud), and *Abhyankar's conjecture on Galois groups over curves*, Invent. Math. **117** (1994) 1-25 (Harbater).

Twenty-Sixth award, 1997: To Andrew J. Wiles for his work on the Shimura-Taniyama conjecture and Fermat's Last Theorem, published in *Modular elliptic curves and Fermat's Last Theorem*, Ann. of Math. **141** (1995), 443-551.

Twenty-Seventh award, 2000: To Andrei Suslin for his work on motivic cohomology, and to Aise Johan de Jong for his important work on the resolution of singularities by generically finite maps.

The Levi L. Conant Prize

This prize was established in 2000 in honor of Levi L. Conant to recognize the best expository paper published in either the *Notices of the AMS* or the *Bulletin of the AMS* in the preceding five years. The $1,000 prize is awarded annually.

First award, 2001: To Carl Pomerance for his paper,"A Tale of Two Sieves," *Notices of the AMS* **43**, no. 12 (1996), 1473-1485.

The Delbert Ray Fulkerson Prize

Gifts of friends of the late Professor Fulkerson have provided a fund in excess of $7,000. Part or all of the proceeds is to be used jointly by the Mathematical Programming Society and the American Mathematical Society for the award of one or more prizes in discrete mathematics at regular intervals.

First award, 1979: To Richard M. Karp, for *On the computational complexity of combinatorial problems*, Networks, volume 5 (1975), pp. 45-68; to Kenneth Appel and Wolfgang Haken, for *Every planar map is four colorable*, Part I: *Discharging*, Illinois Journal of Mathematics, volume 21 (1977), pp. 429-490; and to Paul D. Seymour, for *The matroids with the max-flow min-cut property*, Journal of Combinatorial Theory, Series B, volume 23 (1977), pp. 189-222.

Second award, 1982: To D. B. Judin and A. S. Nemirovskii, for *Informational complexity and effective methods of solution for convex extremal problems*, Ekonomika i Matematicheskie Metody 12 (1976), 357-369, and to L. G. Khachiyan for *A polynomial algorithm in linear programming*, Akademiia Nauk SSSR. Doklady 244 (1979), 1093-1096; to G. P. Egorychev, for *The solution of van der Waerden's problem for permanents*, Akademiia Nauk SSSR. Doklady 258 (1981), 1041-1044, and D. I. Falikman, for *A proof of the van der Waerden conjecture on the permanent of a doubly stochastic matrix*, Matematicheskie Zametki 29 (1981), 931-938; and to M. Grötschel, L. Lovasz, and A. Schrijver, for *The ellipsoid method and its consequences in combinatorial optimization*, Combinatorica 1 (1981), 169-197.

Third award, 1985: To Jozsef Beck, for *Roth's estimate of the discrepancy of integer sequences is nearly sharp*, Combinatorica 1 (4),319-325, (1981); and H. W. Lenstra Jr., for *Integer programming with a fixed number of variables*, Mathematics of Operations Research 8 (4), 538-548, (1983); and Eugene M. Luks for *Isomorphism of graphs of bounded valence can be tested in polynomial time*, Journal of Computer and System Sciences 25 (1), 42-65, (1982).

Fourth award, 1988: To Éva Tardos for *A strongly polynomial minimum cost circulation algorithm*, Combinatorica, volume 5 (1985), pp. 247-256; and to Narendra Karmarkar for *A new polynomial-time algorithm for linear programming*, Combinatorica, volume 4 (1984), pp. 373-395.

Fifth award, 1991: To Martin Dyer, Alan Frieze, and Ravi Kannan for *A random polynomial time algorithm for approximating the volume of convex bodies*, Journal of the Association for Computing Machinery, volume 38/1 (1991) pp. 1-17; to Alfred Lehman for *The width-length inequality and degenerate projective planes*, W. Cook and P. D. Seymour (eds.), Polyhedral Combinatorics, DIMACS Series in Discrete Mathematics and Theoretical Computer Science, volume 1, (American Mathematical Society, 1990) pp. 101-105; and to Nikolai E. Mnev for *The universality theorems on the classification problem of configuration varieties and convex polytope varieties*, O. Ya. Viro (ed.), Topology and Geometry-Rohlin Seminar, Lecture Notes in Mathematics 1346 (Springer-Verlag, Berlin, 1988) pp. 527-544.

Sixth Award, 1994: To Lou Billera for *Homology of smooth splines: Generictriangulations and a conjecture of Strang*, Transactions of the AMS, volume 310 (1988) pp. 325-340; to Gil Kalai for *Upper bounds for the diameter and height of graphs of the convex polyhedra*, Discrete and Computational Geometry, volume 8 (1992) pp. 363-372; and to Neil Robertson, Paul D. Seymour, and Robin Thomas for *Hadwiger's conjecture for K_6 free graphs*, Combinatorica, volume 13 (1993) pp. 279-361.

Seventh award, 1997: To Jeong Han Kim for "The Ramsey Number $R(3,t)$ Has Order of Magnitude $\frac{t^2}{\log t}$" which appeared in *Random Structures and Algorithms*, volume 7, issue 3, 1995, pages 173–207.

Eighth award, 2000: To Michel X. Goemans and David P. Williamson for "Improved approximation algorithms for the maximum cut and satisfiability problems using semidefinite programming", *Journal of the Association for Computing Machinery*, **42** (1995), no. 6, pages 1115–1145; and to Michele Conforti, Gerard Cornuejols, and M. R. Rao for "Decomposition of balanced matrices", *Journal of Combinatorial Theory, Series B*, **77** (1999), no. 2, pages 292-406.

The Frank and Brennie Morgan Prize for Outstanding Research in Mathematics by an Undergraduate Student

This prize, which was established in 1995, is to be awarded to an undergraduate student (or students having submitted joint work) for outstanding research in mathematics: it is entirely endowed by a gift of approximately $25,000 from Mrs. Frank (Brennie) Morgan. Any student who is an undergraduate in a college or university in Canada, Mexico, or the United States or its possessions is eligible to be considered for this prize. No more than one prize shall be awarded each year and a few honorable mentions may be made. The award is made jointly by the American Mathematical Society, the Mathematical Association of America, and the Society for Industrial and Applied Mathematics.

First award, 1995: Kannan Soundararajan for truly exceptional research in analytic number theory. Honorable mention: Kiran Kedlaya.

Second award, 1996: Manjul Bhargava for truly outstanding mathematical research in algebra. Honorable mention: Lenhard L. Ng.

Third award, 1997: Jade Vinson for wide-ranging research in analysis and geometry. Honorable mention: Vikaas Sohal.

Fourth award, 1998: Daniel Biss for his remarkable breadth, as well as depth. The most exciting aspect of his submission was his extension of a category which more closely binds the associations between combinatorial group theory and combinatorial topology. Honorable mention: Aaron E. Archer.

Fifth award, 1999: Sean McLaughlin for his proof of the "Dodecahedral Conjecture", a major problem in discrete geometry related to, but distinct from, Kepler's sphere-packing problem and a conjecture that has resisted the efforts of the strongest workers in this area for nearly sixty years. Honorable mention: Samit Dasgupta.

Sixth award, 2000: Jacob Lurie for his paper "On simply laced Lie algebras and their miniscule representations". Honorable mention: Wai Ling Yee.

The Award for Distinguished Public Service

To provide encouragement and recognition to those individuals who contribute their time to public service activities in support of mathematics, the Council of the Society established the Award for Distinguished Public Service. The award was established in response to a recommendation by the Society's Committee on Science Policy. The award is presented every two years to a research mathematician who has made a distinguished contribution to the mathematics profession during the preceding five years.

First award, 1990: Kenneth M. Hoffman for his outstanding leadership in establishing channels of communication between the mathematical community and makers of public policy as well as the general public.

Second award, 1992: Harvey B. Keynes for his multifaceted efforts to revitalize mathematics education, especially for young people.

Third award, 1993: Isadore M. Singer in recognition of his outstanding contributions to his profession, to science more broadly, and to the public good by bringing the best of mathematics and his own insights to bear on the activities of the National Academy of Sciences; on committees of the National Research Council, including the two so-called David Committees on the health of the mathematical sciences, and the Committee on Science, Engineering, and Public Policy; on the President's Science Advisory Council; on decisions of Congress, through testimony concerning the support of mathematics and mathematical research; and on a host of critical situations over many years in which his wisdom and intervention helped gain a hearing for the problems of his community and the contributions it makes to the nation.

Fourth award, 1995: Donald J. Lewis for his many contributions to mathematical education, mathematics policy, and mathematical research and administration during a career that has spanned several decades.

Fifth award, 1997: No award made.

Sixth award, 1998: Kenneth C. Millett for his work devoted to underrepresented minority students in the mathematical sciences. Professor Millett founded the University of California, Santa Barbara, Achievement Program and directed the mathematics component of the Summer Academic Research Internship and the Summer Institute in Mathematics at UCSB.

Seventh award, 2000: Paul J. Sally Jr. for the quality of his research, for his service to the (American Mathematical) Society as Trustee, but more importantly for his many efforts in improvement of mathematics education for the nation's youth and especially for members of minority and underrepresented groups and for his longitudinal mentoring of students, in particular the mathematics majors at Chicago.

The Citation for Public Service

To provide encouragement and recognition for contributions to public service activities in support of mathematics, the Council of the Society established the Citation for Public Service. The award is no longer being made.

First award, 1991: Andre Z. Manitius for the contributions he made to the mathematical community while employed in the Division of Mathematical Sciences at the National Science Foundation.

Second award, 1992: Marcia P. Sward for her contributions toward establishing and directing the Mathematical Sciences Education Board from its inception in the fall of 1985 until August 1989.

Third award, 1998: Liang-Shin Hahn and Arnold E. Ross. Liang-Shin Hahn for carrying forward and developing the New Mexico High School Mathematics Contest and for exposition and popularization of mathematics attractive to and suitable for potential candidates for the contest and others with similar intellectual interests. Arnold E. Ross for inspiring generations of young people through the mathematics programs he created and has continued to run for nearly forty years.

The Ruth Lyttle Satter Prize in Mathematics

The prize was established in 1990 using funds donated by Joan S. Birman in memory of her sister, Ruth Lyttle Satter. Professor Birman requested that the prize be established to honor her sister's commitment to research and to encouraging women in science. The prizes are awarded every two years to recognize an outstanding contribution to mathematics research by a woman in the previous five years.

First award, 1991: To Dusa McDuff for her outstanding work during the past five years on symplectic geometry.

Second award, 1993: To Lai-Sang Young for her leading role in the investigation of the statistical (or ergodic) properties of dynamical systems.

Third award, 1995: To Sun-Yung Alice Chang for her deep contributions to the study of partial differential equations on Riemannian manifolds and in particular for her work on extremal problems in spectral geometry and the compactness of isospectral metrics within a fixed conformal class on a compact 3-manifold.

Fourth award, 1997: To Ingrid Daubechies for her deep and beautiful analysis of wavelets and their applications.

Fifth award, 1999: To Bernadette Perrin-Riou for her number theoretical research on p-adic L-functions and Iwasawa Theory.

Sixth award, 2001: To Karen E. Smith for her outstanding work in commutative algebra, and to Sijue Wu for her work on a long-standing problem in the water wave equation.

The Leroy P. Steele Prizes

These prizes were established in 1970 in honor of George David Birkhoff, William Fogg Osgood, and William Caspar Graustein, and are endowed under the terms of a bequest amounting to $145,000 from Leroy P. Steele. From 1970 to 1976 one or more prizes were awarded each year for outstanding published mathematical research; most favorable consideration was given to papers distinguished for their exposition and covering broad areas of mathematics. In 1977 the Council of the AMS modified the terms under which the prizes are awarded. Since then, up to three prizes have been awarded each year in the following categories: (1) for the cumulative influence of the total mathematical work of the recipient, high level of research over a period of time, particular influence on the development of a field, and influence on mathematics through Ph.D. students; (2) for a book or substantial survey or expository-research paper; (3) for a paper, whether recent or not, that has proved to be of fundamental or lasting importance in its field, or a model of important research. In 1993, the Council formalized the three categories of the prize by naming each of them: (1) The Leroy P. Steele Prize for Lifetime Achievement; (2) The Leroy P. Steele Prize for Mathematical Exposition; and (3) The Leroy P. Steele Prize for Seminal Contribution to Research.

August 1970: To Solomon Lefschetz for his paper, *A page of mathematical autobiography*, Bulletin of the American Mathematical Society,volume 74 (1968), pp. 854–879.

August 1971: To James B. Carrell for his paper, written jointly with Jean A. Dieudonne, *Invariant theory, old and new*, Advances in Mathematics, volume 4 (1970), pp. 1–80.

August 1971: To Jean A. Dieudonné for his paper, *Algebraic geometry*, Advances in Mathematics, volume 3 (1969), pp. 223–321, and for his paper, written jointly with James B. Carrell, *Invariant theory, old and new*, Advances in Mathematics, volume 4 (1970), pp. 1–80.

August 1971: To Phillip A. Griffiths for his paper, *Periods of integrals on algebraic manifolds*, Bulletin of the American Mathematical Society, volume 76 (1970), pp. 228–296.

August 1972: To Edward B. Curtis for his paper, *Simplicial homotopy theory*, Advances in Mathematics, volume 6 (1971), pp. 107–209.

August 1972: To William J. Ellison for his paper, *Waring's problem*, American Mathematical Monthly, volume 78 (1971), pp. 10–36.

August 1972: To Lawrence F. Payne for his paper, *Isoperimetric inequalities and their applications*, SIAM Review, volume 9 (1967), pp. 453–488.

August 1972: To Dana S. Scott for his paper, *A proof of the independence of the continuum hypothesis*, Mathematical Systems Theory, volume 1 (1967), pp. 89–111.

January 1975: To Lipman Bers for his paper, *Uniformization, moduli, and Kleinian groups*, Bulletin of the London Mathematical Society, volume 4 (1972), pp. 257–300.

January 1975: To Martin D. Davis for his paper, *Hilbert's tenth problem is unsolvable*, American Mathematical Monthly, volume 80 (1973), pp. 233–269.

January 1975: To Joseph L. Taylor for his paper, *Measure algebras*, CBMS Regional Conference Series in Mathematics, Number 16, American Mathematical Society, 1972.

August 1975: To George W. Mackey for his paper, *Ergodic theory and its significance for statistical mechanics and probability theory*, Advances in Mathematics, volume 12 (1974), pp. 178–286.

August 1975: To H. Blaine Lawson for his paper, *Foliations*, Bulletin of the American Mathematical Society, volume 80 (1974), pp. 369–418.

1976, 1977, 1978: No awards were made.

January 1979: To Salomon Bochner for his cumulative influence on the fields of probability theory, Fourier analysis, several complex variables, and differential geometry.

January 1979: To Hans Lewy for three fundamental papers: *On the local character of the solutions of an atypical linear differential equation in three variables and a related theorem for regular functions of two complex variables*, Annals of Mathematics, Series 2, volume 64 (1956), pp. 514–522; *An example of a smooth linear partial differential equation without solution*, Annals of Mathematics, Series 2, volume 66 (1957), pp. 155–158; *On hulls of holomorphy*, Communications in Pure and Applied Mathematics, volume 13 (1960), pp. 587–591.

August 1979: To Antoni Zygmund for his cumulative influence on the theory of Fourier series, real variables, and related areas of analysis.

August 1979: To Robin Hartshorne for his expository research article *Equivalence relations on algebraic cycles and subvarieties of small codimension*, Proceedings of Symposia in Pure Mathematics, volume 29, American Mathematical Society, 1975, pp. 129–164; and his book *Algebraic geometry*, Springer-Verlag, Berlin and New York, 1977.

August 1979: To Joseph J. Kohn for his fundamental paper *Harmonic integrals on strongly convex domains*. I, II, Annals of Mathematics, Series 2, volume 78 (1963), pp. 112–248 and volume 79 (1964), pp. 450–472.

August 1980: To André Weil for the total effect of his work on the general course of twentieth century mathematics, especially in the many areas in which he has made fundamental contributions.

August 1980: To Harold M. Edwards for mathematical exposition in his books *Riemann's zeta function*, Pure and Applied Mathematics, number 58, Academic Press, New York and London, 1974; and *Fermat's last theorem*, Graduate Texts in Mathematics, number 50, Springer-Verlag, New York and Berlin, 1977.

August 1980: To Gerhard P. Hochschild for his significant work in homological algebra and its applications.

August 1981: To Oscar Zariski for his work in algebraic geometry, especially his fundamental contributions to the algebraic foundations of this subject.

August 1981: To Eberhard Hopf for three papers of fundamental and lasting importance: *Abzweigung einer periodischen Lösung von einer stationären Lösung eines Differential systems*, Berichte über die Verhandlungen der Sächsischen Akademie der Wissenschaften zu Leipzig. Mathematisch-Naturwissenschaftliche Klasse, volume 95 (1943), pp. 3–22; *A mathematical example displaying features of turbulence*, Communications on Applied Mathematics, volume 1 (1948), pp. 303–322; and *The partial differential equation* $u_t + uu_x = \mu u_{xx}$, Communications on Pure and Applied Mathematics, volume 3 (1950), pp. 201–230.

August 1981: To Nelson Dunford and Jacob T. Schwartz for their expository book, *Linear operators*, Part I, *General theory*, 1958; Part II, *Spectral theory*, 1963; Part III, *Spectral operators*, 1971, Interscience Publishers, New York.

August 1982: To Lars V. Ahlfors for his expository work in *Complex analysis* (McGraw-Hill Book Company, New York, 1953), and in *Lectures on quasiconformal mappings* (D. Van Nostrand Co., Inc., New York, 1966) and *Conformal invariants* (McGraw-Hill Book Company, New York, 1973).

August 1982: To Tsit-Yuen Lam for his expository work in his book *Algebraic theory of quadratic forms* (1973), and four of his papers: *K_0 and K_1-an introduction to algebraic K-theory* (1975), *Ten lectures on quadratic forms over fields* (1977), *Serre's conjecture* (1978), and *The theory of ordered fields* (1980).

August 1982: To John W. Milnor for a paper of fundamental and lasting importance, *On manifolds homeomorphic to the 7-sphere*, Annals of Mathematics (2) 64 (1956), pp. 399–405.

August 1982: To Fritz John for the cumulative influence of his total mathematical work, high level of research over a period of time, particular influence on the development of a field, and influence on mathematics through Ph.D. students.

August 1983: To Paul R. Halmos for his many graduate texts in mathematics and for his articles on how to write, talk, and publish mathematics.

August 1983: To Steven C. Kleene for three important papers which formed the basis for later developments in generalized recursion theory and descriptive set theory: *Arithmetical predicates and function quantifiers*, Transactions of the American Mathematical Society 79 (1955), pp. 312–340; *On the forms of the predicates in the theory of constructive ordinals (second paper)*, American Journal of Mathematics 77 (1955), pp. 405–428; and *Hierarchies of number-theoretic predicates*, Bulletin of the American Mathematical Society 61 (1955), pp. 193–213.

August 1983: To Shiing-Shen Chern for the cumulative influence of his total mathematical work, high level of research over a period of time, particular influence on the development of the field of differential geometry, and influence on mathematics through Ph.D. students.

August 1984: To Elias M. Stein for his book, *Singular integrals and the differentiability properties of functions*, Princeton University Press (1970).

August 1984: To Lennart Carleson for his papers: *An interpolation problem for bounded analytic functions*, American Journal of Mathematics, volume 80 (1958), pp. 921–930; *Interpolation by bounded analytic functions and the Corona problem*, Annals of Mathematics (2), volume 76 (1962), pp. 547–559; and *On convergence and growth of partial sums of Fourier series*, Acta Mathematica volume 116 (1966), pp. 135–157.

August 1984: To Joseph L. Doob for his fundamental work in establishing probability as a branch of mathematics and for his continuing profound influence on its development.

August 1985: To Michael Spivak for his five-volume set, *A Comprehensive Introduction to Differential Geometry* (second edition, Publish or Perish, 1979).

August 1985: To Robert Steinberg for three papers on various aspects of the theory of algebraic groups: *Representations of algebraic groups*, Nagoya Mathematical Journal, volume 22 (1963), pp. 33–56; *Regular elements of semisimple algebraic groups*, Institut des Hautes Études Scientifiques, Publications Mathématiques, volume 25 (1965), pp. 49–80; and *Endomorphisms of linear algebraic groups*, Memoirs of the American Mathematical Society, volume 80 (1968).

August 1985: To Hassler Whitney for his fundamental work on geometric problems, particularly in the general theory of manifolds, in the study of differentiable functions on closed sets, in geometric integration theory, and in the geometry of the tangents to a singular analytic space.

January 1986: To Donald E. Knuth for his expository work, *The Art of Computer Programming*, 3 Volumes (1st Edition 1968, 2nd Edition 1973).

January 1986: To Rudolf E. Kalman for his two fundamental papers: *A new approach to linear filtering and prediction problems*, Journal of Basic Engineering, volume 82, (1960), pp. 35–45; and *Mathematical description of linear dynamical systems*, SIAM Journal on Control and Optimization, volume 1 (1963), pp. 152–192; and for his contribution to a third paper, (with R. S. Bucy) *New results in linear filtering and prediction theory*, Journal of Basic Engineering, volume 83D (1961), pp. 95–108.

January 1986: To Saunders Mac Lane for his many contributions to algebra and algebraic topology, and in particular for his pioneering work in homological and categorical algebra.

August 1987: To Martin Gardner for his many books and articles on mathematics and particularly for his column "Mathematical Games" in *Scientific American*.

August 1987: To Herbert Federer and Wendell Fleming for their pioneering paper, *Normal and integral currents*, Annals of Mathematics, volume 72 (1960), pp. 458–520.

August 1987: To Samuel Eilenberg for his fundamental contributions to topology and algebra, in particular for his classic papers on singular homology and his work on axiomatic homology theory which had a profound influence on the development of algebraic toplogy.

August 1988: To Sigurdur Helgason for his books *Differential Geometry and Symmetric Spaces* (Academic Press, 1962), *Differential Geometry, Lie Groups, and Symmetric Spaces* (Academic Press, 1978); and *Groups and Geometric Analysis* (Academic Press, 1984).

August 1988: To Gian-Carlo Rota for his paper *On the foundations of combinatorial theory, I. Theory of Möbius functions*, Zeitschrift für Wahrscheinlichkeitstheorie und Verwandte Gebiete, volume 2 (1964), pp. 340–368.

August 1988: To Deane Montgomery for his lasting impact on mathematics, particularly mathematics in America. He is one of the founders of the modern theory of transformation groups and is particularly known for his contributions to the solution of Hilbert's fifth problem.

August 1989: To Daniel Gorenstein for his book *Finite Simple Groups, An Introduction to their Classification* (Plenum Press, 1982); and his two survey articles *The classification of finite simple groups* and *Classifying the finite simple groups*, Bulletin of the American Mathematical Society, volume 1 (1979) pp. 43–199, and volume 14 (1986) pp. 1–98, respectively.

August 1989: To Alberto P. Calderon for his paper *Uniqueness in the Cauchy problem for partial differential equations*, American Journal of Mathematics, volume 80 (1958), pp. 16–36.

August 1989: To Irving Kaplansky for his lasting impact on mathematics, particularly mathematics in America. By his energetic example, his enthusiastic exposition, and his overall generosity, he has made striking changes in mathematics and has inspired generations of younger mathematicians.

August 1990: To R. D. Richtmyer for his book *Difference Methods for Initial-Value Problems* (Interscience, 1st Edition 1957 and 2nd Edition, with K. Morton, 1967).

August 1990: To Bertram Kostant for his paper, *On the existence and irreducibility of certain series of representations*, Lie Groups and their Representations (1975), pp. 231–329.

August 1990: To Raoul Bott for having been instrumental in changing the face of geometry and topology, with his incisive contributions to characteristic classes, K-theory, index theory, and many other tools of modern mathematics.

August 1991: To Jean-François Treves for *Pseudodifferential and Fourier Integral Operators*, Volumes 1 and 2 (Plenum Press, 1980).

August 1991: To Eugenio Calabi for his fundamental work on global differential geometry, especially complex differential geometry.

August 1991: To Armand Borel for his extensive contributions in geometry and topology, the theory of Lie groups, their lattices and representations and the theory of automorphic forms, the theory of algebraic groups and their representations, and extensive organizational and educational efforts to develop and disseminate modern mathematics.

January 1993: To Jacques Dixmier for his books *von Neumann Algebras* (*Algèbres de von Neumann*), Gauthier-Villars, Paris (1957); *C*-Algebras* (*Les C*-Algèbres et leurs Representations*), Gauthier-Villars, Paris (1964); and *Enveloping Algebras* (*Algèbres Enveloppantes*), Gauthier-Villars, Paris (1974).

January 1993: To James Glimm for his paper, *Solution in the large for nonlinear hyperbolic systems of conservation laws*, Communications on Pure and Applied Mathematics, XVIII (1965), pp. 697–715.

January 1993: To Peter D. Lax for his numerous and fundamental contributions to the theory and applications of linear and nonlinear partial differential equations and functional analysis, for his leadership in the development of computational and applied mathematics, and for his extraordinary impact as a teacher.

August 1993 – Mathematical Exposition: To Walter Rudin for his books *Principles of Mathematical Analysis*, McGraw-Hill (1953, 1964, and 1976); and *Real and Complex Analysis*, McGraw-Hill (1966, 1974, and1976).

August 1993 – Seminal Contribution to Research: To George Daniel Mostow for his paper *Strong rigidity of locally symmetric spaces*, Annals of Mathematics Studies, number 78, Princeton University Press (1973).

August 1993 – Lifetime Achievement: To Eugene B. Dynkin for his foundational contributions to Lie algebras and probability theory over a long period and his production of outstanding research students in both Russia and the United States, countries to whose mathematical life he has contributed so richly.

August 1994 – Mathematical Exposition: To Ingrid Daubechies for her book, *Ten Lectures on Wavelets* (CBMS 61, SIAM, 1992, ISBN 0-8987-1274-2).

August 1994 – Seminal Contribution to Research: To Louis de Branges for his proof of the Bieberbach Conjecture.

August 1994 – Lifetime Achievement: To Louis Nirenberg for his numerous basic contributions to linear and nonlinear partial differential equations and their application to complex analysis and differential geometry.

August 1995 – Mathematical Exposition: To Jean-Pierre Serre for his 1970 book *Cours d'Arithmétique*, with its English translation, published in 1973 by Springer Verlag, *A Course in Arithmetic.*

August 1995 – Seminal Contribution to Research: To Edward Nelson for the following two papers in mathematical physics characterized by leaders of the field as extremely innovative: "A quartic interaction in two dimensions" in *Mathematical Theory of Elementary Particles*, MIT Press, 1966, pages 69–73; and "Construction of quantum fields from Markoff fields" in *Journal of Functional Analysis*, 12 (1973), 97–112. In these papers he showed for the first time how to use the powerful tools of probability theory to attack the hard analytic questions of constructive quantum field theory, controlling renormalizations with L^p estimates in the first paper, and in the second turning Euclidean quantum field theory into a subset of the theory of stochastic processes.

August 1995 – Lifetime Achievement: To John T. Tate for scientific accomplishments spanning four and a half decades. He has been deeply influential in many of the important developments in algebra, algebraic geometry, and number theory during this time.

August 1996 – Mathematical Exposition: To Bruce C. Berndt for the four volumes, *Ramanujan's Notebooks*, Parts I, II, III, and IV (Springer, 1985, 1989, 1991, and 1994).

August 1996 – Mathematical Exposition: To William Fulton for his book, *Intersection Theory*, Springer-Verlag, "Ergebnisse series," 1984.

August 1996 – Seminal Contribution to Research: To Daniel Stroock and S.R.S. Varadhan for their four papers: *Diffusion processes with continuous coefficients I and II*, Comm. Pure Appl. Math. 22 (1969), 345–400, 479–530; *On the support of diffusion processes with applications to the strong maximum principle*, Sixth Berkeley Sympos. Math. Statist. Probab., vol. III, 1970, pp. 333–360; *Diffusion processes with boundary conditions*, Comm. Pure Appl. Math. 34 (1971), 147–225; *Multidimensional diffusion processes*, Springer-Verlag, 1979.

August 1996 – Lifetime Achievement: To Goro Shimura for his important and extensive work on arithmetical geometry and automorphic forms; concepts introduced by him were often seminal, and fertile ground for new developments, as witnessed by the many notations in number theory that carry his name and that have long been familiar to workers in the field.

January 1997 – Mathematical Exposition: To Anthony W. Knapp for his book, *Representation Theory of Semisimple Groups (An overview based on examples)*, Princeton University Press, 1986, a beautifully written book which starts from scratch but takes the reader far into a highly developed subject.

January 1997 – Seminal Contribution to Research: To Mikhael Gromov for his paper, *Pseudo-holomorphic curves in symplectic manifolds*, Inventiones Math. **82** (1985), 307–347, which revolutionized the subject of symplectic geometry and topology and is central to much current research activity, including quantum cohomology and mirror symmetry.

January 1997 – Lifetime Achievement: To Ralph S. Phillips for being one of the outstanding analysts of our time. His early work was in functional analysis: his beautiful theorem on the relation between the spectrum of a semigroup and its infinitesimal generator is striking as well as very useful in the study of PDEs. His extension theory for dissipative linear operators predated the interpolation approach to operator theory and robust control. He made major contributions to acoustical scattering theory in his joint work with Peter Lax, proving remarkable results on local energy decay and the connections between poles of the scattering matrix and the analytic properties of the resolvent. He later extended this work to a spectral theory for the automorphic Laplace operator, relying on the Radon transform on horospheres to avoid Eisenstein series. In the last fifteen years, Ralph Phillips has done brilliant work, in collaboration with others, on spectral theory for the Laplacian on symmetric spaces, on the existence and stability of cusp forms for general noncompact quotients of the hyperbolic plane, on the explicit construction of sparse optimal expander graphs, and on the structure of families of isospectral sets in two dimensions (the collection of drums that sound the same).

January 1998 – Lifetime Achievement: To Nathan Jacobson for his many contributions to research, teaching, exposition, and the mathematical profession. Few mathematicians have been as productive over such a long career or have had as much influence on the profession as has Professor Jacobson.

January 1998 – Seminal Contribution to Research: To Herbert Wilf and Doron Zeilberger for their joint paper, "Rational functions certify combinatorial identities," *Journal of the American Mathematical Society*, **3** (1990), 147–158.

January 1998 – Mathematical Exposition: To Joseph Silverman for his books, *The Arithmetic of Elliptic Curves*, Graduate Texts in Mathematics 106, Springer-Verlag, New York-Berlin, 1986; and *Advanced Topics in the Arithmetic of Elliptic Curves*, Graduate Texts in Mathematics 151, Springer-Verlag, New York, 1994.

January 1999 – Lifetime Achievement: To Richard V. Kadison. For almost half a century, Professor Kadison has been one of the world leaders in the subject of operator algebras, and the tremendous flourishing of this subject in the last thirty years is largely due to his efforts.

January 1999 – Seminal Contribution to Research: To Michael G. Crandall for two seminal papers: "Viscosity solutions of Hamilton-Jacobi equations" (joint with P.-L. Lions), *Trans. Amer. Math. Soc.* **277** (1983), 1–42; and "Generation of semi-groups of nonlinear transformations on general Banach spaces" (joint with T. M. Liggett), *Amer. J. Math.* **93** (1971), 265–298.

January 1999 – Seminal Contribution to Research: To John F. Nash for his remarkable paper "The embedding problem for Riemannian manifolds," *Ann. of Math.* (2) **63** (1956), 20–63

January 1999 – Mathematical Exposition: To Serge Lang for his many books. Among Lang's most famous texts are *Algebra* [Addison-Wesley, Reading, MA, 1965; Second edition, 1984; Third edition, 1993, ISBN 0-201-55540-9] and *Algebraic Number Theory* [Addison-Wesley, Reading, MA, 1970; Second edition, Graduate Texts in Mathematics 110, Springer-Verlag, New York, 1994, ISBN 0-387-94225-4].

January 2000 – Lifetime Achievement: To Isadore M. Singer. Singer's series of five papers with Michael F. Atiyah on the Index Theorem for elliptic operators (which appeared in 1968-71) and his three papers with Atiyah and V.K. Patodi on the Index Theorem for manifolds with boundary (which appeared in 1975-76) are among the great classics of global analysis.

January 2000 – Seminal Contribution to Research: To Barry Mazur for his paper "Modular curves and the Eisenstein ideal" in *Publications Mathematiques de l'Institut des Hautes Études Scientifiques*, no. 47 (1978), 33-186.

January 2000 – Mathematical Exposition: To John H. Conway in recognition of his many expository contributions in automata, the theory of games, lattices, coding theory, group theory, and quadratic forms.

January 2001 – Lifetime Achievement: To Harry Kesten for his many and deep contributions to probability theory and its applications.

January 2001 – Seminal Contribution to Research: To Leslie F. Greengard and Vladimir Rokhlin for the paper "A fast algorithm for particle simulations", *J. Comput. Phys.* **73**, no. 2 (1987), 325-348.

January 2001 – Mathematical Exposition: To Richard P. Stanley in recognition of the completion of his two-volume work *Enumerative Combinatorics*.

The Oswald Veblen Prize in Geometry

This prize was established in 1961 in memory of Professor Oswald Veblen through a fund contributed by former students and colleagues. The fund was later doubled by the widow of Professor Veblen, bringing the fund to $2,000. The prize is awarded for research in geometry or topology under conditions similar to those for the Bôcher Prize. The first two awards of the prize were made in 1964 and the next in 1966. From 1996–2001 an award was ordinarily made every five years. Starting in 2004, an award will be made every three years.

First award, 1964: To C. D. Papakyriakopoulos for his papers, *On solid tori*, Annals of Mathematics, Series 2, volume 66 (1957), pp. 1-26, and *On Dehn's lemma and the asphericity of knots*, Proceedings of the National Academy of Sciences, volume 43 (1957), pp. 169-172.

Second award, 1964: To Raoul Bott for his papers, *The space of loops on a Lie group*, Michigan Mathematical Journal, volume 5 (1958), pp. 35-61, and *The stable homotopy of the classical groups*, Annals of Mathematics, Series 2, volume 70 (1959), pp. 313-337.

Third award, 1966: To Steven Smale for his contributions to various aspects of differential topology.

Fourth award, 1966: To Morton Brown and Barry Mazur for their work on the generalized Schoenflies theorem.

Fifth award, 1971: To Robion C. Kirby for his paper, *Stable homeomorphisms and the annulus conjecture*, Annals of Mathematics, Series 2, volume 89 (1969), pp.575-582.

Sixth award, 1971: To Dennis P. Sullivan for his work on the Hauptvermutung summarized in the paper, *On the Hauptvermutung for manifolds*, Bulletin of the American Mathematical Society, volume 73 (1967), pp. 598-600.

Seventh award, 1976: To William P. Thurston for his work on foliations.

Eighth award, 1976: To James Simons for his work on minimal varieties and characteristic forms.

Ninth award, 1981: To Mikhael Gromov for his work relating topological and geometric properties of Riemannian manifolds.

Tenth award, 1981: To Shing-Tung Yau for his work in nonlinear partial differential equations, his contributions to the topology of differentiable manifolds, and for his work on the complex Monge-Ampère equation on compact complex manifolds.

Eleventh award, 1986: To Michael H. Freedman for his work in differential geometry and, in particular, the solution of the four-dimensional Poincaré conjecture.

Twelfth award, 1991: To Andrew J. Casson for his work on the topology of low-dimensional manifolds, and to Clifford H. Taubes for his foundational work in Yang-Mills theory.

Thirteenth award, 1996: To Richard Hamilton for his continuing study of the Ricci flow and related parabolic equations for a Riemannian metric, and to Gang Tian for his contributions to geometric analysis.

Fourteenth award, 2001: To Jeff Cheeger for his work in differential geometry, to Yakov Eliashberg for his work in symplectic and contact topology, and to Michael J. Hopkins for his work in homotopy theory.

The Albert Leon Whiteman Memorial Prize

This prize was established in 1999 using funds donated by Mrs. Sally Whiteman in memory of her husband, Albert Leon Whiteman, to recognize notable exposition and exceptional scholarship in the history of mathematics. The prize is awarded every four years.

First award, 2001: To Thomas Hawkins to recognize an outstanding historian of mathematics whose current research and numerous publications display the highest standards of mathematical and historial sophistication.

The Norbert Wiener Prize in Applied Mathematics

This prize was established in 1967 in honor of Professor Norbert Wiener and was endowed by a fund amounting to $2,000 from the Department of Mathematics of the Massachusetts Institute of Technology. The prize is awarded for an outstanding contribution to "applied mathematics in the highest and broadest sense." From 1970–2000 the prize was normally awarded every five years. Beginning in 2001, the prize will be awarded every three years. The award is made jointly by the American Mathematical Society and the Society for Industrial and Applied Mathematics. The recipient must be a member of one of these societies and a resident of the United States, Canada, or Mexico.

First award, 1970: To Richard E. Bellman for his pioneering work in the area of dynamic programming, and for his related work on control, stability, and differential-delay equations.

Second award, 1975: To Peter D. Lax for his broad contributions to applied mathematics, in particular, for his work on numerical and theoretical aspects of partial differential equations and on scattering theory.

Third award, 1980: To Tosio Kato for his distinguished work in the perturbation theory of quantum mechanics.

Fourth award, 1980: To Gerald B. Whitham for his broad contributions to the understanding of fluid dynamical phenomena and his innovative contributions to the methodology through which that understanding can be constructed.

Fifth award, 1985: To Clifford S. Gardner for his contributions to applied mathematics in the areas of supersonic aerodynamics, plasma physics and hydromagnetics, and especially for his contributions to the truly remarkable development of inverse scattering theory for the solution of nonlinear partial differential equations.

Sixth award, 1990: To Michael Aizenman for his outstanding contribution of original and nonperturbative mathematical methods in statistical mechanics by means of which he was able to solve several long open important problems concerning critical phenomena, phase transitions, and quantum field theory; and to Jerrold E. Marsden for his outstanding contributions to the study of differential equations in mechanics: he proved the existence of chaos in specific classical differential equations; his work on the momentum map, from abstract foundations to detailed applications, has had great impact.

Seventh award, 1995: To Hermann Flaschka for deep and original contributions to our understanding of completely integrable systems; and to Ciprian Foias, for basic contributions to operator theory, analysis, and dynamics and their applications.

Eighth award, 2000: To Alexandre J. Chorin in recognition of his seminal work in computational fluid dynamics, statistical mechanics, and turbulence; and to Arthur T. Winfree in recognition of his profound impact on the field of biological rhythms, otherwise known as coupled nonlinear oscillators.

Funds

AMS Centennial Fellowship Fund

This fund was established by the Society in 1973 and provides one-year Research Fellowships awarded each year in March. In 1988 the Fellowship was named to honor the AMS Centennial. The number of fellowships granted each year depends on the contributions the Society receives, matched by a contribution from the Society of not more than $50,000. Over the years the fund has been targeted at different groups. In 2001 the Council of the AMS voted to direct the fellowships toward applicants who have held their doctoral degree for at least three years and not more than twelve years and currently hold a tenured, tenure-track, postdoctoral, or comparable position at an institution in North America.

First award, 1974-1975: Fred G. Abramson, James Li-Ming Wang.

Second award, 1975-1976: Terence J. Gaffney, Paul Nèvai, George M. Reed.

Third award, 1976-1977: Fredric D. Ancel, Joseph A. Sgro.

Fourth award, 1977-1978: Steven Kalikow, Charles Patton, Duong-Hong Phong, David Vogan.

Fifth award, 1978-1979: Alan Dankner, David Harbater, Howard Hiller, Steven P. Kerckhoff, Robert C. McOwen.

Sixth award, 1979-1980: Scott W. Brown, Jeffrey E. Hoffstein, Jeffry N. Kahn, James E. McClure, Rick L. Smith, Mark Steinberger.

Seventh award, 1980-1981: Robert K. Lazarsfeld, Thomas H. Parker, Robert Sachs.

Eighth award, 1981-1982: Lawrence Man-Hou Ein, Mark Williams.

Ninth award, 1982-1983: Nicholas J. Kuhn.

Tenth award, 1983-1984: Russell David Lyons.

Eleventh award, 1984-1985: Richard Timothy Durrett.

Twelfth award, 1985-1986: R. Michael Beals.

Thirteenth award, 1986-1987: Dinakar Ramakrishnan.

Fourteenth award, 1987-1988: Richard Hain, Bill Jacob.

Fifteenth award, 1988-1989: Steven R. Bell, Don M. Blasius, David Gabai.

Sixteenth award, 1989-1990: Isaac Y. Efrat, John M. Lee, Ralf J. Spatzier.

Seventeenth award, 1990-1991: Michael Anderson, Carolyn Gordon, Steven Mitchell.

Eighteenth award, 1991-1992: Daniel Blump, Kari Vilonen.

Nineteenth award, 1992-1993: Krzysztof Kurdzy, William Menasco, David Morrison.

Twentieth award, 1993-1994: Jacques Hurtubise, Andre Scedrov, David Webb.

Twenty-first award, 1994-1995: Patricia E. Bauman, David E. Marker.

Twenty-second award, 1995–1996: Rafael de la Llave, William Gordon McCallum, Kent Edward Orr.

Twenty-third award, 1996–1997: Yi Hu, Robert McCann, Alexander Voronov, Jiaping Wang.

Twenty-fourth award, 1997-1998: Ovidiu Costin, Fred Diamond, Gang Liu, Zhongwei Shen, Stephanie Singer.

Twenty-fifth award, 1998–1999: Mark Andrea A. de Cataldo, Stavros Garoufalidis, Sándor Kovács, Yanguang Li.

Twenty-sixth award, 1999-2000: Charles W. Rezk, Bin Wang, Changyou Wang, Tonghai Yang.

Twenty-seventh award, 2000-2001: Siqi Fu, Christopher Herald, Wei-Dong Ruan, Vasily Strela.

Twenty-eighth award, 2001-2002: Ivan Dimitrov, Ravi Vakil, Jiahong Wu, Meijun Zhu.

Endowment Fund

In 1923 an Endowment Fund was collected to meet the greater demands on the publication program of the Society, demands caused by the ever-increasing number of important mathematical memoirs. Of this fund, which amounted to approximately $94,000 in 1960, a considerable proportion was contributed by members of the Society. In 1961, upon the death of the last legatees under the will of the late Robert Henderson—for many years a Trustee of the Society—the entire principal of the estate was received by the Society, thereby bringing the Endowment Fund to approximately $648,000.

Epsilon Fund

In 1999 the Society started the Epsilon Fund to help support existing summer programs for mathematically talented high school students. The name for the fund was chosen in remembrance of the late Paul Erdos, who was fond of calling children "epsilons." At its meeting in November 2000, the AMS Board of Trustees approved the Society's engagement in a sustained effort to raise an endowment for the Epsilon Fund. In addition, a Board-designated fund of $500,000 was created as a start for the endowment. As a start for the program, the AMS used money from its Program Development Fund to award Epsilon grants for activities during summer 2000 and 2001. Once the Epsilon Fund endowment has reached the targeted amount of $2,000,000, the AMS intends to award a total of $100,000 in Epsilon grants each year.

First awards, 2000: To All Girls/All Math (University of Nebraska, Lincoln), Hampshire College Summer Studies in Mathematics, Mathcamp, PROMYS (Boston University), Ross Young Scholars Program (Ohio State University), SWT Honors Summer Math Camp (Southwest Texas State University), and the University of Michigan Math Scholars.

Second awards, 2001: To All Girls/All Math (University of Nebraska), Mathcamp (Port Huron, Michigan), Michigan Math & Science Scholars (University of Michigan, Ann Arbor), Mathematics Scholars Academy (Oklahoma State University), Hampshire College Summer Studies in Mathematics (Hampshire College), PROMYS (Boston University), Young Scholars Program (University of Chicago), and Ross Mathematics Program (The Ohio State University).

Friends of Mathematics Fund

A Friends of Mathematics Fund has been created to incorporate monetary gifts to the Society of a general nature. The principal of this fund is now $123,572. The proceeds of the fund are a part of the invested assets of the Society. The following gifts are components of this fund: $1,000 from the estate of Professor Ernest William Brown; $1,000 from the estate of Genevra B. Hutchinson; $3,000 from Solomon A. Joffe; $650 from the estate of Professor Helen A. Merrill; $23,600 from the estate of Dean Marion Reilly; $1,000 from the estate of James K. Whittemore; and $2,700 from an anonymous donor.

The Karl Menger Fund

The family of the late Karl Menger were the major contributors to a fund established at Duke University totalling $40,000. The majority of the income from this fund is to be used by the Society for annual awards at the International Science and Engineering Fair.

First award, 1990: Daniel K. Dugger, Joshua Erlich, Joshua B. Fischman, Min-Horng Chen, Matthew Baker, Michael L. Harrison, Virginia A. DiDomizio.

Second award, 1991: Monwhea Jeng, Hans Christian Gromoll, Jesse L. Tseng, Andrew Olstrom Dittmer, Matthew A. Neimark, Rageshree Ramachandran, Jeb E. Willenbring.

Third award, 1992: Mahesh Kalyana Mahanthappa, Harrison Kwei Tsai, Andrew Olstrom Dittmer, Jonobie Dale Baker, Joshua Brody, Yen-Hsiang Li, Robert Jordon Pollack.

Fourth award, 1993: Mahesh Kalyana Mahanthappa, Steve Shaw-Tang Chien, Andrew Olstrom Dittmer, Moon Duchin, Robert Michael Kirby II, Sarah Ann Lord, Anna Ruth Terry.

Fifth award, 1994: Davesh Maulik, Eric Matthew Dennis, Sarah Ann Lord, Timothy Stephen Eller, Rahul Manu Kohli, Fam-ye Lin, Benedek Valko, Mary Kathleen Clavenna, Vinay Kumak Goyal-Singhal, Jan Kristian Haugland, Wes Andres Watters, Ian George Zacharia.

Sixth award, 1995: Davesh Maulik, Benjamin Michael Goetz, Jacob Lurie, Daniel Kalman Biss, Samit Dasgupta, Yueh-Hsing Lin, Claus Mazanti Soerensen, Theodore Haw-Yun Hwa, Samuel Jacob Klein Jr., Katherine Anne Paur, Bridget Helen Penny, Scott Nicholas Sanders.

Seventh award, 1996: Davesh Maulik, Nicholas Karl Eriksson, Logan Joseph Kleinwaks, Eric Jon Landquist, Vanesa Miranda-Diaz, Jason Charles Stone, Lauren Kiyomi Williams, Ryan Thomas Hebert, Kendrick Norris Kay, Scott Nicholas Sanders, Claus Mazanti Sorensen, Yvette Karen Wood.

Eighth award, 1997: Davesh Maulik, Nicholas Eriksson, Jeremy Rahe, Jennifer Pelka, Yen-Jen Chen, Sylvain Halle, Melanie Schechter, Matthew Seligman, Thomas Mack, Susannah Rutherglen, Jy-Ying Janet Chen, Chun-Hsiang Fu, Daniel Ying-Jeh Little.

Ninth award, 1998: Jonathan Adam Kelner, Michael Yanchee Lee, Daniel Yamins, Alexey Evgenjevitch Eroshin, Sarah Flannery, Jeremy Ryan Rahe, Jennifer Rose Walk, Richard Lee Barnes, Matthew Christopher Ong, David Carl Rennard, Anna Welling Salamon, Hui Yu.

Tenth award, 1999: Amit Kumar Sabharwal, Andrew Chi, Jennifer Lynn Pelka, Ching-Tang Chen, C. Andrew McManus, Jennifer Rose Walk, Heidi Lee Williams, Jack Nelson Bewley, Adam Douglas Bryant, Jason A. Loy, John William Pope, Bryce Leitner Roberts.

Eleventh award, 2000: Jayce R. Getz, Aadel Ahmed Chaudhuri, Zachary Howard Cohn, Ching Tang Chen, Elaine Pei-San Gee, Siarhei Markouski, Ilya Malakhovsky, Vassily Vladimirovich Starodubtsev, Daniel Richard Green, Daniyar Z. Kamenov, Craig Allan Schroeder.

Twelfth award, 2001: Abdur Rasheed Sabar, Yuri Georgievich Kudryashov, Serge A. Tishchenko, Jason Wah Lone Chiu, Craig Allen Schroeder,Hasuk Francis Song, Daniel Wichs, Jennifer Shyamala Sayaka Balakrishnan, Christopher Ryan Bruner, Lindsey Jo Cable, Michael Harry Kaleta,Matthew Howard Stemm, Heon Joon Choe, Jesse Scott Trana.

The Eliakim Hastings Moore Fund

This fund was donated in 1922 in honor of Professor Eliakim Hastings Moore on the occasion of the twenty-fifth anniversary of the Chicago (Western) section of the Society. The fund is $2,575 and the income from the fund is to be used at the discretion of the Council for the publication of important mathematical books and memoirs and for the award of prizes.

The C. V. Newsom Fund

In 1990 the Society received a bequest of $100,000 from the estate of Carroll V. Newsom. The bequest was made to memorialize John von Neumann and his accomplishments. The income from this fund is to be used to support a quadrennial symposium, called the von Neumann Symposium, that will focus on fundamental concepts in the forefront of mathematics.

The Program Development Fund

In 1993 the Executive Committee and Board of Trustees (ECBT) established the Program Development Fund (formerly referred to as the General Fund). Gifts to the Program Development Fund are directed toward initiatives which address immediate needs of the mathematics community, enabling the AMS to act decisively and quickly. Contributions are matched dollar-for-dollar to a maximum of $50,000. Programs supported are approved by the ECBT.

The Joseph Fels Ritt Memorial Fund

From the estate of Estelle F. Ritt, the income from a fund of $22,500 is available for the publication of works in the field of mathematics as shall be determined by the governing bodies of the Society.

The Waldemar J. Trjitzinsky Memorial Fund

The Society received a bequest from the estate of Waldemar J., Barbara G., and Juliet Trjitzinsky, the income from which is used to assist students who have declared a major in mathematics at a college or university that is an institutional member of the AMS. These funds help support students who lack adequate financial resources and who may be in danger of not completing the degree program in mathematics for financial reasons. Each year the Society selects four geographically distributed schools who in turn make one-time awards to beginning mathematical students to assist them in pursuit of careers in mathematics. As the Trjitzinsky fund has grown over the years, the number of schools and the amount of each scholarship have been increased accordingly. From 1991–1995, four schools were selected and the awards were $2,500 each; from 1996–2000, four schools wre selected and the awards were $3,750 each; starting in 2001, eight schools were selected and the awards were $4,000 each.

First award, 1991: Duke University (Robert Lane Bassett, Linie Yunwen Chang, Kara Lee Lavender), University of Scranton (Thomas A. Shimkus), Montana State University (Melissa Cockerill, Deborah Fagan, Sherry Heis), Howard Payne University (Pamela Jo Chaney).

Second award, 1992: Allegheny College (Julianne Stile), Memphis State University (Cassandra Burns), University of California at Irvine (James Anthony Nunez), University of Puerto Rico (Juan Ramon Romero-Oliveras).

Third award, 1993: University of California at Los Angeles (Michelle L. Lanir), State University of New York at Geneseo (Jodi C. Wright), Eastern New Mexico University (Rebecca K. Moore), University of Virginia (Mikhail Krichman).

Fourth award, 1994: Boise State University (William Hudson and Margaret Norris), Illinois Institute of Technology (Guanghong Xu), Temple University (Coleen Clemetson), University of Maryland at College Park (Mikhail G. Konikov).

Fifth award, 1995: University of Arizona (Mark Robert Moseley), Arkansas State University (Donna J. Shepherd), Mississippi State University (Clayton T. Hester), Montclair State College (James R. Jarrell III).

Sixth award, 1996: Murray State University (Christie M. Safin), Stanford University (Andreea Nicoara), Union College (Allison Pacelli), Western Illinois University (Lorna Renee Sanders).

Seventh award, 1997: Georgetown University (Martin Akguc), Loyola Marymount University (Laura Steiner, Claudia Catalan, Elizabeth Madrigal), New York University (Emily Press), Southern Illinois University at Carbondale (Laura Wasser).

Eighth award, 1998: Stevens Institute of Technology (Kelly Cornish), Georgia State University (Kevin A. Wilson), Iowa State University (Matthew A. Halverson), University of Nevada at Las Vegas (Dumitru C. Tutuianu).

Ninth award, 1999: City University of New York (Hulya Cebeciouglu), Reed College (Jeremy Copeland), University of Texas at San Antonio (Danielle Lyles), Western Kentucky University (Marcia Jean Mercer).

Tenth award, 2000: California State University at Long Beach (Yen Hai Le), Case Western Reserve University (Alexander Statnikov), Clarkson University (Matthew Bartholomew), University of Houston (Alyssa Burns).

Eleventh award, 2001: Columbia University (Alexander Ivanov Sotirov), Florida Atlantic University (Gregory Nevil Leuchiali Maxwell), Henderson State University (Ann Smith), John Carroll University (Andrea C. Forney), Seattle University (Sinead Pollom), University of Texas at Austin (Virginia Roberts), University of Utah (Paul T. Watkins), Worcester Polytechnic Institute (Yakov Kronrod and Megan Lally).

Mathematics Calendar

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

November 2001

*10 **Graph Theory Day 42**, DIMACS Center, Rutgers University, Piscataway, New Jersey.

Sponsors: DIMACS Center and the New York Academy of Sciences (NYAS).

Organizers: M. Gargano, Pace Univ.; J. W. Kennedy, Queens College, CUNY; L. V. Quintas, Pace Univ.; F. Roberts, Rutgers Univ.; M. Janowitz, Rutgers Univ.

Short Description: Graph Theory Day 42 is designed to stimulate activity and interest among graph theorists by presenting timely and interesting talks by leading researchers. GTD42 will also be an opportunity to explore various software packages that in one way or another make or prove conjectures involving graph theory.

Invited Speakers: S. Fajtlowicz, Univ. of Houston, Houston, Texas; P. Hansen, École des Haute Études Commerciales, Montréal, Québec, Canada; D. Cvetkovic, Univ., of Belgrade, Belgrade, Yugoslavia.

Contacts: L. V. Quintas, Pace Univ., `lquintas@pace.edu`.

Local Arrangements: J. Herold, DIMACS Center, `jessicah@dimacs.rutgers.edu`, tel: 732-445-5928.

Information: `http://dimacs.rutgers.edu/Workshops/index.html`.

December 2001

*3-8 **Second International Gabor Workshop**, University of Vienna, Vienna, Austria.

Program: Our goal is to promote interaction of researchers in the area of Gabor analysis and the exchange of ideas and to discuss new developments in mathematical time-frequency analysis.

Organizers: M. Doerfler, H. G. Feichtinger, K. Groechenig, N. Kaiblinger.

Topics: Topics of interest include but are not limited to the following: Gabor frames and their applications, general time-frequency decompositions, modulation spaces and their applications, time-frequency methods in the theory of pseudodifferential operators, hard analysis and time-frequency methods, nonlinear approximation and greedy algorithms.

Preliminary List of Participants: R. Balan (Princeton, USA), P. Casazza (Missouri, USA), O. Christensen (Denmark), S. Dahlke (Bremen, Germany), C. Heil (Georgia Tech, USA), F. Hlawatsch (Vienna), W. Madych (Storrs, USA), G. Matz (Vienna), B. Torresani (Marseille, France).

Registration: Preferably directly at the workshop website `http://www.univie.ac.at/NuHAG/Gabor01/`. Deadline: October 15, 2001. Registration fee: AS 500.00, US $35.00.

Information: `gabor2001.mathematik@univie.ac.at`. For updated information see NuHAG website, `http://www.univie.ac.at/NuHAG/Gabor01/`.

*13-14 **SAGA 2001—1st Symposium on Stochastic Algorithms, Foundations and Applications**, Berlin, Germany.

Organizers: GMD-German National Research Center for Information Technology, FIRST-Research Institute for Computer Architecture and Software.

Topics: Original research papers (including significant work-in-progress and work identifying and exploring directions of future research) or state-of-the-art surveys are solicited in all aspects of algorithms employing stochastic components, including but not limited to: Stochastic algorithms for combinatorial optimization, stochastic local search methods, stochastic machine-learning methods, run-time analysis and speed of convergence, average-case behavior and experimental analysis, parallel and network algorithms, stochastic complexity results, various applications.

Information: SAGA 2001, GMD FIRST, Kekulestr. 7, 12489 Berlin,

---

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 **six 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, 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/`.

Germany; phone: +49 30 6392 1800; fax: +49 30 6392 1805; e-mail: saga01@first.gmd.de. Further information can be found at http://www.first.gmd.de/saga01/.

* 14-18 **NSF-CBMS Regional Research Conference: Using Spectral Data to Solve Inverse Problems**, The University of Texas-Pan American, Edinburg, Texas.
Program: J. McLaughlin, the Ford Foundation Professor of Mathematics at Rensselaer Polytechnic Institute, will provide a self-contained and comprehensive exposition on the use of natural frequencies and selected mode shape measurements to determine material properties of objects. Ten one-hour lectures will present the newest methods for solving these problems and give both mathematical and experimental insight into how the data depends on the material properties to be recovered. Emphasis will be on two-dimensional problems, with a brief introduction and insight given for one-dimensional problems.
Financial Support: The conference is funded by the National Science Foundation, which will provide support for local expenses and travel for some participants. Graduate students, postdocs, and other mathematicians early in their career are strongly encouraged to request financial support.
Information: Registration, travel, and support information can be found at http://www.math.panam.edu/cbms/.
Organizer/Contact: R. Knobel, e-mail: knobel@panam.edu, tel: 956-316-7064.

January 2002

* 2-4 **Seventh International Symposium on Artificial Intelligence and Mathematics**, Fort Lauderdale, Florida.
Sponsors: The symposium is partially supported by the *Annals of Math and AI* and Florida Atlantic University.
Program: The International Symposium on Artificial Intelligence and Mathematics is the seventh of a biennial series. The objective of the symposium is to foster interactions between mathematics, theoretical CS, and artificial intelligence. Traditionally, the symposium attracts around 100 participants from a variety of disciplines, thereby providing a unique forum for active scientific exchange. The AI & Math Symposia series was started in 1990 and is held every two years, alternating with the AI & Statistics meetings. The meeting includes paper presentations, invited speakers, and special topic sessions.
Invited Speakers: S. Kraus (Bar-Ilan Univ.), G. Turan (Univ. of Illinois at Chicago), T. Dean (Brown Univ.)—to be confirmed. Additional invited speakers may be added at a later date.
Information: Further information and future announcements can be obtained from the conference website at http://rutcor.rutgers.edu/~amai/ or by (e)mail to hoffman@acc.fau.edu or F. Hoffman, Florida Atlantic University, Department of Mathematics, P.O. Box 3091, Boca Raton, FL 33431.

* 5-10 **Mathematics and Molecular Biology VII: Modeling across the Scales—Atoms to Organisms**, La Fonda Hotel, Santa Fe, New Mexico.
Description: The Program in Mathematics and Molecular Biology (PMMB) actively promotes interdisciplinary education and research through sponsorship and organization of the international conference series Mathematics and Molecular Biology, periodically held in Santa Fe. The upcoming meeting is the seventh in the series and is supported by the Burroughs Wellcome Fund Interfaces Program and the National Science Foundation. This meeting is intended to reach a broad multidisciplinary audience of students and researchers active at the interface between mathematics (broadly defined) and biology. One of the unique features of the meeting is an opening day of tutorials which prepare the attendees for the lectures, with mathematical scientists introducing basic principles to biologists and biologists giving tutorials for the quantitative scientists. We are planning two sessions of special interest to students, focusing on issues of importance to students working at the interface between the computational sciences and biology. Students are especially welcome to attend and present posters on their work.
Topics: Mathematics tutorial, biology tutorial, trainee workshop, modeling molecules, modeling organisms, bioinformatics, single molecules, cellular gene expression, mesoscale modeling.
Speakers: U. Alon (Weizmann), B. Berger (MIT), D. Buck (Johns Hopkins), C. Burge (MIT), S. Dudoit (UC Berkeley), R. Ebright (Rutgers), J. Fernandez (Mayo Clinic), J. Gelles (Brandeis), M. Gerstein (Yale), J. Hopfield (Princeton), N. Kopell (Boston Univ.), C. Lawrence (Wadsworth Center), S. Levene (UT Dallas), M. Levitt (Stanford), G. Meyers (Celera Genomics), D. Mumford (Brown), T. Schlick (NYU), K. Schulten (Illinois), A. Sengupta (Lucent), D. Siegmund (Stanford), S. Smith (UC Berkeley), R. Stoughton (Rosetta Inpharmatics), N. Sung (Burroughs Wellcome Fund), D. Swigon (Rutgers), W. Walker (Abgenix Inc.), M. Wang (Cornell), S. Wilson (NIH), W. H. Wong (Harvard), S. Xie (Harvard).
Deadlines: Poster abstracts November 1; early registration December 1.
Information: Limited support is available for students and young faculty. For information and application forms, see our website, http://www.math.fsu.edu/~pmmb/.

* 21-February 1 **DynamicSummer: Topics in Nonlinear Dynamics**, The Australian National University, Canberra, Australia.
Program: The scope of the 2002 Summer School, DynamicSummer, is envisaged to encompass the dynamics of nonlinear processes and the emergence of structure through symmetry breaking. It will include the fundamentals of nonlinear dynamics theory and practice as well as modern developments in theory and computational modelling, applications and experiments in nonlinear physics. DynamicSummer is targeted towards 3rd-year, 4th-year, and postgraduate students and researchers from Australian and foreign universities whose first degree is not necessarily in mathematics but who can be assumed to have at least 2nd-year maths knowledge. The level of exposition will be senior undergraduate/beginning postgraduate. The organisers expect to be able to offer some financial assistance to student participants from universities outside Canberra.
Invited Lecturers: B. Davies, ANU: Introductory material, computation using Java-based software; A. Newell, Warwick: Wave Turbulence and Pattern Formation; R. MacKay, Warwick: Discrete Breathers; C. Holmes, Qld.: Applications of Hamiltonian Dynamics; N. Joshi, Sydney: Hunting Nonlinear Mathematical Butterflies; C. Weiss, PTB Braunschweig: Experiments on pattern formation and spatial solitons; J. Brindley, Leeds: Cod, Climate and Calculus: Nonlinearity in the Seas; T. Roberts, S. Qld.: Dissipative Fluid Dynamics; M. Lieberman, UC Berkeley: The Dynamics of Fermi Acceleration: From Cosmic Rays to Discharge Heating.
Registration: Register online at http://www.anu.edu.au/dynamicsummer/, or contact one of the organisers. Registration is free.
Information: R. Ball, Rowena.Ball@anu.edu.au (convenor); V. Robins, Vanessa.Robins@anu.edu.au, R. Dewar, Robert.Dewar@anu.edu.au, and N. Akhmediev, Nail.Akhmediev@anu.edu.au (co-convenors); H. Jackson and N. Gyorgi-Faul (administrators), adm105@rsphysse.anu.edu.au; fax: 61 (0)2 6125 4676; phone: 61 (0)2 6125 2943; Department of Theoretical Physics, Research School of Physical Sciences & Engineering, Le Couteur Building, Bldg. 59, The Australian National University, Canberra ACT 0200, Australia.

February 2002

* 13-15 **DIMACS Workshop on Internet and WWW Measurement, Mapping and Modeling**, DIMACS Center, Rutgers University, Piscataway, New Jersey.
Sponsors: DIMACS Center.
Organizers: J. Byers, Boston Univ.; D. Raz, Technion/Bell Labs; Y. Shavitt, Tel Aviv Univ./Bell Labs.
Short Description: The goal of this workshop is to examine the Internet structure and the structure of its most widely used application, the WWW, and to examine tools, methods, and instrumentations designed to map and understand the Internet structure.

Invited Speakers: A. L. Barabasi, Univ. of Notre Dame; A. Bestavros, Boston Univ.; M. Crovella, Boston Univ.; M. Faloutsos, Univ. of California, Riverside; R. Govindan, USC/ISI; S. Jamin, Univ. of Michigan; N. Linial, Hebrew Univ.

Contacts: Y. Shavitt, Tel Aviv Univ./Bell Labs, shavitt@research.bell-labs.com.

Information: J. Herold, DIMACS Center, jessicah@dimacs.rutgers.edu; 732-445-5928; http://dimacs.rutgers.edu/Workshops/index.html.

*21-23 **Pacific Institute for Mathematical Sciences (PIMS) Workshop on Representations of Reductive p-Adic Groups**, Banff, Alberta, Canada.

Themes: The construction of types for admissible representations of reductive p-adic groups, applications to character theory, results on L-packets, applications of adic and rigid analytic geometry to p-adic group representation theory.

Organizers: C. Cunningham, University of Calgary, cunning@math.ucalgary.ca; F. Murnaghan, University of Toronto, fiona@math.utoronto.ca.

Information: http://www.pims.math.ca/rrpg/.

March 2002

*15-17 **SEAM XVIII (South Eastern Analysis Meeting XVIII)**, University of North Carolina, Chapel Hill, North Carolina.

Program: Five 1-hour invited talks by leading experts in the areas of operator theory and function theory. The remainder of the program will consist of contributed 20-minute talks.

Organizers: J. A. Cima, W. R. Wogen.

Information: Information on speakers and financial support and a more detailed schedule will appear here and on our Web page, http://www.math.unc.edu/, at a later date.

April 2002

*22-24 **Heat Transfer 2002: Seventh International Conference on Advanced Computational Methods in Heat Transfer**, Halkidiki, Greece.

Organizer: Wessex Institute of Technology, UK.

Paper Deadline: December 4, 2001.

Information: Contact: Conference Secretariat, Heat 2002; e-mail: gcossutta@wessex.ac.uk; tel: 44 (0) 238 029 3223; fax: 44 (0) 238 029 2853; website: http://www.wessex.ac.uk/conferences/2002/ht02/.

May 2002

*19-25 **Canadian Number Theory Association-VII Meeting**, Centre de Recherches Mathematiques, Montréal, Québec, Canada.

Conference Organizers: H. Kisilevsky (Concordia) and E. Z. Goren (McGill).

Short Description: The purpose of the Canadian Number Theory Association (CNTA) is to enhance and promote learning and research in number theory. To advance these goals the CNTA organizes major international conferences, with the aim of exposing students and researchers to the latest developments in number theory worldwide. The program consists of 45 plenary talks and over 100 contributed talks presented in five parallel sessions: Algebraic Number Theory (M. Kolster, McMaster), Analytic Number Theory (K. S. Williams, Carleton), Arithmetic Algebraic Geometry (E. Z. Goren, McGill), Computational Number Theory (G. Walsh, Ottawa), Diophantine Analysis and Approximation (D. Roy, Ottawa).

Information and List of Principal Speakers: http://www.math.mcgill.ca/cnta7/.

Deadline for Submission of Abstracts: February 15, 2002. Contact the session organizers.

June 2002

*3-8 **Abel Bicentennial Conference 2002**, University of Oslo, Oslo, Norway.

Program: The conference will present an overview of the mathematical heritage of Niels Henrik Abel and, based upon this heritage, identify new mathematical trends for the 21st century.

Topics: The Abel Bicentennial Conference 2002 will include sections on: history of mathematics, algebraic geometry, complex analysis, differential equations, noncommutative geometry.

Organizer: O. A. Laudal, University of Oslo.

Scientific Committee: M. Artin, G. Faltings, P. A. Griffiths, G. Henkin, C. Houzel, O. A. Laudal, J. Palis.

Invited Speakers (as of August 31, 2001): M. Artin, M. van den Bergh, F. Catanese, C. Ciliberto, H. Clemens, G. Faltings, J. E. Fornæs, G. Frei, W. Fulton, M. Green, P. Griffiths, G. Henkin, C. Houzel, S. Kleiman, I. M. Krichever, H. W. Lenstra, R. Novikov, J. Palis, N. Schappacher, A. Selberg, Y.-T. Siu.

Information: http://www.math.uio.no/abel/conference/index.html.

*12-15 **Bachelier Finance Society: 2nd World Congress**, Crete, Greece.

Aim: The Bachelier Finance Society was founded in 1996 by a group of researchers in mathematical finance to serve as a platform where academics and practitioners can meet and exchange ideas spanning mathematics, finance, economics, econometrics, and insurance. To achieve this goal, every two years the BFS organizes an international congress.

Plenary Speakers: Y. Ait-Sahalia (Princeton), K. J. Arrow* (Stanford), N. El Karoui (École Polytechnique), V. Kaminski (Enron), I. Karatzas (Columbia), P.-L. Lions (Paris IX), M. Musiela (BNP Paribas), M. O' Hara (Cornell), K. Singleton (Stanford), W. Zame (UCLA) (* not yet confirmed).

Scientific Committee: G. Constantinides (Chicago), M. H. A. Davis (Imperial College), F. Delbaen (ETH), D. Duffie (Stanford), H. Foellmer (Humboldt), M. Jeanblanc (Evry), E. Platen (UTS), T. Zariphopoulou (UT-Austin).

Submissions: Participants are encouraged to submit a research paper. Submissions can be either a completed paper or an extended summary (two to four pages long). The deadline for submissions is November 30, 2001. Instructions regarding submissions are posted on the website of the congress.

Information: http://www.ma.utexas.edu/Bachelier2002/; correspondence: T. Zariphopoulou, Chair of the Scientific Committee, zariphop@math.utexas.edu.

*13-15 **19th Annual Workshop in Geometric Topology**, Calvin College, Grand Rapids, Michigan.

Sponsors: National Science Foundation, Calvin College, and the University of Tennessee.

Description: This is the 19th in the series of annual workshops in geometric topology. The featured speaker is A. Dranishnikov, who will present a series of three 1-hour talks on "Dimension Theory: Local and global". At the conclusion of the workshop there will be a special session in honor of B. Daverman on the occasion of his 60th birthday. Speaking at the special session will be J. Bryant, J. Cannon, and C. Guilbault.

Invited Speakers: A. Dranishnikov, J. Bryant, J. Cannon, C. Guilbault.

Information: G. A. Venema, venema@calvin.edu; http://www.calvin.edu/~venema/workshop/main.html.

*17-19 **24th International Conference on Boundary Element Methods and Meshless Solutions Seminar**, Sintra, Portugal.

Organizers: Wessex Institute of Technology, UK, and University of Coimbra, Portugal. Sponsored by the International Society of Boundary Elements (ISBE) and the International Journal of Engineering Analysis with Boundary Elements.

Paper Deadline: January 15, 2002.

Information: Conference Secretariat, BEMO2, Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southhampton, S040 7AA, UK; tel: 44 (0) 238 029 3223; fax: 44 (0) 238 029 2853; e-mail: rgreen@wessex.ac.uk; http://www.wessex.ac.uk/conferences/2002/be02/.

July 2002

* 15–20 **IV Brazilian Workshop on Continuous Optimization**, IMPA–Instituto de Matematica Pura e Aplicada, Rio de Janeiro, Brazil.
Main Topics: Subjects to be discussed encompass theoretical, computational and implementation issues in both linear and nonlinear programming, including variational inequalities, complementarity problems, nonsmooth optimization, vector optimization, generalized equations, etc. The backbone of the workshop will consist of plenary lectures of 45 minutes each offered by invited speakers.
Speakers: The following plenarists have already agreed to attend the workshop: A. Auslender (Univ. de Lyon, France), A. Lewis (Simon Fraser Univ., Canada), B. F. Svaiter (Inst. de Matematica Pura e Aplicada, Brazil), C. Gonzaga (Univ. Federal de Santa Catarina, Brazil), D. Goldfarb (Columbia Univ., USA), J. Dennis (Rice Univ., USA), J.-S. Pang (John Hopkins Univ., USA), J. Nocedal (Northwestern Univ., USA), J. M. Martinez (Univ. Estadual de Campinas, Brazil), M. Solodov (Inst. de Matematica Pura e Aplicada, Brazil), R. Wets (Univ. of California at Davis, USA).
Organizing Committee: A. Iusem, chairman (IMPA), R. Burachik (Univ. Federal de Rio de Janeiro), A. Friedlander (Univ. de Campinas), C. Gonzaga (Univ. Federal de Santa Catarina), J. M. Martinez (Univ. de Campinas), C. Sagastizábal (IMPA), M. Solodov (IMPA), B. F. Svaiter (IMPA).
Early Registration: Until April 15, 2002: R $150,00 (Brazilian participants); US$120.00 (foreign participants). Late registration (after April 15, 2002): R $200.00 (Brazilian participants); US $150.00 (foreign participants).
Information: IV Brazilian Workshop on Continuous Optimization, IMPA, Estrada Dona Castorina 110, Jardim Botânico, 22460-320-Rio de Janeiro, RJ, Brazil; tel: 55-21-2529-5000; fax: 55-21-2529-5131; e-mail: `optim@impa.br`.

* 23–August 2 **EDGE Mid-Term Summer School and Conference**, ICMS, Edinburgh, Scotland, UK.
Description: The European Differential Geometry Endeavour (EDGE) is a research network funded by the European Commission under Framework 5. Please see `http://edge.imada.sdu.dk/` for more information about this network. This meeting will survey the activities of all researchers in EDGE and will provide training for young researchers in key areas of current interest. The training will take place in the Summer School, which will run from the morning of Tuesday, July 23, to lunchtime on Saturday, July 27. The second part of the meeting will be an open conference and will run for five days, from Monday, July 29, to the afternoon of Friday, August 2. Despite the European focus of this meeting, participation by non-EC-nationals is strongly encouraged.
Topics: Low dimensional geometry, Gauge theory and symplectic geometry, Special holonomy and special Lagrangian fibrations, Minimal surfaces and rigidity.
Scientific Organizing Committee: H. Pedersen (chair), M. Singer (local coordinator), G. Besson, R. Bielawski, F. Burstall, D. Calderbank, B. Feix, O. Garcia-Prada, M. Gross, D. Kotschick, M. Micallef, R. Thomas.
Registration Deadline: January 10, 2002.
Information: `http://www.ma.hw.ac.uk/icms/meetings/2002/edge/index.html`.

August 2002

* 7–10 **The Second International Conference on Neural, Parallel, and Scientific Computations**, Morehouse College, Atlanta, Georgia.
Sponsor: Under the auspices of the International Federation for Nonlinear Analysts.
Conference Topics: Computational methods on all aspects of neural, parallel, and scientific computing such as algorithm designs, hardware/software engineering, computer modeling, networking dynamics, neurodynamics, pattern recognition, performance measurements, computer vision, imaging, cognition, speech modeling, computational mathematics, biomedical engineering, artificial intelligence, systolic algorithms, evaluation and prediction of computer complexes, cluster computing, VLSI design, computer architectures, simulation, ODL (open distance learning) systems, systems security, combinatorics, graph theory, fuzzy systems, and simulation.
Call for Papers: Authors of contributed and invited papers are requested to submit, before January 15, 2002, an article not exceeding 4 pages of their research presentation (each additional page costs US$50.00 per page). Please type each article single-spaced on one side of 8.5x11 size paper with a one-inch margin on all sides. The publication in the conference proceedings of the papers submitted to the conference is subject to submitting the paper before the deadline, acceptance of the paper, and preregistration of one of the authors of each article before April 30, 2002.
Registration: Preregistration: (on or before April 30, 2002) US $175.00 (Students: US $100.00). Registration: (after May 1, 2002) US $200.00 (Students: US $125.00). Banquet: August 8, 2002. Registration includes copy of the proceedings, banquet, and coffee and snacks during the meeting.
Information: Department of Mathematics, Morehouse College, Atlanta, GA 30314. To receive the second announcement send (e-mail) your name, address, telephone number, and e-mail address before December 1, 2001. Conference coordinator: M. Sambandham, ICNPSC2, Department of Mathematics, Morehouse College; phone: 404-215-2614; fax: 404-589-1661; e-mail: `icnpsc2@yahoo.com`; `http://www.dynamicpublishers.com/`.

* 12–16 **Infinite Dimensional Function Theory**, Pohang University of Science and Technology (POSTECH), Pohang, South Korea.
Description: The meeting's formal name is the International Conference on Infinite Dimensional Function Theory in Pohang, a satellite conference to the International Congress of Mathematics 2002 in Beijing, and in abbreviated form: Infinite Dimensional Function Theory Pohang 2002. It will take place in Pohang, South Korea, as a joint venture of Pohang University of Science and Technology (POSTECH) and Combinatorial and Computational Mathematics Center (Com^2Mac) in the week before ICM 2002, i.e., August 12–16, 2002. This conference will focus on current research progress of polynomials and holomorphic mappings on infinite dimensional spaces and applications of this research.
Organizing Committee: R. M. Aron (Kent State Univ., USA), Y. S. Choi (POSTECH, Korea), S. Dineen (UCD, Ireland), J. G. Llavona (Univ. Complutense, Madrid, Spain), M. Nishihara (Fukuoka Inst. Tech., Japan), M. Maestre (Univ. Valencia, Spain).
Invited Speakers (tentative): R. M. Aron (USA), S. Dineen (Ireland), L. Harris (USA), T. Gamelin (USA), J. G. Llavona (Spain), M. Maestre (Spain), J. Mujica (Brazil), R. Payá (Spain), Y. Sarantopoulos (Greece), I. Zalduendo (Argentina).
Contributed Talks and Posters: Contributed posters will be presented at extended poster sessions during the meeting. Approximately 20–25 contributed talks of 30 minutes each will be selected by the program committee from among those who wish to be considered for a contributed talk.
Conference Deadlines: April 15, 2002: Abstract for talks/posters. May 15, 2002: Notification of acceptance of contributed talks/posters.
Contact: Y. S. Choi, Dept. of Math., Pohang Univ. of Science and Technology (POSTECH), Pohang, South Korea (790-784); e-mail: `conf@euclid.postech.ac.kr`.
Information: Regularly updated information can be obtained from the Web page `http://www.postech.ac.kr/math/conf/`.

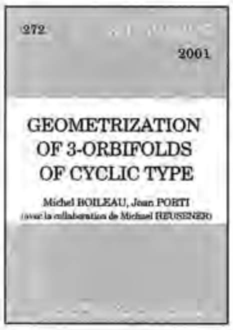
* 24–28 **Compstat 2002—Conference for Computational Statistics**, Humboldt-Universität zu Berlin, Berlin, Germany.
Organizer: The Compstat 2002, organized by the Institute for Statistics and Econometrics of the School for Business and Economics, is the leading conference in and covers all fields of computational statistics.
Topics: Computational finance. statistics of e-commerce, mining very large statistical databases, complex datastructures in the biosciences, net-based statistics.
Invited Speakers: C. Hafner, Electrabel; T. Hastie; S. Brooks; C.-h. Chen; G. Kitagawa; J. S. Marron; J. Symanzik; M. Valderrama; T. Yee; K. Yoshioka; S. Dobratz, Humboldt-Univ.

Information: For a detailed description of topics, deadlines, or more information, please refer to `http://www.compstat2002.de/`.

*29–September 2 **International Conference on Nonlinear Partial Differential Equations—Theory and Approximation,** City University of Hong Kong, Hong Kong.
Organizers: P. G. Ciarlet, Univ. Pierre et Marie Curie, France; R. Wong, City Univ. of Hong Kong.
Project Objective: The conference aims to review and discuss the latest trends in nonlinear partial differential equations. World leaders in the field will be delivering plenary lectures. This event will provide an excellent opportunity for international exposure and interaction among scientists.
Project Nature: This event is a satellite conference of the International Congress of Mathematicians, to be held August 20–28, 2002, in Beijing, China.
Session Topics: Theory: Existence theory, uniqueness and non-uniqueness of solutions, Boltzmann equation, plasma physics, Navier-Stokes equations, nonlinear elasticity, phase transitions, micro-structures. Approximation: Finite difference methods, finite element methods, finite volume methods, computational mechanics, computational chemistry.
Plenary Speakers: S. S. Antman, Univ. of Maryland; D. N. Arnold, Univ. of Minnesota; J. M. Ball, Univ. of Oxford, UK; A. Bressan, International School for Advanced Studies, Italy; M. Chipot, Univ. Zurich, Switzerland; P. G. Ciarlet, Univ. Pierre et Marie Curie, France; C. M. Dafermos, Brown Univ.; R. Glowinski, Univ. of Houston; R. V. Kohn, New York Univ.; C. Le Bris, École Nationale des Ponts et Chaussees, France; Y. Maday, Univ. Pierre et Marie Curie, France; L. Nirenberg, New York Univ.; A. Quarteroni, École Polytechnique Federale de Lausanne, Switzerland; C. Schwab, ETH Zurich, Switzerland; R. Temam, Univ. de Paris-Sud, France; R. S. Varga, Kent State Univ.; E. Zuazua, Univ. Complutense de Madrid, Spain.
Information: J. Fung, Conference Secretary, Liu Bie Ju Centre for Mathematical Sciences, City Univ. of Hong Kong, 83 Tat Chee Avenue, Kowloon, Hong Kong; tel.: (852) 2788 9816; fax: (852) 2788 7446; e-mail: `MCLBJ@cityu.edu.hk`. Please visit our website, `http://www.cityu.edu.hk/rcms/NPDE2002/`, or contact our conference secretariat for updated information regarding the program.

New Publications Offered by the AMS

Geometry and Topology



Geometrization of 3-Orbifolds of Cyclic Type

Michel Boileau, *CNRS, Université Paul Sabatier, Toulouse, France*, and **Joan Porti**, *Universitat Autònoma de Barcelona, Bellaterra, Spain*

A publication of the Société Mathématique de France.

In this book, the authors prove the orbifold theorem in the cyclic case: If $\mathcal{O}$ is a compact oriented irreducible atoroidal 3-orbifold whose ramification locus is a non-empty submanifold, then $\mathcal{O}$ is geometric, i.e. it has a hyperbolic, a Euclidean or a Seifert fibred structure. This theorem implies Thurston's geometrization conjecture for compact orientable irreducible three-manifolds having a non-free symmetry.

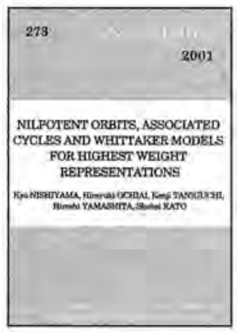
Distributed by the AMS in the United States, Canada, and Mexico. Orders from other countries should be sent to the SMF, Maison de la SMF, B.P. 67, 13274 Marseille cedex 09, France, or to Institut Henri Poincaré, 11 rue Pierre et Marie Curie, 75231 Paris cedex 05, France. Members of the SMF receive a 30% discount from list.

Contents: Introduction; Cone manifolds; Proof of Thurston's orbifold theorem for very good 3-orbifolds; A compactness theorem for cone 3-manifolds with cone angles bounded above by π; Local soul theorem for cone 3-manifolds with cone angles less than or equal to π; Sequences of closed hyperbolic cone 3-manifolds with cone angles less than π; Very good orbifolds and sequences of hyperbolic cone 3-manifolds; Uniformization of small 3-orbifolds; Haken 3-orbifolds; Examples; Limit of hyperbolicity for spherical 3-orbifolds; Thurston's hyperbolic Dehn filling Theorem; Bibliography; Index.

Astérisque, Number 272

205 pages, ISBN 2-85629-100-7, 2000 *Mathematics Subject Classification*: 57M50, 57M60, 53C20, 53C23, **Individual member $50**, List $55, Order code AST/272N

Algebra and Algebraic Geometry



Nilpotent Orbits, Associated Cycles and Whittaker Models for Highest Weight Representations

Kyo Nishiyama, *Kyoto University, Japan*, **Hiroyuki Ochiai**, *Tokyo Institute of Technology, Japan*, **Kenji Taniguchi**, *Aoyama Gakuin University, Tokyo, Japan*, **Hiroshi Yamashita**, *Hokkaido University, Sapporo, Japan*, and **Shohei Kato**, *Nakakasai, Edogawa-ku, Tokyo, Japan*

A publication of the Société Mathématique de France.

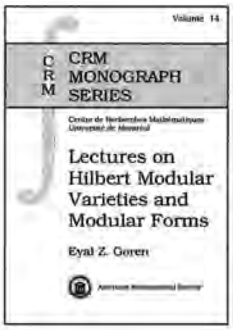
Let G be a reductive Lie group of Hermitian type. The authors investigate irreducible (unitary) highest weight representations of G which are not necessarily in the holomorphic discrete series. The results of three articles of this volume include the determination of the associated cycles, the Bernstein degrees, and the generalized Whittaker models for such representations. They give a convenient description of K-types via branching rules for representations of classical groups. An integral formula for the degrees of small nilpotent orbits is established for arbitrary Hermitian Lie algebras. The generalized Whittaker models for each unitary highest weight module are specified by means of the principal symbol of a gradient-type differential operator, and also in relation to the multiplicity in the associated cycle. They also present expository introductions of the key notions treated in this volume, such as associated cycles, Howe correspondence for dual pairs where one member of the pair is compact, and the realization of highest weight representations on the kernels of the differential operators of gradient type.

Distributed by the AMS in the United States, Canada, and Mexico. Orders from other countries should be sent to the SMF, Maison de la SMF, B.P. 67, 13274 Marseille cedex 09, France, or to Institut Henri Poincaré, 11 rue Pierre et Marie Curie, 75231 Paris cedex 05, France. Members of the SMF receive a 30% discount from list.

Contents: Introduction to this volume; **K. Nishiyama**, **H. Ochiai**, and **K. Taniguchi**, Bernstein degree and associated cycles of Harish-Chandra modules—Hermitian symmetric case; **H. Yamashita**, Cayley transform and generalized Whittaker models for irreducible highest weight modules; **S. Kato** and **H. Ochiai**, The degrees of orbits of the multiplicity-free actions; Concluding remarks.

Astérisque, Number 273

May 2001, ISBN 2-85629-101-5, 2000 *Mathematics Subject Classification*: 22E46, 32M15, 14L30, 58J70, **Individual member $40**, List $44, Order code AST/273N



Lectures on Hilbert Modular Varieties and Modular Forms

Eyal Z. Goren, *McGill University, Montreal, PQ, Canada*

This book is devoted to certain aspects of the theory of p-adic Hilbert modular forms and moduli spaces of abelian varieties with real multiplication.

The theory of p-adic modular forms is presented first in the elliptic case, introducing the reader to key ideas of N. M. Katz and J.-P. Serre. It is re-interpreted from a geometric point of view, which is developed to present the rudiments of a similar theory for Hilbert modular forms.

The theory of moduli spaces of abelian varieties with real multiplication is first presented very explicitly over the complex numbers. Aspects of the general theory are then exposed, in particular, local deformation theory of abelian varieties in positive characteristic.

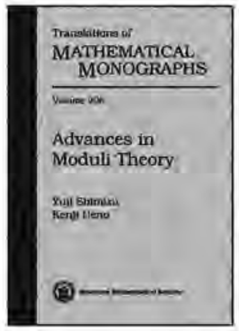
The arithmetic of p-adic Hilbert modular forms and the geometry of moduli spaces of abelian varieties are related and used to study q-expansions of Hilbert modular forms, on the one hand, and stratifications of moduli spaces on the other hand.

The book is addressed to graduate students and non-experts. It attempts to provide the necessary background to all concepts exposed in it. It may serve as a textbook for an advanced graduate course.

Contents: Introduction; Tori and abelian varieties; Complex abelian varieties with real multiplication and Hilbert modular forms; Abelian varieties with real multiplication over general fields; p-adic elliptic modular forms; p-adic Hilbert modular forms; Deformation theory of abelian varieties; Group schemes; Calculating with cusps; Bibliography; Notation index; Index.

CRM Monograph Series

November 2001, 270 pages, Hardcover, ISBN 0-8218-1995-X, 2000 *Mathematics Subject Classification*: 11G10, 11G18, 14G35, 11F33, 11F41, **Individual member $41**, List $69, Institutional member $55, Order code CRMM/14N



Supplementary Reading

Advances in Moduli Theory

Yuji Shimizu and **Kenji Ueno**, *Kyoto University, Japan*

The word "moduli" in the sense of this book first appeared in the epoch-making paper of B. Riemann, *Theorie der Abel'schen Funktionen*, published in 1857. Riemann defined a Riemann surface of an algebraic function field as a branched covering of a one-dimensional complex projective space and found out that Riemann surfaces have parameters. This work gave birth to the theory of moduli.

However, the viewpoint regarding a Riemann surface as an algebraic curve became the mainstream, and the moduli meant the parameters for the figures (graphs) defined by equations.

In 1913, H. Weyl defined a Riemann surface as a complex manifold of dimension one. Moreover, Teichmüller's theory of quasiconformal mappings and Teichmüller spaces made a start for new development of the theory of moduli, making possible a complex analytic approach toward the theory of moduli of Riemann surfaces. This theory was then investigated and made complete by Ahlfors, Bers, Rauch, and others. However, the theory of Teichmüller spaces utilized the special nature of complex dimension one, and it was difficult to generalize it to an arbitrary dimension in a direct way.

It was Kodaira-Spencer's deformation theory of complex manifolds that allowed one to study arbitrary dimensional complex manifolds. Initial motivation in Kodaira-Spencer's discussion was the need to clarify what one should mean by number of moduli. Their results, together with further work by Kuranishi, provided this notion with intrinsic meaning.

This book begins by presenting the Kodaira-Spencer theory in its original naive form in Chapter 1 and introduces readers to moduli theory from the viewpoint of complex analytic geometry. Chapter 2 briefly outlines the theory of period mapping and Jacobian variety for compact Riemann surfaces, with the Torelli theorem as a goal. The theory of period mappings for compact Riemann surfaces can be generalized to the theory of period mappings in terms of Hodge structures for compact Kähler manifolds. In Chapter 3, the authors state the theory of Hodge structures, focusing briefly on period mappings. Chapter 4 explains conformal field theory as an application of moduli theory.

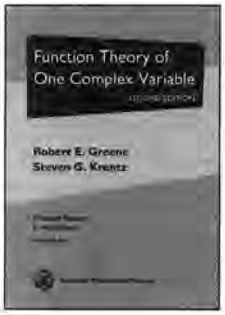
This is the English translation of a book originally published in Japanese. Other books by Kenji Ueno published in this AMS series, Translations of Mathematical Monographs, include *An Introduction to Algebraic Geometry*, Volume 166, *Algebraic Geometry 1: From Algebraic Varieties to Schemes*, Volume 185, and *Algebraic Geometry 2: Sheaves and Cohomology*, Volume 197.

Contents: Kodaira-Spencer mapping; Torelli's theorem; Period mappings and Hodge theory; Conformal field theory; Prospects and remaining problems; Solutions to problems; Bibliography; Index.

Translations of Mathematical Monographs (*Iwanami Series in Modern Mathematics*)

December 2001, approximately 320 pages, Softcover, ISBN 0-8218-2156-3, LC 2001046395, 2000 *Mathematics Subject Classification*: 54C40, 14E20; 46E25, 20C20, **All AMS members** $39, List $49, Order code MMONO-206N

Analysis



Recommended Text

Function Theory of One Complex Variable

Second Edition

Robert E. Greene, *University of California, Los Angeles*, and **Steven G. Krantz**, *Washington University, St. Louis, MO*

From a review of the First Edition:

The book is carefully and precisely written in a lively and soft style. It is extremely clear ... and very detailed. Moreover, it is stimulating and very suitable for self-study ... Certainly, the book reflects the authors' experience in teaching. The other features include the fruitful connection with real analysis ... the authors have produced a modern, quality work that could serve as an excellent model for writing and teaching graduate texts ... it will occupy a distinguished place in the extensive literature on the subject ... I read this book with great pleasure and I warmly recommend it for all those who are interested in complex analysis of one variable.

—Mathematical Reviews

Complex analysis is one of the most beautiful subjects that we learn as graduate students. Part of the joy comes from being able to arrive quickly at some "real theorems". The fundamental techniques of complex variables are also used to solve real problems in neighboring subjects, such as number theory or PDEs.

This book is a text for a first-year graduate course in complex analysis. It is an engaging and modern introduction to the subject, reflecting the authors' expertise both as mathematicians and as expositors.

All the material usually treated in such a course is covered here, but following somewhat different principles. To begin with, the authors emphasize how this subject is a natural outgrowth of multivariable real analysis. Complex function theory has long been a flourishing independent field. However, an efficient path into the subject is to observe how its rudiments arise directly from familiar ideas in calculus. The authors pursue this point of view by comparing and contrasting complex analysis with its real variable counterpart.

Explanations of certain topics in complex analysis can sometimes become complicated by the intermingling of the analysis and the topology. Here, the authors have collected the primary topological issues in a separate chapter, leaving the way open for a more direct and less ambiguous approach to the analytic material.

The book concludes with several chapters on special topics, including full treatments of special functions, the prime number theorem, and the Bergman kernel. The authors also treat H^p spaces and Painlevé's theorem on smoothness to the boundary for conformal maps.

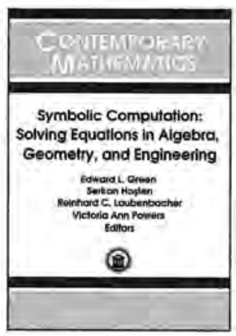
A large number of exercises are included. Some are simply drills to hone the students' skills, but many others are further developments of the ideas in the main text. The exercises are also used to explore the striking interconnectedness of the topics that constitute complex analysis.

Contents: Fundamental concepts; Complex line integrals; Applications of the Cauchy integral; Meromorphic functions and residues; The zeros of a holomorphic function; Holomorphic functions as geometric mappings; Harmonic functions; Infinite series and products; Applications of infinite sums and products; Analytic continuation; Topology; Rational approximation theory; Special classes of holomorphic functions; Hilbert spaces of holomorphic functions, the Bergman kernel, and biholomorphic mappings; Special functions; The prime number theorem; Real analysis; The statement and proof of Goursat's theorem; References; Index.

Graduate Studies in Mathematics, Volume 40

December 2001, approximately 528 pages, Hardcover, ISBN 0-8218-2905-X, LC 2001046415, 2000 *Mathematics Subject Classification*: 30-01; 30-00, 30-02, **All AMS members $55**, List $69, Order code GSM/40N

Applications



Symbolic Computation: Solving Equations in Algebra, Geometry, and Engineering

Edward L. Green, *Virginia Polytechnic Institute and State University, Blacksburg*, **Serkan Hoşten**, *San Francisco State University, CA*, **Reinhard C. Laubenbacher**, *New Mexico State University, Las Cruces*, and **Victoria Ann Powers**, *Emory University, Atlanta, GA*, Editors

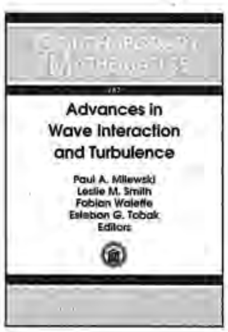
This volume presents the proceedings from the research conference, "Symbolic Computation: Solving Equations in Algebra, Analysis, and Engineering," held at Mount Holyoke College (MA). It provides an overview of current research in symbolic computation as it applies to the solution of polynomial systems. The conference brought together pure and applied mathematicians, computer scientists, and engineers, who use symbolic computation to solve systems of equations or who develop the theoretical background and tools needed for this purpose. Within this general framework, the conference focused on several themes: systems of polynomials, systems of differential equations, noncommutative systems, and applications.

This item will also be of interest to those working in algebra and algebraic geometry.

Contents: D. A. Cox, Equations of parametric curves and surfaces via syzygies; **G. M. Díaz-Toca** and **L. González-Vega**, An explicit description for the triangular decomposition of a zero-dimensional ideal through trace computations; **A. J. Sommese**, **J. Verschelde**, and **C. W. Wampler**, Numerical irreducible decomposition using projections from points on the components; **K. Gatermann**, Counting stable solutions of sparse polynomial systems in chemistry; **I. S. Kotsireas**, Central configurations in the Newtonian N-body problem of celestial mechanics; **D. Napoletani**, A power function approach to Kouchnirenko's conjecture; **J. M. Rojas**, Finiteness for arithmetic fewnomial systems; **D. Grigoriev**, Constructing double-exponential number of vectors of multiplicities of solutions of polynomial systems; **C. D'Andrea** and **I. Z. Emiris**, Computing sparse projection operators; **B. Sturmfels**, Gröbner bases of abelian matrix groups; **G. Boffi** and **F. Rossi**, Lexicographic Gröbner bases of 3-dimensional transportation problems; **E. Briales**, **A. Campillo**, **P. Pisón**, and **A. Vigneron**, Simplicial complexes and syzygies of lattice ideals; **U. Walther**, Algorithmic determination of the rational cohomology of complex varieties via differential forms; **M. Saito** and **W. N. Traves**, Differential algebras on semigroup algebras; **M. J. Bardzell**, Noncommutative Gröbner bases and Hochschild cohomology.

Contemporary Mathematics

December 2001, approximately 248 pages, Softcover, ISBN 0-8218-2679-4, 2000 *Mathematics Subject Classification*: 68W30, 12Y05, 14Q99, 13P10, 11C08, **Individual member $35**, List $59, Institutional member $47, Order code CONM-POWERSN



Advances in Wave Interaction and Turbulence

Paul A. Milewski, **Leslie M. Smith**, and **Fabian Waleffe**, *University of Wisconsin, Madison*, and **Esteban G. Tabak**, *New York University-Courant Institute of Mathematical Sciences, NY*, Editors

We often think of our natural environment as being composed of very many interacting particles, undergoing individual chaotic motions, of which only very coarse averages are perceptible at scales natural to us. However, we could as well think of the world as being made out of individual waves. This is so not just because the distinction between waves and particles becomes rather blurred at the atomic level, but also because even phenomena at much larger scales are better described in terms of waves rather than of particles: It is rare in both fluids and solids to observe energy being carried from one region of space to another by a given set of material particles; much more often, this transfer occurs through chains of particles, neither of them moving much, but each communicating with the next, and hence creating these immaterial objects we call waves.

Waves occur at many spatial and temporal scales. Many of these waves have small enough amplitude that they can be approximately described by linear theory. However, the joint effect of large sets of waves is governed by nonlinear interactions which are responsible for huge cascades of energy among very disparate scales. Understanding these energy transfers is crucial in order to determine the response of large systems, such as the atmosphere and the ocean, to external forcings and dissipation mechanisms which act on scales decades apart.

The field of wave turbulence attempts to understand the average behavior of large ensembles of waves, subjected to forcing and dissipation at opposite ends of their spectrum. It does so by studying individual mechanisms for energy transfer, such as resonant triads and quartets, and attempting to draw from them effects that should not survive averaging.

This book presents the proceedings of the AMS-IMS-SIAM Joint Summer Research Conference on Dispersive Wave Turbulence held at Mt. Holyoke College (MA). It drew together a group of researchers from many corners of the world, in the context of a perceived renaissance of the field, driven by heated debate about the fundamental mechanism of energy transfer among large sets of waves, as well as by novel applications—and old ones revisited—to the understanding of the natural world. These proceedings reflect the spirit that permeated the conference, that of friendly scientific disagreement and genuine wonder at the rich phenomenology of waves.

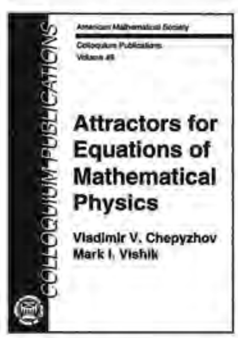
This item will also be of interest to those working in differential equations.

Contents: **A. Babin**, **A. Mahalov**, and **B. Nicolaenko**, Strongly stratified limit of 3D primitive equations in an infinite layer; **A. M. Balk**, Anomalous transport by wave turbulence; **R. Jordan** and **B. Turkington**, Statistical equilibrium theories for the nonlinear Schrödinger equation; **R. M. Kerr**, Is there a 2D cascade in 3D convection?; **F. Menzaque**, **R. R. Rosales**, **E. G. Tabak**, and **C. V. Turner**, The forced inviscid Burgers equation as a model for nonlinear interactions among dispersive waves; **P. Panayotaros**, Traveling surface elastic waves in the half-plane; **L. M. Smith**, Numerical study of two-dimensional stratified turbulence; **V. E. Zakharov**, **P. Guyenne**, **A. N. Pushkarev**, and **F. Dias**, Turbulence of one-dimensional weakly nonlinear dispersive waves.

Contemporary Mathematics, Volume 283

October 2001, 116 pages, Softcover, ISBN 0-8218-2714-6, LC 2001046252, 2000 *Mathematics Subject Classification*: 76B15, 35Q53, 37K10, 76B60, 74J20, 74J30, 76F55, 76F65, **Individual member $23**, List $39, Institutional member $31, Order code CONM/283N

Differential Equations



Independent Study

Attractors for Equations of Mathematical Physics

Vladimir V. Chepyzhov and **Mark I. Vishik**, *Russian Academy of Sciences, Moscow, Russia*

One of the major problems in the study of evolution equations of mathematical physics is the investigation of the behavior of the solutions to these equations when time is large or tends to infinity. The related important questions concern the stability of solutions or the character of the instability if a solution is unstable. In the last few decades, considerable progress in this area has been achieved in the study of autonomous evolution partial differential equations. For a number of basic evolution equations of mathematical physics, it was shown that the long time behavior of their solutions can be characterized by a very important notion of a global attractor of the equation.

In this book, the authors study new problems related to the theory of infinite-dimensional dynamical systems that were intensively developed during the last 20 years. They construct the attractors and study their properties for various non-autonomous equations of mathematical physics: the 2D and 3D Navier-Stokes systems, reaction-diffusion systems, dissipative wave equations, the complex Ginzburg-Landau equation, and others. Since, as it is shown, the attractors usually have infinite dimension, the research is focused on the Kolmogorov ε-entropy of attractors. Upper estimates for the ε-entropy of uniform attractors of non-autonomous equations in terms of ε-entropy of time-dependent coefficients are proved.

Also, the authors construct attractors for those equations of mathematical physics for which the solution of the corresponding Cauchy problem is not unique or the uniqueness is not proved. The theory of the trajectory attractors for these equations is developed, which is later used to construct global attractors for equations without uniqueness. The method of trajectory attractors is applied to the study of finite-dimensional approximations of attractors. The perturbation theory for trajectory and global attractors is developed and used in the study of the attractors of equations with terms rapidly oscillating with respect to spatial and time variables. It is shown that the attractors of these equations are contained in a thin neighborhood of the attractor of the averaged equation.

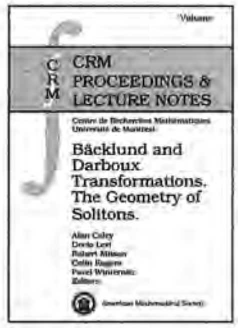
The book gives systematic treatment to the theory of attractors of autonomous and non-autonomous evolution equations of mathematical physics. It can be used both by specialists and by those who want to get acquainted with this rapidly growing and important area of mathematics.

This item will also be of interest to those working in applications.

Contents: Introduction; *Attractors of autonomous equations:* Attractors of autonomous ordinary differential equations; Attractors of autonomous partial differential equations; Dimension of attractors; *Attractors of non-autonomous equations:* Processes and attractors; Translation compact functions; Attractors of non-autonomous partial differential equations; Semiprocesses and attractors; Kernels of processes; Kolmogorov ε-entropy of attractors; *Trajectory attractors:* Trajectory attractors of autonomous ordinary differential equations; Attractors in Hausdorff spaces; Trajectory attractors of autonomous equations; Trajectory attractors of autonomous partial differential equations; Trajectory attractors of non-autonomous equations; Trajectory attractors of non-autonomous partial differential equations; Approximation of trajectory attractors; Perturbation of trajectory attractors; Averaging of attractors of evolution equations with rapidly oscillating terms; Proofs of Theorems II.1.4 and II.1.5; Lattices and coverings; Bibliography; Index.

Colloquium Publications, Volume 49

December 2001, 363 pages, Hardcover, ISBN 0-8218-2950-5, LC 2001046406, 2000 *Mathematics Subject Classification*: 35K90, 35B40, 37C70, 37L30; 35Q99, 35Q30, 35L70, 35K57, **All AMS members $55**, List $69, Order code COLL/49N



Bäcklund and Darboux Transformations. The Geometry of Solitons

Alan Coley, *Dalhousie University, Halifax, NS, Canada*, **Decio Levi**, *University of Rome III, Italy*, **Robert Milson**, *Dalhousie University, Halifax, NS, Canada*, **Colin Rogers**, *University of New South Wales, Sydney, NSW, Australia*, and **Pavel Winternitz**, *Université de Montréal, QC, Canada*, Editors

This book is devoted to a classical topic that has undergone rapid and fruitful development over the past 25 years, namely Bäcklund and Darboux transformations and their applications in the theory of integrable systems, also known as soliton theory.

The book consists of two parts. The first is a series of introductory pedagogical lectures presented by leading experts in the field. They are devoted respectively to Bäcklund transformations of Painlevé equations, to the dressing method and Bäcklund and Darboux transformations, and to the classical geometry of Bäcklund transformations and their applications to soliton theory. The second part contains original contributions that represent new developments in the theory and applications of these transformations.

Both the introductory lectures and the original talks were presented at an International Workshop that took place in Halifax, Nova Scotia (Canada). This volume covers virtually all recent developments in the theory and applications of Bäcklund and Darboux transformations.

Contents: *Introductory lectures:* **V. I. Gromak**, Bäcklund transformations of the higher order Painlevé equations; **D. Levi** and **O. Ragnisco**, Dressing method and Bäcklund and Darboux transformations; **C. Rogers** and **W. K. Schief**, The classical geometry of Bäcklund transformations. Introduction to applications in soliton theory; **W. K. Schief**, An introduction to integrable difference and differential geometries: Affine spheres, their natural generalization and discretization; *Original contributions:* **Yu. Aminov** and **A. Sym**, On Bianchi and Bäcklund transformations of two dimensional surfaces in four dimensional Euclidean space; **I. M. Anderson**, **M. E. Fels**, and **C. G. Torre**, Group invariant solutions without transversality and the principle of symmetric criticality; **H. Aratyn**, **E. Nissimov**, and **S. Pacheva**, Multi-component matrix KP hierarchies as symmetry-enhanced scalar KP hierarchies and their Darboux-Bäcklund solutions; **J. L. Cieśliński**, The Darboux-Bäcklund transformation and Clifford algebras; **P. A. Clarkson**, **E. L. Mansfield**, and **H. N. Webster**, On discrete Painlevé equations as Bäcklund transformations; **J. N. Clelland**, A Bäcklund transformation for timelike surfaces of constant mean curvature in $\mathbb{R}^{1,2}$; **A. V. Corro**, **W. Ferreira**, and **K. Tenenblat**, On Ribaucour transformations; **A. Doliwa**, The Ribaucour congruences of spheres within Lie sphere geometry; **N. M. Ercolani**, Bäcklund transformations for the reduced Maxwell-Bloch equations; **E. V. Ferapontov**, Transformations of quasilinear systems originating from the projective theory of congruences; **E. V. Ferapontov** and **A. M. Grundland**, Bäcklund links between different analytic descriptions of constant mean curvature surfaces; **F. Finkel**, On the integrability of Weingarten surfaces; **F. Finkel** and **A. S. Fokas**, A new immersion formula for surfaces on Lie algebras and integrable equations; **J. D. Finley III**, Difficulties with the SDiff(2) Toda equation; **M. Havlíček**, **S. Pošta**, and **P. Winternitz**, Superposition formulas based on nonprimitive group action; **R. H. Heredero**, **D. Levi**, **M. A. Rodríguez**, and **P. Winternitz**, Symmetries of differential difference equations and Lie algebra contractions; **J. Hietarinta**, Bäcklund transformations from the bilinear viewpoint; **L. Hlavatý**, Towards the Lax formulation of SU(2) principal models with nonconstant metric; **C. A. Hoenselaers** and **S. Micciché**, Transcendental solutions of the sine-Gordon equation; **T. Ioannidou**, **B. Piette**, and **W. J. Zakrzewski**, Three dimensional skyrmions and harmonic maps; **B. G. Konopelchenko** and **G. Landolfi**, Induced surfaces and their integrable deformations; **M. Kovalyov**, Properties of a class of slowly decaying oscillatory solutions of KdV; **S. Lafortune**, **A. Ramani**, **B. Grammaticos**, **Y. Ohta**, and **K. M. Tamizhmani**, Blending two discrete integrability criteria: Singularity confinement and algebraic entropy; **W.-X. Ma** and **X. Geng**, Bäcklund transformations of soliton systems from symmetry constraints; **P. Mathieu**, Open problems for the super KdV equations; **R. Milson**, Combinatorial aspects of the Darboux transformation; **M. Musette**, **R. Conte**, and **C. Verhoeven**, Bäcklund transformation and nonlinear superposition formula of the Kaup-Kupershmidt and Tzitzéica equations; **P. J. Olver**, **J. A. Sanders**, and **J. P. Wang**, Classification of symmetry-integrable evolution equations; **E. G. Reyes**, Integrability of evolution equations and pseudo-spherical surfaces; **C. Rogers** and **W. K. Schief**, Infinitesimal Bäcklund transformations of *K*-nets. The 2 + 1-dimensional Sinh-Gordon system; **W. K. Schief**, Isothermic surfaces and the Calapso equation: The full Monty; **R. Schmid**, Bäcklund transformations induced by symmetries. Application: Discrete mKdV; **H. Steudel**, Darboux transformation for a spectral problem quadratic in the spectral parameter; **Z. Thomova** and **P. Winternitz**, Separation of variables and Darboux transformations; **P. Winternitz**, Bäcklund transformations as nonlinear ordinary differential, or difference equations with superposition formulas.

CRM Proceedings & Lecture Notes

November 2001, approximately 456 pages, Softcover, ISBN 0-8218-2803-7, 2000 *Mathematics Subject Classification*: 37K35, 35Q51, 17B80, 35Qxx, 37Kxx, **Individual member $71**, List $119, Institutional member $95, Order code CRMP-WINTERNITZN

General and Interdisciplinary

Supplementary Reading

Kvant Selecta: Combinatorics, I

Serge Tabachnikov, *University of Arkansas at Fayetteville*, Editor

There is a tradition in Russia that holds that mathematics can be both challenging and fun. One fine outgrowth of that tradition is the magazine, *Kvant*, which has been enjoyed by many of the best students since its founding in 1970. The articles in *Kvant* assume only a minimal background, that of a good high school student, yet are capable of entertaining mathematicians of almost any level. Sometimes the articles require careful thought or a moment's work with a pencil and paper. However, the industrious reader will be generously rewarded by the elegance and beauty of the subjects.

This book is the third collection of articles from *Kvant* to be published by the AMS. The volume is devoted mainly to combinatorics and discrete mathematics. Several of the topics are well known: nonrepeating sequences, detecting a counterfeit coin, and linear inequalities in economics, but they are discussed here with the entertaining and engaging style typical of the magazine. The two previous collections treat aspects of algebra and analysis, including connections to number theory and other topics. They were published as Volumes 14 and 15 in the Mathematical World series.

The articles are written so as to present genuine mathematics in a conceptual, entertaining, and accessible way. The books are designed to be used by students and teachers who love mathematics and want to study its various aspects, deepening and expanding upon the school curriculum.

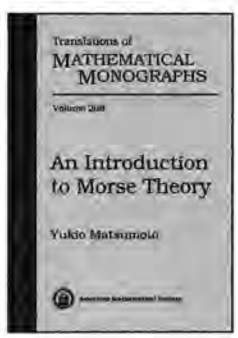
This item will also be of interest to those working in discrete mathematics and combinatorics.

Contents: I. M. Yaglom, Two games with matchsticks; **A. B. Katok**, Economics and linear inequalities; **A. B. Katok**, Economics and linear inequalities (Continuation); **R. V. Freivald**, Switching networks; **G. M. Adel'son-Vel'skiĭ**, **I. N. Bernshteĭn**, and **M. L. Gerver**, Who will go to Rio?; **A. L. Toom**, From the life of units; **G. A. Gurevich**, Nonrepeating sequences; **A. M. Stepin** and **A. T. Tagi-Zade**, Words with restrictions; **S. Ovchinnikov**, Planar switching circuits; **P. Bleher** and **M. Kelbert**, Classification algorithms; **G. Shestopal**, How to detect a counterfeit coin; **M. Mamikon**, The generalized problem of counterfeit coins; **P. Bleher**, Truthtellers, liars, and deceivers; **V. A. Uspenskiĭ** and **A. L. Semenov**, Solvable and unsolvable algorithmic problems; **P. A. Pevzner**, Best bet for simpletons.

Mathematical World

January 2002, approximately 136 pages, Softcover, ISBN 0-8218-2171-7, 2000 *Mathematics Subject Classification*: 00–01, 00A08; 97A20, **All AMS members $23**, List $29, Order code MAWRLD/17N

Geometry and Topology



Supplementary Reading

An Introduction to Morse Theory

Yukio Matsumoto, *University of Tokyo, Japan*

In a very broad sense, "spaces" are objects of study in geometry, and "functions" are objects of study in analysis. There are, however, deep relations between functions defined on a space and the shape of the space, and the study of these relations is the main theme of Morse theory. In particular, its feature is to look at the critical points of a function, and to derive information on the shape of the space from the information about the critical points.

Morse theory deals with both finite-dimensional and infinite-dimensional spaces. In particular, it is believed that Morse theory on infinite-dimensional space will become more and more important in the future as mathematics advances.

This book describes Morse theory for finite dimensions. Finite-dimensional Morse theory has an advantage in that it is easier to present fundamental ideas than in infinite-dimensional Morse theory, which is theoretically more involved. Therefore, finite-dimensional Morse theory is more suitable for beginners to study.

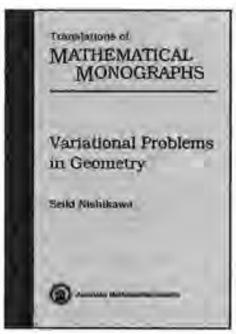
On the other hand, finite-dimensional Morse theory has its own significance, not just as a bridge to infinite dimensions. It is an indispensable tool in the topological study of manifolds. That is, one can decompose manifolds into fundamental blocks such as cells and handles by Morse theory, and thereby compute a variety of topological invariants and discuss the shapes of manifolds. These aspects of Morse theory will continue to be a treasure in geometry for years to come.

This textbook aims at introducing Morse theory to advanced undergraduates and graduate students. It is the English translation of a book originally published in Japanese.

Contents: Morse theory on surfaces; Extension to general dimensions; Handelbodies; Homology of manifolds; Low dimensional manifolds; A view from current mathematics; Answers to exercises; Bibliography; Recommended reading; Index.

Translations of Mathematical Monographs (*Iwanami Series in Modern Mathematics*)

December 2001, approximately 232 pages, Softcover, ISBN 0-8218-1022-7, 2000 *Mathematics Subject Classification*: 57-01; 57R19, 57R65, 57R70, 57M25, 57M99, **All AMS members $31**, List $39, Order code MMONO-208N



Supplementary Reading

Variational Problems in Geometry

Seiki Nishikawa, *Mathematical Institute, Tohoku University, Sendai, Japan*

A minimal length curve joining two points in a surface is called a geodesic. One may trace the origin of the problem of finding geodesics back to the birth of calculus.

Many contemporary mathematical problems, as in the case of geodesics, may be formulated as variational problems in surfaces or in a more generalized form on manifolds. One may characterize geometric variational problems as a field of mathematics that studies global aspects of variational problems relevant in the geometry and topology of manifolds. For example, the problem of finding a surface of minimal area spanning a given frame of wire originally appeared as a mathematical model for soap films. It has also been actively investigated as a geometric variational problem. With recent developments in computer graphics, totally new aspects of the study on the subject have begun to emerge.

This book is intended to be an introduction to some of the fundamental questions and results in geometric variational problems, studying the variational problems on the length of curves and the energy of maps.

The first two chapters treat variational problems of the length and energy of curves in Riemannian manifolds, with an in-depth discussion of the existence and properties of geodesics viewed as solutions to variational problems. In addition, a special emphasis is placed on the facts that concepts of connection and covariant differentiation are naturally induced from the formula for the first variation in this problem, and that the notion of curvature is obtained from the formula for the second variation.

The last two chapters treat the variational problem on the energy of maps between two Riemannian manifolds and its solution, harmonic maps. The concept of a harmonic map includes geodesics and minimal submanifolds as examples. Its existence and properties have successfully been applied to various problems in geometry and topology. The author discusses in detail the existence theorem of Eells-Sampson, which is considered to be the most fundamental among existence theorems for harmonic maps. The proof uses the inverse function theorem for Banach spaces. It is presented to be as self-contained as possible for easy reading.

Each chapter may be read independently, with minimal preparation for covariant differentiation and curvature on manifolds. The first two chapters provide readers with basic knowledge of Riemannian manifolds. Prerequisites for reading this book include elementary facts in the theory of manifolds and functional analysis, which are included in the form of appendices. Exercises are given at the end of each chapter.

This is the English translation of a book originally published in Japanese. It is an outgrowth of lectures delivered at Tohoku University and at the Summer Graduate Program held at the Institute for Mathematics and its Applications at the University of Minnesota. It would make a suitable textbook for advanced undergraduates and graduate students. This item will also be of interest to those working in analysis.

Contents: Arc-length of curves and geodesics; First and second variation formulas; Energy of maps and harmonic maps; Existence of harmonic maps; Fundamentals of theory of manifolds and functional analysis; Prospects for contemporary mathematics; Books; Solutions to exercise problems; Bibliography; Index.

Translations of Mathematical Monographs (*Iwanami Series in Modern Mathematics*)

January 2002, approximately 240 pages, Softcover, ISBN 0-8218-1356-0, LC 2001046350, 2000 *Mathematics Subject Classification*: 53-01, 53C21, 53C43, 58E20, 58J35, **All AMS members $31**, List $39, Order code MMONO-NISHIKAWAN

Mathematical Physics

Collected Papers on Wave Mechanics
Third Edition
Erwin Schrödinger

This third, augmented edition contains the six original, famous papers in which Schrödinger created and developed the subject of Wave Mechanics as published in the original edition. As the author points out, at the time each paper was written the results of the later papers were largely unknown to him. The papers and lectures in this volume were revised by the author and translated into English, and afford the reader a striking and valuable insight into how Wave Mechanics developed.

Contents: *Papers:* Quantisation as a problem of proper values. Part I; Quantisation as a problem of proper values. Part II; The continuous transition from micro- to macro-mechanics; On the relation between the quantum mechanics of Heisenberg, Born, and Jordan, and that of Schrödinger; Quantisation as a problem of proper values. Part III; Quantisation as a problem of proper values. Part IV; The Compton effect; The energy-momentum theorem for material waves; The exchange of energy according to wave mechanics; *Lectures:* Derivation of the fundamental idea of wave mechanics from Hamilton's analogy between ordinary mechanics and geometrical optics; Ordinary mechanics only an approximation, which no longer holds for very small systems; Bohr's stationary energy-levels derived as the frequencies of proper vibrations of the waves; Rough description of the wave-systems in the hydrogen atom. Degeneracy. Perturbation; The physical meaning of the wave function. Explanation of the selection rules and of the rules for the polarization of spectral lines; Derivation of the wave equation (properly speaking) which contains the time; An atom as perturbed by an alternating electric field; Theory of secondary radiation and dispersion; Theory of resonance radiation, and of changes of the state of the atom produced by incident radiation whose frequency coincides, or nearly coincides, with a natural emission frequency; Extension of wave mechanics to systems other than a single mass-point; Examples: the oscillator, the rotator; Correction for motion of the nucleus in the hydrogen atom; Perturbation of an arbitrary system; Interaction between two arbitrary systems; The physical meaning of the generalized ψ-function.

AMS Chelsea Publishing

October 1997, 224 pages, Softcover, ISBN 0-8218-2976-9, 2000 *Mathematics Subject Classification*: 01A75, 81-03; 81-XX, **All AMS members $18**, List $20, Order code CHEL/302.SN

Previously Announced Publications

Recommended Text

Geometry of Manifolds
Richard L. Bishop, *University of Illinois, Urbana*, and Richard J. Crittenden

From a review for the First Edition:

This book represents an excellent treatment of a wide section of modern differential geometry ... The style is elegant and at the same time considerate for the needs of a beginner ... a great number of well chosen problems with pertinent references ... anybody who chooses to base his course on differential geometry at the graduate level on this book could do no better.
—Mathematical Reviews

From the Preface of the First Edition: "Our purpose in writing this book is to put material which we found stimulating and interesting as graduate students into form. It is intended for individual study and for use as a text for graduate level courses such as the one from which this material stems, given by Professor W. Ambrose at MIT in 1958–1959. Previously the material had been organized in roughly the same form by him and Professor I. M. Singer, and they in turn drew upon the work of Ehresmann, Chern, and É. Cartan. Our contributions have been primarily to fill out the material with details, asides and problems, and to alter notation slightly.

"We believe that this subject matter, besides being an interesting area for specialization, lends itself especially to a synthesis of several branches of mathematics, and thus should be studied by a wide spectrum of graduate students so as to break away from narrow specialization and see how their own fields are related and applied in other fields. We feel that at least part of this subject should be of interest not only to those working in geometry, but also to those in analysis, topology, algebra, and even probability and astronomy. In order that this book be meaningful, the reader's background should include real variable theory, linear algebra, and point set topology."

This volume is a reprint with few corrections of the original work published in 1964. Starting with the notion of differential manifolds, the first six chapters lay a foundation for the study of Riemannian manifolds through specializing the theory of connections on principle bundles and affine connections. The geometry of Riemannian manifolds is emphasized, as opposed to global analysis, so that the theorems of Hopf-Rinow, Hadamard-Cartan, and Cartan's local isometry theorem are included, but no elliptic operator theory. Isometric immersions are treated elegantly and from a global viewpoint. In the final chapter are the more complicated estimates on which much of the research in Riemannian geometry is based: the Morse index theorem, Synge's theorems on closed geodesics, Rauch's comparison theorem, and the original proof of the Bishop volume-comparison theorem (with Myer's Theorem as a corollary).

The first edition of this book was the origin of a modern treatment of global Riemannian geometry, using the carefully conceived notation that has withstood the test of time. The primary source material for the book were the papers and course notes of brilliant geometers, including É. Cartan, C. Ehresmann, I. M. Singer, and W. Ambrose. It is tightly organized, uniformly very precise, and amazingly comprehensive for its length.

AMS Chelsea Publishing

October 2001, 273 pages, Hardcover, ISBN 0-8218-2923-8, 2000 *Mathematics Subject Classification*: 53-01, **All AMS members $35**, List $39, Order code CHEL/344.HRT111

Independent Study

Mathematics of Information and Coding

Te Sun Han and **Kingo Kobayashi**, *The University of Electro-Communications, Tokyo, Japan*

This book is intended to provide engineering and/or statistics students, communications engineers, and mathematicians with the firm theoretic basis of *source coding* (or *data compression*) in information theory. Although information theory consists of two main areas, source coding and channel coding, the authors choose here to focus only on source coding. The reason is that, in a sense, it is more basic than channel coding, and also because of recent achievements in source coding and compression. An important feature of the book is that whenever possible, the author describes *universal* coding methods, i.e., the methods that can be used without prior knowledge of the statistical properties of the data. The authors approach the subject of source coding from the very basics to the top frontiers in an intuitively transparent, but mathematically sound manner.

The book serves as a theoretical reference for communication professionals and statisticians specializing in information theory. It will also serve as an excellent introductory text for advanced-level and graduate students taking elementary or advanced courses in telecommunications, electrical engineering, statistics, mathematics, and computer science.

Translations of Mathematical Monographs

December 2001, approximately 296 pages, Hardcover, ISBN 0-8218-0534-7, LC 2001041262, 2000 *Mathematics Subject Classification*: 00A69, 94-02, 94A24, 94A29, 94A15, 94A45, 68P30, 62F03, 62F12, **Individual member $59**, List $99, Institutional member $79, Order code MMONO-HANRT111

Lebesgue's Theory of Integration: Its Origins and Development

Thomas Hawkins, *Boston University, MA*

From reviews for the original edition:

Thomas Hawkins has set out to place Lebesgue's early work on integration theory ... within its proper historical context ... He has succeeded brilliantly ... [He] has been able to convey the excitement of discovery and groping that must attend the birth of any fundamental theory ... [He] has written a book that is the epitome of what a mathematical history should be.

—Science

This is a book which can be recommended to every mathematician.

—Zentralblatt für Mathematik

A clear exposition ...

—Nature

Hawkins has written an excellent book, of value both to mathematicians and historians of science ... Any teacher of advanced calculus will find the material in this book invaluable in motivating the introduction of Lebesgue's theory.

—Isis

The success of the book will be ensured because it is a genuinely historical study.

—British Journal of the History of Science

An interesting book ... valuable to the worker in the field ... brings out a number of ideas and results ... It can be recommended highly to students who are getting their introduction to Lebesgue integration, particularly because it shows how an important mathematical idea develops, sometimes slowly, until it becomes an aesthetically satisfying structure.

—MAA Monthly

Lebesgue integration is one of the great success stories of modern mathematics, and Hawkins tells it very well. An introductory chapter sets the scene, describing how the first rigorous theory of integration took shape at the hands of Cauchy and Riemann. The book then plunges into fifty years of ferment, as researchers struggle to deal with "assumptionless" functions which will not fit the theory. Differentiable functions turn up with bounded derivatives which are not (Riemann) integrable; do they satisfy the fundamental theorem of calculus? Rectifiable curves are defined without assuming differentiability; must we give up the integral formula for length? To prove uniqueness for trigonometric series, we need a term-by-term integration of a series not converging uniformly; can it be justified? [One] falls into traps through not understanding the complexity of nowhere-dense sets, and through confusing them with the sets negligible in integration. The valid theorems have complicated hypotheses and even more complicated proofs. At the end of the century Hermite exclaims, "I turn away with fright and horror from this lamentable plague of functions which do not have derivatives." And then the key idea enters from a quite unexpected source.

—Bulletin of the AMS

In this book, Hawkins elegantly places Lebesgue's early work on integration theory within in proper historical context by relating it to the developments during the nineteenth century that motivated it and gave it significance and also to the contributions made in this field by Lebesgue's contemporaries.

Hawkins was awarded the 1997 MAA Chauvenet Prize and the 2001 AMS Albert Leon Whiteman Memorial Prize for notable exposition and exceptional scholarship in the history of mathematics.

This item will also be of interest to those working in analysis.

AMS Chelsea Publishing

September 2001, 227 pages, Hardcover, ISBN 0-8218-2963-7, 2000 *Mathematics Subject Classification*: 28-03, 01A05; 01A75, **All AMS members $26**, List $29, Order code CHEL/282.HRT111

Stochastic Analysis on Manifolds

Elton P. Hsu, *Northwestern University, Evanston*

Probability theory has become a convenient language and a useful tool in many areas of modern analysis. The main purpose of this book is to explore part of this connection concerning the relations between Brownian motion on a manifold and analytical aspects of differential geometry. A dominant theme of the book is the probabilistic interpretation of the curvature of a manifold.

The book begins with a brief review of stochastic differential equations on Euclidean space. After presenting the basics of stochastic analysis on manifolds, the author introduces Brownian motion on a Riemannian manifold and studies the effect of curvature on its behavior. He then applies Brownian motion to geometric problems and vice versa, using many well-known examples, e.g., short-time behavior of the heat kernel on a manifold and probabilistic proofs of the Gauss-Bonnet-Chern theorem and the Atiyah-Singer index theorem for Dirac operators. The book concludes with an introduction to stochastic analysis on the path space over a Riemannian manifold.

This item will also be of interest to those working in geometry and topology.

Graduate Studies in Mathematics, Volume 38

November 2001, approximately 273 pages, Hardcover, ISBN 0-8218-0802-8, LC 2001046052, 2000 *Mathematics Subject Classification*: 58J65, 60J60, 60J65, **All AMS members $35**, List $44, Order code GSM/38RT111

The Concentration of Measure Phenomenon

Michel Ledoux, *Université Paul-Sabatier, Toulouse, France*

The observation of the concentration of measure phenomenon is inspired by isoperimetric inequalities. A familiar example is the way the uniform measure on the standard sphere S^n becomes concentrated around the equator as the dimension gets large. This property may be interpreted in terms of functions on the sphere with small oscillations, an idea going back to Lévy. The phenomenon also occurs in probability, as a version of the law of large numbers, due to Emil Borel. This book offers the basic techniques and examples of the concentration of measure phenomenon. The concentration of measure phenomenon was put forward in the early seventies by V. Milman in the asymptotic geometry of Banach spaces. It is of powerful interest in applications in various areas, such as geometry, functional analysis and infinite-dimensional integration, discrete mathematics and complexity theory, and probability theory. Particular emphasis is on geometric, functional, and probabilistic tools to reach and describe measure concentration in a number of settings.

The book presents concentration functions and inequalities, isoperimetric and functional examples, spectrum and topological applications, product measures, entropic and transportation methods, as well as aspects of M. Talagrand's deep investigation of concentration in product spaces and its application in discrete mathematics and probability theory, supremum of Gaussian and empirical processes, spin glass, random matrices, etc. Prerequisites are a basic background in measure theory, functional analysis, and probability theory.

This item will also be of interest to those working in probability.

Mathematical Surveys and Monographs, Volume 89

October 2001, 181 pages, Hardcover, ISBN 0-8218-2864-9, LC 2001041310, 2000 *Mathematics Subject Classification*: 28Axx, 46Bxx, 52Axx, 60-XX; 28C20, 28D20, 46G12, 58C30, 62G30, 82B44, **Individual member $35**, List $59, Institutional member $47, Order code SURV/89RT111

Independent Study

Oscillating Patterns in Image Processing and Nonlinear Evolution Equations

The Fifteenth Dean Jacqueline B. Lewis Memorial Lectures

Yves Meyer, *École Normale Supérieure de Cachan, France*

Image compression, the Navier-Stokes equations, and detection of gravitational waves are three seemingly unrelated scientific problems that, remarkably, can be studied from one perspective. The notion that unifies the three problems is that of "oscillating patterns", which are present in many natural images, help to explain nonlinear equations, and are pivotal in studying chirps and frequency-modulated signals.

The first chapter of this book considers image processing, more precisely algorithms of image compression and denoising. This research is motivated in particular by the new standard for compression of still images known as JPEG-2000. The second chapter has new results on the Navier-Stokes and other nonlinear evolution equations. Frequency-modulated signals and their use in the detection of gravitational waves are covered in the final chapter.

In the book, the author describes both what the oscillating patterns are and the mathematics necessary for their analysis. It turns out that this mathematics involves new properties of various Besov-type function spaces and leads to many deep results, including new generalizations of famous Gagliardo-Nirenberg and Poincaré inequalities.

This book is based on the "Dean Jacqueline B. Lewis Memorial Lectures" given by the author at Rutgers University. It can be used either as a textbook in studying applications of wavelets to image processing or as a supplementary resource for studying nonlinear evolution equations or frequency-modulated signals. Most of the material in the book did not appear previously in monograph literature.

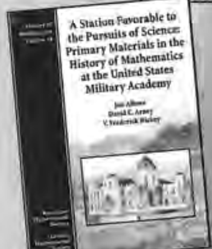
This item will also be of interest to those working in analysis.

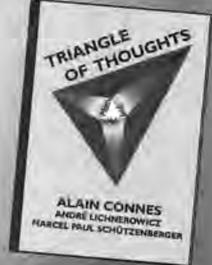
University Lecture Series, Volume 22

September 2001, approximately 136 pages, Softcover, ISBN 0-8218-2920-3, 2000 *Mathematics Subject Classification*: 35Q30, 42C40, 65T60, 76D05, 76D06, **All AMS members $20**, List $25, Order code ULECT/22RT111

American Mathematical Society

PUBLICATIONS *of* CONTINUING INTEREST





Selected Publications of General Interest

These are some of our popular selections in the area of general interest. These books offer to a broad audience definitive historical, biographical, and educational perspectives on mathematics. For more publications in this subject area, visit the AMS Bookstore at **www.ams.org/bookstore.**

A Station Favorable to the Pursuits of Science: Primary Materials in the History of Mathematics at the United States Military Academy

Joe Albree, *Auburn University at Montgomery, AL,* and **David C. Arney** and **V. Frederick Rickey**, *United States Military Academy, West Point, NY*

The heart of this valuable reference work is the first complete, unified bibliographical listing of the 1,340 extant mathematical items acquired by the United States Military Academy at West Point from its founding in 1802 to the beginning of the First World War. ***—Mathematical Reviews***

Copublished with the London Mathematical Society. Members of the LMS may order directly from the AMS at the AMS member price. The LMS is registered with the Charity Commissioners.

History of Mathematics, Volume 18; 2000; ISBN 0-8218-2059-1; 272 pages; Hardcover; **Individual member $35**, List $59, Institutional member $47, Order Code HMATH/18CT111

Recommended Text

Triangle of Thoughts

Alain Connes, **André Lichnerowicz**, and **Marcel Paul Schützenberger**

2001; ISBN 0-8218-2614-X; 179 pages; Hardcover; **All AMS members $24**, List $30, Order Code TOTCT111

Supplementary Reading

The Game's Afoot! Game Theory in Myth and Paradox

Alexander Mehlmann, *Vienna University of Technology, Austria*

From reviews of the German edition:

The author, well known for various imaginative, entertaining and instructive writings in the area of game theory, and for his game-theoretic excursions into classical literature, has now brought out this delightful little book on the basics of noncooperative games ... [The book is] rewarding reading for a rather wide variety of reasonably well-educated persons. The reader will gain an appreciation for the mathematical modelling of conflict in economics, the social sciences and biology, and get a glimpse of game-theoretic analysis of conflict in some of the classical literature. ***—Zentralblatt für Mathematik***

Student Mathematical Library, Volume 5; 2000; ISBN 0-8218-2121-0; 159 pages; Softcover; **All AMS members $21**, List $26, Order Code STML/5CT111

The Fermat Diary

C. J. Mozzochi, *Princeton, NJ*

The author provides a splendid eyewitness account of the drama surrounding the proof of Fermat's Last Theorem by Andrew Wiles ... The text provides compulsive reading ... I cannot imagine anyone directly involved with the events leading up to the proof of Fermat's Last Theorem not wanting a copy of this lovely book. For others, the book provides an entertaining and marvelous record of a landmark in mathematical history. ***—Mathematical Reviews***

2000; ISBN 0-8218-2670-0; 196 pages; Hardcover; **All AMS members $23**, List $29, Order Code FERMATDCT111

Timely Topic

Chaotic Elections! A Mathematician Looks at Voting

Donald G. Saari, *University of California, Irvine*

2001; ISBN 0-8218-2847-9; 159 pages; Softcover; **All AMS members $18**, List $23, Order Code ELECTCT111

Recommended Text

A Gentle Introduction to Game Theory

Saul Stahl, *University of Kansas, Lawrence*

This book is an excellent introduction to the mathematical aspects of game theory for beginners without a background in calculus. ***—Journal of Mathematical Psychology***

There is not a faster read in the realm of higher mathematics. Recommended for college libraries. Undergraduates and up. ***—CHOICE***

Mathematical World, Volume 13; 1999; ISBN 0-8218-1339-0; 176 pages; Softcover; **All AMS members $21**, List $26, Order Code MAWRLD/13CT111

To order, call: 1-800-321-4AMS (4267), in the U.S. and Canada, or 1-401-455-4000; fax: 1-401-455-4046; email: cust-serv@ams.org. Visit the AMS Bookstore and order online at www.ams.org/bookstore. Or write to: American Mathematical Society, 201 Charles St., Providence, RI 02904-2294. Prices subject to change without notice.

AMS
American Mathematical Society

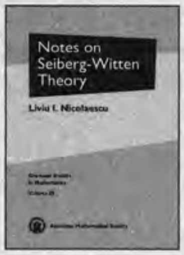
For more publications in your subject area visit the AMS Bookstore: www.ams.org/bookstore.

American Mathematical Society

AMS Publisher's Discount *on* Books in Popular Series

Limited time only! These and many more titles are available at substantial discounts on the AMS Bookstore. Order online at www.ams.org/bookstore. Sale ends 12/20/01.

Graduate Studies *in* Mathematics



Subject range and in-depth topic coverage make this series appealing to both students and professors. Books in this series are specifically designed as graduate studies texts and are also ideal for supplementary course reading or independent study.

Recommended Text

Algebraic Curves and Riemann Surfaces

Rick Miranda, *Colorado State University, Ft. Collins*

A wealth of concrete examples ... enhance the rich theoretical material developed in the course of the exposition, very much so to the benefit of the reader. Another advantage of this excellent text is provided by the pleasant and vivid manner of writing ... Altogether, the present book is a masterly written, irresistible invitation to complex algebraic geometry and its generalization to the rich theory of algebraic schemes.

—Zentralblatt für Mathematik

Graduate Studies in Mathematics, Volume 5; 1995; 390 pages; Hardcover; ISBN 0-8218-0268-2; List $49; **Sale Price $29**; Order code GSM/5DU202

Recommended Text

A Course in Operator Theory

John B. Conway, *University of Tennessee, Knoxville*

This is an excellent course in operator theory and operator algebras ... leads the reader to deep new results and modern research topics ... the author has done more than just write a good book—he has managed to reveal the unspeakable charm of the subject, which is indeed the "source of happiness" for operator theorists.

—Mathematical Reviews

Graduate Studies in Mathematics, Volume 21; 2000; 372 pages; Hardcover; ISBN 0-8218-2065-6; List $49; **Sale Price $29**; Order code GSM/21DU202

Recommended Text

Foliations I

Alberto Candel, *California Institute of Technology, Pasadena*, and **Lawrence Conlon**, *Washington University, St. Louis, MO*

Overall presentation is first-rate ... diagrams ... are well-crafted and reflect the strongly "graphical" nature of the subject ... A prospective reader who cares to invest the time needed to plough seriously through the book ought to be rewarded with a gratifying mathematical experience ... can also be recommended to more advanced researchers, who would enjoy seeing a compendium of major results.

—Bulletin of the London Mathematical Society

Graduate Studies in Mathematics, Volume 23; 2000; 402 pages; Hardcover; ISBN 0-8218-0809-5; List $54; **Sale Price $32**; Order code GSM/23DU202

Select Publications
Popular Series
Substantial Discounts!
Recent Titles

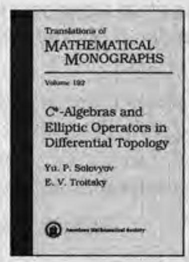
Recommended Text

Notes on Seiberg-Witten Theory

Liviu I. Nicolaescu, *University of Notre Dame, IN*

Graduate Studies in Mathematics, Volume 28; 2000; 484 pages; Hardcover; ISBN 0-8218-2145-8; List $59; **Sale Price $35**; Order code GSM/28DU202

Mathematical Surveys *and* Monographs



This series of high-level monographs is published by the Society to meet the need for careful expositions in research fields of current interest. Each book includes a brief introduction to recent developments and unsolved problems.

Rings and Things and a Fine Array of Twentieth Century Associative Algebra

Carl Faith, *Professor Emeritus, Rutgers University, New Brunswick, NJ*

Researchers in algebra should find it both enjoyable to read and very useful in their work. In all cases, [Faith] cites full references as to the origin and development of the theorem .... I know of no other work in print which does this as thoroughly and as broadly.

—John O'Neill, University of Detroit at Mercy

Mathematical Surveys and Monographs, Volume 65; 1999; 422 pages; Hardcover; ISBN 0-8218-0993-8; List $104; **Sale Price $52**; Order code SURV/65DU202

A Classic!

Surgery on Compact Manifolds
Second Edition

C. T. C. Wall, *University of Liverpool, England*, and **A. A. Ranicki (Editor)**, *University of Edinburgh, Scotland*

Mathematical Surveys and Monographs, Volume 69; 1999; 302 pages; Hardcover; ISBN 0-8218-0942-3; List $59; **Sale Price $35**; Order code SURV/69DU202

An Introduction to the Analysis of Paths on a Riemannian Manifold

Daniel W. Stroock, *Massachusetts Institute of Technology, Cambridge*

Mathematical Surveys and Monographs, Volume 74; 2000; 269 pages; Hardcover; ISBN 0-8218-2020-6; List $40; **Sale Price $28**; Order code SURV/74DU202

Arithmeticity in the Theory of Automorphic Forms

Goro Shimura, *Princeton University, NJ*

Mathematical Surveys and Monographs, Volume 82; 2000; 302 pages; Hardcover; ISBN 0-8218-2671-9; List $69; **Sale Price $35**; Order code SURV/82DU202

AMS
American Mathematical Society

Classified Advertisements

Positions available, items for sale, services available, and more

CALIFORNIA

HARVEY MUDD COLLEGE
Department of Mathematics

Harvey Mudd College invites applications for a tenure-track assistant professorship. Excellence in teaching is absolutely essential, as is evidence of a strong and ongoing research program. Areas of special interest in pure or applied mathematics include analysis, topology, algebraic geometry, dynamical systems, partial differential equations, and mathematical modeling, but all research specialities will be considered. Candidates must be willing to supervise undergraduate research and work with others in the development of departmental programs.

Harvey Mudd College is a highly selective undergraduate institution of science, engineering, and mathematics; the average SAT score of entering students is over 1480. More than one-third of the student body are National Merit Finalists, and one year of high school calculus is a requirement for admission. Each year there are over 20 graduates in mathematics, with approximately half going to graduate school. Over 40% of mathematics alumni from HMC have obtained a Ph.D. degree. The college enrolls about 680 students and is a member of the Claremont College consortium, which consists of four other undergraduate colleges and two graduate institutions, forming an academic community of about 5,000 students. There is an active and vital research community of over 40 mathematicians in Claremont.

Claremont is situated approximately 35 miles east of downtown Los Angeles, in the foothills of the San Gabriel Mountains. The community is known for its tree-lined streets and village charm. It is an easy drive from Claremont to the cultural attractions and universities of the greater Los Angeles area, as well as the ocean, mountains, and deserts of southern California.

Applicants should send a curriculum vitae, a description of their teaching philosophy and experience, and a description of their current research program, and arrange to have sent three letters of recommendation to the address that appears below. Further information about the college, department, and position may be found at `http://www.math.hmc.edu/`. Preference will be given to applications completed by January 4, 2002.

Harvey Mudd College is an Equal Opportunity Employer and is committed to the recruitment of applicants historically underrepresented on college faculties. Address for applications:

Professor Arthur T. Benjamin
Chair, Search Committee
Department of Mathematics
Harvey Mudd College
Claremont, CA 91711-5990

UNIVERSITY OF CALIFORNIA, BERKELEY
Department of Statistics

We invite applications for two faculty positions to begin July 1, 2002. Preference will be given to tenured or nontenured candidates who have received the Ph.D. within 12 years of the appointment date. We will consider strong candidates in any area of theoretical, applied, or computational statistics, or probability, with particular interest in interdisciplinary activities. Apply by December 17, 2001, to:

Chair, Department of Statistics
University of California, Berkeley
367 Evans Hall #3860
Berkeley, CA 94720-3860
fax: 510-642-7892
e-mail: `recruit@stat.berkeley.edu`

Include résumé, three letters of reference, and request that referees read the university's confidentiality statement at `http://www.chance.berkeley.edu/apo/evalltr.html` prior to submitting their letters. The department is particularly interested in hearing from suitably qualified women or members of minorities currently underrepresented in faculty positions. The University of California is an Equal Opportunity/Affirmative Action Employer.

UNIVERSITY OF CALIFORNIA, IRVINE
Department of Mathematics
Irvine, CA 92697-3875

Applications are invited for several one- or three-year Visiting Assistant Professor positions in the following areas of research: (1) applied and computational mathematics, (2) analysis and PDE (includes mathematical physics), (3) geometry and topology (includes geometric analysis), (4) logic and set theory, (5) probability, (6)

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 2001 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 advertising.

Upcoming deadlines for classified advertising are as follows: December 2001 issue–September 27, 2001; January 2002 issue–October 24, 2001; February 2002 issue–November 20, 2001; March 2002 issue–December 28, 2001; April 2001 issue–January 25, 2002; May 2001 issue– February 26, 2002.

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 e-mail to `classads@ams.org`. AMS location for express delivery packages is 201 Charles Street, Providence, Rhode Island 02904. Advertisers will be billed upon publication.

algebra and number theory (includes algebraic and arithmetic geometry). Candidates must possess a Ph.D. Strong promise in research and teaching is required. Current annual salary is set at $46,100. Teaching load: 5 to 6 quarter-courses per year. Applicants should send résumé, preprints, dissertation abstract and ask three people to send letters of recommendation to: Visiting Assistant Professor Search Committee at the above address. Electronic submissions not accepted.

The deadline for applications is November 30, 2001, or until the positions are filled. The University of California, Irvine, is an Equal Opportunity Employer committed to excellence through diversity.

UNIVERSITY OF CALIFORNIA, IRVINE
Department of Mathematics
Irvine, CA 92697-3875

Applications are invited for tenure-track or tenured positions. Priorities will be placed on the following areas: (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, (F) algebra and number theory (includes algebraic and arithmetic geometry). Candidates must possess a Ph.D. Strong record and potential in research and teaching are required for the positions. Send curriculum vitae (include e-mail address), list of publications, preprints, reprints, and research plan to the Recruiting Committee at the above address. Designate area by letter A-F. Applicants should also arrange for four letters of recommendation to be sent. If possible, use the AMS cover sheet. Electronic submissions not accepted.

The deadline for applications is November 30, 2001, or until the positions are filled. The University of California, Irvine, is an Equal Opportunity Employer committed to excellence through diversity.

UNIVERSITY OF CALIFORNIA, LOS ANGELES
Department of Mathematics

Subject to availability of resources and administrative approval, the following positions are available:

1) Several tenure-track and senior positions in all areas of mathematics.

2) Several E. R. Hedrick Assistant Professorships. Salary is $52,900. Three-year appointment. Teaching load: four quarter-courses per year, which may include one advanced course in the candidate's field.

3) Several Research Assistant Professorships in Computational and Applied Mathematics (CAM). Salary is $52,900. Three-year appointment. Teaching load: normally reduced to two or three quarter-courses per year by research funding as available; may include one advanced course in the candidate's field.

4) Several Adjunct Assistant Professorships or Lectureships in the Program in Computing (PIC). Applicants for the Adjunct position must show very strong promise in teaching and research in an area related to computing. Teaching load: four one-quarter programming courses each year and one seminar every two years. One-year initial appointment, with the option of applying for renewal for a second year and possibly longer, up to a maximum service of four years. Salary is $56,600. Applicants for the Lectureship must show very strong promise in the teaching of programming. An M.S. in Computer Science or equivalent degree is preferred. Teaching load: 6 one-quarter programming courses per year. One-year appointment, probably renewable one or more times, depending on the needs of the program. Salary is $43,152 or more, depending on experience.

5) Several VIGRE Assistant Professorships. Hedrick, CAM, or PIC applicants who are U.S. citizens or permanent residents may also apply for a VIGRE Assistant Professor position. Three-year appointment. Salary is $52,900. The successful recipient will receive a summer stipend of $6,500 for two summers and $2,500 per year for travel, equipment, and supplies for three years. Teaching load: 3 courses per year.

6) Several Adjunct Assistant Professorships and Research Postdocs. Up to one-year appointment, with the possibility of renewal. Strong research and teaching background required. Salary $48,700-$52,900. Teaching load for adjuncts: 5 quarter-courses per year.

7) Several visiting instructorships.

For more details, see `http://www.math.ucla.edu/~search/`. To apply, complete the application on the website, or send e-mail to `search@math.ucla.edu`, or write to: Staff Search, Department of Mathematics, University of California, Los Angeles, CA 90095-1555. Preference will be given to applications completed by January 7, 2002.

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.

UNIVERSITY OF CALIFORNIA, SANTA BARBARA
Department of Mathematics
Faculty Positions

The University of California, Santa Barbara, invites applications for the following anticipated positions in the Department of Mathematics, with the appointments to be effective July 1, 2002.

ASSISTANT PROFESSOR POSITION: Candidates for this tenure-track position must possess a Ph.D. by September 2002. The department's priority is analysis, including operator algebras and noncommutative geometry, harmonic analysis and complex analysis, but all fields will be considered. Demonstrated research excellence and potential to become an effective teacher are required. Candidates who best enhance the long-term research plans of the department will be given preference.

VISITING POSITIONS: One or more special one-year visiting assistant professorships may be available, with possibility of renewal for additional years, up to three years in total. These positions carry a teaching load of 4 one-quarter courses per year. Excellence in research, potential for interaction with faculty at UC Santa Barbara, and evidence of good teaching are required. Candidates must possess a Ph.D. by September 2002.

Applicants for these positions should send application materials to the appropriate committee (the Assistant Professor Committee or the Visiting Assistant Professor Committee) at the Department of Mathematics, University of California, Santa Barbara, CA 93106-3080. These materials should include a vita, a publication list, a statement of research interests and teaching philosophy, and the American Mathematical Society cover sheet (available online at `http://www.ams.org/`). Include an e-mail address and fax number if available. Applicants should also arrange to have at least four letters of recommendation (at least one of which is directed towards teaching) sent to the appropriate committee. Applicants for the tenure-track position will automatically be considered for the visiting positions unless noted otherwise, so duplicate applications are unnecessary. Applications which are postmarked by December 21, 2001, will be given full consideration.

UCSB is an Affirmative Action/Equal Opportunity Employer.

UNIVERSITY OF CALIFORNIA, SANTA CRUZ
Mathematics Department
Visiting Assistant Professorships in Mathematics

The mathematics department at University of California, Santa Cruz, is recruiting for:

1) Contingent on administrative approval, one tenure-track or tenured position for assistant professor to associate professor in the area of quantum mathematics, the mathematics surrounding string theory, e.g., C^* algebras, knot theory, quantum topology, conformal field theory, mirror symmetry, Hopf algebras, category theory, and infinite-dimensional Lie algebras. The position will begin fall 2002. The teaching load is 4 one-quarter courses per year. Appointees will be expected to teach, pursue their research, and perform some department and university service. Minimum Qualifications: Assistant Professor: Ph.D. or equivalent by 6/30/02

in mathematics or physics; demonstrated achievements or potential for excellence in research, teaching, and professional service. Associate Professor: Ph.D. or equivalent in mathematics or physics and record of excellence in research, teaching, and service. The campus is especially interested in candidates who can contribute to the diversity and excellence of the academic community through their research, teaching, and/or service. Salary: $46,100–$57,100 (step and salary commensurate with experience). Deadline: November 19, 2001. Applicants should send a curriculum vitae; a summary of research and teaching experience; and four letters of recommendation, with at least one letter addressing teaching experience and ability (all letters will be treated as confidential documents). Please refer to position #039-02 (Assistant) or #039T-02 (Associate) in your reply.

2) Contingent on administrative approval, one tenure-track or tenured position for assistant professor to associate professor in the area of analysis with an emphasis on, but not limited to, partial differential equations. The position will begin fall 2002. The teaching load is 4 one-quarter courses per year. Appointees will be expected to teach, pursue their research, and perform some department and university service. Minimum Qualifications: Assistant Professor: Ph.D. or equivalent by 6/30/02 in mathematics or physics; demonstrated achievements or potential for excellence in research, teaching, and professional service. Associate Professor: Ph.D. or equivalent in mathematics or physics and record of excellence in research, teaching, and service. The campus is especially interested in candidates who can contribute to the diversity and excellence of the academic community through their research, teaching, and/or service. Salary: $46,100-$57,100 (step and salary commensurate with experience). Deadline: November 19, 2001. Applicants should send a curriculum vitae; a summary of research and teaching experience; and four letters of recommendation, with at least one letter addressing teaching experience and ability (all letters will be treated as confidential documents). Please refer to position #570-02 (Assistant) or #570T-02 (Associate) in your reply.

3) One or more Youngs Visiting Assistant Professorships effective summer or fall 2002. We invite applications from qualified mathematicians in all fields. Appointees are expected to teach and pursue their research. Available for periods of two years, with a possible extension to a third year. Minimum Qualifications: Ph.D. (or equivalent by 6/30/02) in mathematics or a closely related field. Demonstrated excellence in research and teaching. Salary range: $46,100–$51,400. Deadline: January 14, 2002. Applicants should send curriculum vitae; a summary of research and teaching experience; and three letters of recommendation, with at least one letter addressing teaching experience and ability (all letters will be treated as confidential documents). Please refer to position #T02-06 in your reply.

All applications should be sent to: Recruitment Committee, Mathematics Department, University of California, 1156 High Street, Santa Cruz, CA 95064. Inquiries (not applications) can be sent to mathcr@cats.ucsc.edu. UCSC is an EEO/AA Employer.

GEORGIA

GEORGIA INSTITUTE OF TECHNOLOGY
School of Mathematics

The School of Mathematics at Georgia Tech expects to have several visiting, tenure-track, and senior positions available beginning fall 2002 and will consider applications in pure and applied mathematics and statistics. The school is interested in adding new areas of expertise to complement its existing strengths. Candidates with strong research and teaching records or potential should arrange for a résumé, 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. Review of applications will begin in September 2001 and will continue until all positions have been filled. Georgia Tech, an institution of the University System of Georgia, is an Equal Opportunity/Affirmative Action Employer.

UNIVERSITY OF GEORGIA
Department of Mathematics

The Department of Mathematics at the University of Georgia invites applications for a tenure-track position in applied mathematics at the assistant professor rank; the particular areas of interest include applied PDE, financial mathematics, and biotechnology (for more details see our website, http://www.math.uga.edu/). The position will begin fall semester 2002. To assure full consideration, applications must be received by January 4, 2002.

Applicants should have a Ph.D. in pure or applied mathematics and exhibit outstanding research potential in mathematics with a commitment to excellence in teaching. They should arrange to have three letters of reference concerning research and one letter concerning teaching sent directly to the address below. The application should include a completed AMS Standard Cover Sheet, a curriculum vitae, a statement about their current and future research plans, and a statement about teaching experiences and philosophy. Submit the application to the Chair, Search Committee, Department of Mathematics, University of Georgia, Athens, GA 30602. E-mails can be directed to search@math.uga.edu.

The University of Georgia is an Affirmative Action/Equal Opportunity Employer that is committed to increasing the diversity of its faculty. We especially encourage applications from women, minorities, and underrepresented groups.

HAWAII

UNIVERSITY OF HAWAII
Department of Mathematics

The Department of Mathematics invites applications for an assistant professor, position number 84092, tenure-track position, to begin August 1, 2002. Candidates should have significant promise or achievements in research in some field of pure or applied mathematics. Evidence of effective teaching is essential, as duties include undergraduate and graduate teaching. To apply, send your curriculum vitae and arrange for four letters of recommendations to be sent to: The Hiring Committee, Department of Mathematics, University of Hawaii, Honolulu, HI 96822-2273. At least one of the letters of recommendation should concern the candidate's experience and abilities as a teacher. All application materials, including letters of reference, must be postmarked by December 15, 2001. Information concerning the department and the position can be found at http://www.math.hawaii.edu/. The University of Hawaii encourages applications from members of racial or ethnic minorities and from women. EEO/AA Employer.

ILLINOIS

NORTHWESTERN UNIVERSITY
Department of Mathematics
2033 Sheridan Road
Evanston, IL 60208-2730

Applications are invited for anticipated tenure-track or tenured positions starting September 2002, pending final approval. Priority will be given to exceptionally promising research mathematicians. Fields of interest within the department include algebra, algebraic geometry, analysis, dynamical systems, mathematical physics, probability, partial differential equations, and topology.

Application material should be sent to the Personnel Committee at the department address and should include: (1) the American Mathematical Society's Standard Cover Sheet for Academic Employment; (2) a curriculum vitae; and (3) at least four letters of recommendation, including one which discusses in some detail the candidate's teaching qualifications. Inquiries may be sent via e-mail to hiring@math.nwu.edu.

Applications are welcome at any time, but the review process starts in October 2001. Northwestern University is an

Affirmative Action/Equal Opportunity Employer committed to fostering a diverse faculty; women and minority candidates are especially encouraged to apply.

NORTHWESTERN UNIVERSITY
Department of Mathematics
2033 Sheridan Road
Evanston, IL 60208-2730
Boas Assistant Professor

Applications are solicited from people whose research is related to nonlinear partial differential equations and related analysis for two Ralph Boas assistant professorships of three years each starting in September 2002. These positions are non-tenure-track and are part of the Emphasis Year in Nonlinear Partial Differential Equations which the department will be sponsoring in 2002-03.

Applications should be sent to the Emphasis Year Committee at the department address and should include: (1) the American Mathematical Society's Standard Cover Sheet for Academic Employment; (2) a curriculum vitae; and (3) three letters of recommendation, including one which discusses in some detail the candidate's teaching qualifications. Inquiries may be sent via e-mail to `hiring@math.nwu.edu`.

Applications are welcome at any time, but
the review process starts December 1, 2001. Northwestern University is an Affirmative Action/Equal Opportunity Employer committed to fostering a diverse faculty; women and minority candidates are especially encouraged to apply.

UNIVERSITY OF CHICAGO
Department of Mathematics

The University of Chicago Department of Mathematics invites applications for the following positions:

1. **L.E. Dickson Instructor:** This is open to mathematicians who have recently completed or will soon complete a doctorate in mathematics and whose work shows remarkable promise in mathematical research and teaching. The appointment is for two years, with the possibility of renewal for a third year. The teaching obligation is 4 one-quarter courses per year.

2. **VIGRE Dickson Instructor:** This is open to mathematicians who are U.S. citizens or permanent residents, have recently completed or will soon complete a doctorate in mathematics, and whose work shows remarkable promise in mathematical research and teaching. The appointment is for three years, and the teaching obligation is 3 one-quarter courses per year. Additional resources will be available for summer support and travel. Applicants should be aware that NSF Mathematical Sciences Postdoctoral Fellowships cannot be held prior to or concurrently with VIGRE Dickson Instructorships. The option of early decision on applications, with an early deadline for a response if an offer is made, is available to applicants upon request. The deadline for applications request-
ing early consideration is **November 15, 2001**. Applications which do not result in early offers will be reconsidered as part of the general pool of applications. Applications which do not request early consideration should be received by **December 15, 2001**.

3. **Assistant Professor:** This is open to mathematicians who are further along in their careers, typically two or three years past the doctorate. These positions are intended for mathematicians whose work has been of outstandingly high caliber. Appointees are expected to have the potential to become leading figures in their fields. The appointment is for three years, and the teaching obligation is 3 one-quarter courses per year.

Complete applications consist of (a) an AMS cover sheet; (b) a curriculum vitae (including citizenship information); (c) three or more letters of reference, including one which addresses teaching ability; and (d) a description of previous research and plans for future research, including a brief (200 words or less) summary of your research interests. If you have applied for an NSF Mathematical Sciences Postdoctoral Fellowship, please include that information in your application and let us know how you plan to use it if awarded. Applications should be sent to:

Appointments Secretary
Department of Mathematics
University of Chicago
5734 S. University Avenue
Chicago, IL 60637

Applications may also be submitted online through `http://www.mathjobs.org/`. The deadline for applications (except as noted above for VIGRE Instructorships) is **December 15, 2001**. The University of Chicago is an Equal Opportunity/Affirmative Action Employer.

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
Department of Mathematics
Open Rank Position in Actuarial Science
OAA #7866

Applications are invited for a full-time open-rank faculty position in actuarial science to commence August 21, 2002. This position is at the tenure-track level, although a tenured appointment may be possible for an exceptional candidate. The person selected will be expected to teach and advise graduate and advanced undergraduate students and to pursue research in actuarial science or a related area such as statistics or financial mathematics. Salary and teaching load are competitive.

Preference will be given to applicants who are associates or fellows of one of the professional societies, have completed the Ph.D. (or equivalent) by the time the appointment begins, and have some experience as practicing actuaries. A strong commitment to teaching is essential. Applicants should send a letter of application, a curriculum vitae and a publication list, and should arrange to have three letters of reference sent directly to the address below. It is the responsibility of applicants to see that letters of recommendation are sent.

Joseph Rosenblatt, Chair
Department of Mathematics
University of Illinois
at Urbana-Champaign
1409 West Green Street
Urbana, IL 61801
tel: (217) 333-3352
e-mail: `search@math.uiuc.edu`

For fullest consideration, complete dossiers, including letters of reference, should be received by November 16, 2001. We encourage use of the application cover sheet provided by the American Mathematical Society. Minority candidates, women, and other designated class members are encouraged to apply. The University of Illinois is an Affirmative Action/Equal Opportunity Employer.

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
Department of Mathematics
Postdoctoral Positions as
J. L. Doob Research Assistant Professor

The Department of Mathematics of the University of Illinois at Urbana-Champaign is soliciting applications for postdoctoral positions. Three appointments will be made starting August 21, 2002; each appointment is for three years and is not renewable. These positions are for recent Ph.D. recipients (with a strong preference for those not more than one year past the Ph.D. degree). The Department of Mathematics and the University of Illinois will provide an excellent scientific environment to pursue research in pure and applied mathematics. The position carries a salary of \$42,500 per year plus a \$1,000 annual travel allowance.

Applicants should send a letter of application, a curriculum vitae and publication list (please provide hard copies of your application and supporting documents), and arrange to have sent three letters of reference directly to the address below. It is the responsibility of applicants to see that letters of recommendation are received in a timely fashion.

Postdoctoral Search Committee
Department of Mathematics
University of Illinois
at Urbana-Champaign
1409 West Green Street

Urbana, IL 61801-2975
e-mail: `search@math.uiuc.edu`

To insure full consideration, all materials, including letters of reference, should be received by November 16, 2001. Late applications will be reviewed until the search is closed. We encourage use of the application cover sheet provided by the American Mathematical Society and indication of the subject area using the AMS subject classification numbers. Minority candidates, women, and other designated class members are encouraged to apply. The University of Illinois is an Affirmative Action/Equal Opportunity Employer.

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
Department of Mathematics
Postdoctoral Positions as NSF VIGRE Research Assistant Professor

The Department of Mathematics of the University of Illinois at Urbana-Champaign is soliciting applications for National Science Foundation VIGRE postdoctoral positions. Appointments are for three years, are not renewable, and will begin August 21, 2002. Eligibility is limited to United States citizens, nationals, and permanent residents who will have a Ph.D. but are not beyond 18 months of completion of their degree at the time of appointment. The Department of Mathematics and the University of Illinois will provide an excellent scientific environment to pursue research in pure and applied mathematics. Each position carries a salary of $36,000 per 9-month academic year, an additional $6,500 for both the first and second summers, and a $7,500 travel allowance over the term of the appointment.

Applicants should send a letter of application, a curriculum vitae and publication list (please provide hard copies of your application and supporting documents), and arrange to have sent three letters of reference directly to the address below. It is the responsibility of applicants to see that letters of recommendation are received in a timely fashion.

Postdoctoral Search Committee
Department of Mathematics
University of Illinois
at Urbana-Champaign
1409 West Green Street
Urbana, IL 61801-2975
e-mail: `search@math.uiuc.edu`

To insure full consideration, all materials, including letters of reference, should be received by November 16, 2001. Late applications will be reviewed until the search is closed. We encourage use of the application cover sheet provided by the American Mathematical Society and indication of the subject area using the AMS subject classification numbers. Minority candidates, women, and other designated class members are encouraged to apply. The University of Illinois is an Affirmative Action/Equal Opportunity Employer.

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
Department of Mathematics
Postdoctoral Research Positions in Model Theory and Its Applications

The Department of Mathematics of the University of Illinois at Urbana-Champaign is soliciting applications for postdoctoral positions in applications of model theory to other areas of mathematics. These research positions are funded by a three-year National Science Foundation Focused Research Grant to the department's model theory research group. Lengths of appointment will be between one and three years and are not renewable. Starting dates are flexible; a first appointment could begin as early as January 2002. Applicants are requested to say which period of appointment they prefer. These positions are for recent Ph.D. recipients. They carry a salary of $42,500 per academic year plus a $1,000 annual travel allowance.

Preferred areas of research interest are (a) the interface of model theory, symbolic dynamics and algebraic geometry; (b) model theory and the algebraic theory of differential equations; (c) nonstandard analysis; (d) model theory and geometry; (e) model theory and bimeromorphic geometry; (f) model theory and ultraproducts of structures based on metric spaces, such as finitely generated groups or Banach spaces; and (g) model theory and number theory.

Applications are encouraged from all recent Ph.D. recipients who have an interest in methods and techniques connected with model theory and mathematical logic. Applicants should send a letter of application, a curriculum vitae and publication list (please provide hard copies of your application and supporting documents), and arrange to have sent three letters of reference directly to the address below. It is the responsibility of applicants to see that letters of recommendation are received in a timely fashion.

Model Theory Postdoctoral
Search Committee
Department of Mathematics
University of Illinois
at Urbana-Champaign
1409 West Green Street
Urbana, IL 61801-2975

To ensure full consideration, all materials, including letters of reference, should be received by November 16, 2001. Late applications will be reviewed until the search is closed. We encourage use of the application cover sheet provided by the American Mathematical Society and indication of the subject area using the AMS subject classification numbers. Minority candidates, women, and other designated class members are encouraged to apply. The University of Illinois is an Affirmative Action/Equal Opportunity Employer.

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
Department of Mathematics
Tenure-Track Position
OAA #7864

Applications are invited for one or more full-time faculty positions to commence August 21, 2002, at the tenure-track (assistant professor) level. Appointees will be expected to pursue a vigorous research program and to teach graduate as well as undergraduate students. The department will consider applicants in all fields of mathematics. We are particularly interested in algebraic geometry, analysis, logic, computational mathematics, discrete mathematics, interdisciplinary mathematics, mathematical physics, number theory, partial differential equations, and probability theory. Salary and teaching load are competitive.

Applicants should have completed the Ph.D. (or equivalent) by the time the appointment begins and are expected to present evidence of excellence in research and teaching. Applicants should send a letter of application, a curriculum vitae and publication list, and also arrange to have sent three letters of reference directly to the address below. It is the responsibility of applicants to see that letters of recommendation are sent.

Joseph Rosenblatt, Chair
Department of Mathematics
University of Illinois
at Urbana-Champaign
1409 West Green Street
Urbana, IL 61801
tel: (217) 333-3352
e-mail: `search@math.uiuc.edu`

For fullest consideration, complete dossiers, including letters of reference, should be received by November 16, 2001. We encourage use of the application cover sheet provided by the American Mathematical Society. Minority candidates, women, and other designated class members are encouraged to apply. The University of Illinois is an Affirmative Action/Equal Opportunity Employer.

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
Department of Mathematics
Tenured Position
OAA #7865

Applications are invited for one or more full-time tenured faculty positions to commence August 21, 2002. Appointees will be expected to pursue an outstanding research program and to teach graduate students as well as undergraduate students. The department will consider applicants in all fields of mathematics. We are particularly interested in algebraic geometry, analysis, logic, computational mathematics, discrete mathematics, interdisciplinary mathematics, mathematical physics, number theory, partial differential equations, and probability theory. Salary and teaching load are competitive.

Applicants are expected to have a Ph.D. (or equivalent) and a documented record of leadership in research as well as of excellence in teaching. Applicants should send a curriculum vitae, a list of publications, a few selected reprints or preprints, and the names and addresses of three references to the address below. The department will solicit letters for the finalists for the tenured positions.

Joseph Rosenblatt, Chair
Department of Mathematics
University of Illinois
at Urbana-Champaign
1409 West Green Street
Urbana, IL 61801
tel: (217) 333-3352
e-mail: search@math.uiuc.edu

For fullest consideration, applications should be on file in our department office by October 5, 2001. We anticipate an ongoing search, but will begin considering applications and conducting interviews following the deadline. We encourage use of the application cover sheet provided by the American Mathematical Society and indication of the subject area using the AMS subject classification numbers. Minority candidates, women, and other designated class members are encouraged to apply. The University of Illinois is an Affirmative Action/Equal Opportunity Employer.

INDIANA

UNIVERSITY OF NOTRE DAME
Department of Mathematics
Notre Dame, IN 46556
Regular Position in Mathematics

The Department of Mathematics of the University of Notre Dame invites applications for the John P. McAndrews Assistant Professorship in Mathematics starting August 24, 2001. Outstanding candidates in any field of pure or applied mathematics are encouraged to apply. The position is at the tenure-track level, though a tenured associate professor appointment may be possible for an exceptional candidate. The teaching load is one course one semester and two courses the other semester. Salaries are competitive, and a research fund is included. Applications, including a curriculum vitae, a letter of application, and a completed AMS Standard Cover Sheet, should be sent to Steven A. Buechler, 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 can 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. Information about the department is available at http://www.math.nd.edu/math/.

UNIVERSITY OF NOTRE DAME
Department of Mathematics
Notre Dame, IN 46556
Regular Position in Stochastic Analysis

The Department of Mathematics of the University of Notre Dame invites applications for a position in the field of applied stochastic analysis to start on August 24, 2001. The position is at the tenure-track level, but a tenured appointment may be possible for an exceptional candidate. 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 Steven A. Buechler, 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. Information about the department is available at http://www.math.nd.edu/math/.

KANSAS

KANSAS STATE UNIVERSITY
Department of Mathematics

Subject to budgetary approval, applications are invited for tenure-track and visiting positions commencing August 4, 2002; 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 and a commitment to excellence in teaching. A Ph.D. in mathematics or a Ph.D. dissertation accepted with only formalities to be completed is required. 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 potential. Offers may begin by December 3, 2001, but applications for positions will be reviewed until February 1, 2002, or until positions are closed. AA/EOE.

UNIVERSITY OF KANSAS
Department of Mathematics

Applications are invited for one or more tenure-track positions at the assistant professor level beginning August 18, 2002; January 1, 2003; or as negotiated. (This position(s) is contingent on final budgetary approval.) Preference will be given to candidates in analysis, algebra/algebraic geometry, and stochastic analysis/control. Candidates must have a Ph.D. in math or a related field or its requirements completed by August 18, 2002. Postdoctoral experience is preferred.

Letter of application, detailed résumé with description of research, completed AMS application form, and at least three recommendation letters should be mailed to: Jack Porter, Chair, Department of Mathematics, University of Lawrence, 1460 Jayhawk Boulevard, Lawrence, KS 66045-7567 (or faxed to 785-864-5255). For more details see http://www.math.ukans.edu/jobs, or contact kumath@math.ukans.edu.

Deadlines: Review of applications will begin on November 10, 2001, and will continue until the position(s) is filled. EO/AA Employer.

UNIVERSITY OF KANSAS
Department of Mathematics

Applications are invited for a temporary position at the assistant professor level beginning August 18, 2002; January 1, 2003; or as negotiated. (This position is contingent on final budgetary approval.) This position is normally renewable for a second and third year. Preference will be given to candidates in complex dynamics, dynamical systems, or probabilistic analysis. Candidates must have a Ph.D. in math or related field or its requirements completed by August 18, 2002.

Letter of application, detailed résumé with description of research, completed AMS application form, and at least three recommendation letters should be mailed to: Jack Porter, Chair, Department of Mathematics, University of Kansas, 1460 Jayhawk Boulevard, Lawrence, KS 66045-7567 (or faxed to 785-864-5255). For more details see http://www.math.ukans.edu/jobs/, or contact kumath@math.ukans.edu.

Deadlines: Review of applications will begin on November 10, 2001, and will continue until the position is filled. EO/AA Employer.

KENTUCKY

UNIVERSITY OF LOUISVILLE
Department of Mathematics

Assistant Professor: The Department of Mathematics at the University of Louisville invites applications for one tenure-track assistant professor position in actuarial science and applied mathematics, to begin July 1, 2002. Preference will be given to candidates whose research interests lie in actuarial science, financial mathematics, or applied analysis who have passed at least one actuarial exam and are interested in continuing the development of an existing actuarial science program. A Ph.D. in mathematics or a related area is required. Candidates must show strong potential in research and teaching and have effective communications skills. Applications should include: (1) the American Mathematical Society's Standard Cover Sheet; (2) curriculum vitae; (3) summary of research interests; (4) statement of teaching qualifications; and (5) at least four letters of recommendation, including letters which discuss, in some detail, the candidate's teaching qualifications and interest in actuarial science. Applications should be sent to: Search Committee, Department of Mathematics, University of Louisville, Louisville, KY 40292. Review of applications will begin January 14, 2002, and will continue until the position is filled. E-mail questions to `math@louisville.edu`. The University of Louisville is an Affirmative Action/Equal Opportunity Employer and encourages women and underrepresented minorities to apply. Applicants must comply with the provisions of the Immigration Reform and Control Act.

MARYLAND

UNIVERSITY OF MARYLAND, COLLEGE PARK
Computational Nonlinear Dynamics Faculty Position

A nonlinear dynamicist with strong interest in computation is sought for a tenured or tenure-track appointment in the Department of Mathematics, possibly joint with the Institute for Physical Science and Technology. An outstanding record of research accomplishments and a proven ability to attract research support are important for a senior position. Good teaching is a priority of the university.

Applications should be sent to: Chair's Office, Computational Nonlinear Dynamics, Department of Mathematics, University of Maryland, College Park, MD 20742-4015. Priority will be given to applications received by December 1, 2001. Appointments will commence in fall 2002. The University of Maryland is an Equal Opportunity/Affirmative Action Employer.

UNIVERSITY OF MARYLAND, COLLEGE PARK
Department of Mathematics

Applications are invited for tenured and tenure-track positions in the Department of Mathematics. Strong preference will be given to candidates in (1) applied statistics, (2) algebraic geometry, (3) dynamics, and (4) geometry, but candidates from all areas will be considered.

Priority will be given to applications received by December 1, 2001. Appointments will commence in fall 2002.

The University of Maryland is an Equal Opportunity/Affirmative Action Employer that strongly encourages applications from female and minority candidates.

Please send a curriculum vitae and AMS Standard Cover Sheet, and three letters of recommendation to:

The Hiring Committee
Department of Mathematics
University of Maryland
College Park, MD 20742

UNIVERSITY OF MARYLAND, COLLEGE PARK
Lectureships in the Department of Mathematics

Applications are invited for Avron Douglis Lectureships, starting in fall 2002. These positions are for recent Ph.D. recipients, with a preference for those not more than one year past the Ph.D. degree. The lectureship is for two years and is nonrenewable. Candidates must have superior research potential and a strong commitment to teaching. The Department of Mathematics provides an excellent scientific environment to foster the professional development of junior mathematicians. The teaching duties consist of three courses per year. The salary is \$47,000 per academic year, supplemented by a \$1,000 research stipend. Priority will be given to applications completed by December 15, 2001.

The University of Maryland is an Equal Opportunity/Affirmative Action Employer that strongly encourages applications from female and minority candidates.

Please send a curriculum vitae and AMS Standard Cover Sheet, and three or more letters of recommendation, at least one of which speaks to the applicant's teaching credentials, to:

Douglis Lectureship Committee
Department of Mathematics
University of Maryland
College Park, MD 20742

MASSACHUSETTS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Mathematics
Tenured or Tenure-Track Faculty
Non-Tenure-Track Faculty

The Department of Mathematics may make appointments, at the level of lecturer and assistant professor or higher, in pure mathematics for the year 2002–03. The teaching load will be nine hours for the academic year (eight hours for assistant professor appointments). These positions are open to mathematicians with doctorates who show definite promise in research. Applications should be complete by January 15. Applicants should arrange to have sent (a) vita, (b) three letters of reference, (c) a description of their most recent research, and (d) a research plan for the immediate future to: Pure Mathematics Committee, Massachusetts Institute of Technology, Room 2-263, 77 Massachusetts Ave., Cambridge, MA 02139-4307. MIT is an Equal Opportunity/Affirmative Action Employer.

For more information about the position or institution see `http://www-math.mit.edu/`.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Mathematics
Non-Tenure-Track Faculty

C.L.E. Moore Instructorships in Mathematics. These positions are open to mathematicians with doctorates who show definite promise in research. The teaching load will be nine hours for the academic year. Applications should be complete by January 15. Applicants should arrange to have sent (a) a vita, (b) three letters of reference, (c) a description of the research in their thesis, and (d) a research plan for the next year to: Pure Mathematics Committee, Massachusetts Institute of Technology, Room 2-263, Cambridge, MA 02139-4307. MIT is an Equal Opportunity/Affirmative Action Employer.

For more information about the position or institution see `http://www-math.mit.edu/`.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Mathematics
Tenured or Tenure-Track Faculty
Non-Tenure-Track Faculty

APPLIED MATHEMATICS:

Applications are invited for a limited number of positions in applied mathematics starting fall 2002. Available positions include instructorships, lectureships, assistant professorships, and possibly higher levels. Appointments will be made mainly on the basis of demonstrated research accomplishments and potential. Complete applications must be received by January 3. To apply, please send a vita with a description of your recent research and research plans, and arrange to have three letters of reference sent to: Committee on Applied Mathematics, Department of Mathematics, Room 2-345, MIT, 77 Massachusetts Ave., Cambridge, MA 02139-4307. MIT is an Equal Opportunity/Affirmative Action Employer.

For more information about the position or institution see http://www-math.mit.edu/.

WILLIAMS COLLEGE
Department of Mathematics and Statistics
Williamstown, MA 01267

Tenure-track position in mathematics or statistics, beginning fall 2002, at the rank of assistant professor; in exceptional cases, however, more advanced appointments may be considered. Excellence in teaching and research and a Ph.D. by time of appointment are required.

Please send a vita and have sent three letters of recommendation on teaching and research to the Hiring Committee, Department of Mathematics and Statistics, Williams College, Williamstown, MA 01267. Evaluation of applications will begin on or after December 10. As an EEO/AA Employer, Williams especially welcomes applications from women and minority candidates.

WILLIAMS COLLEGE
Department of Mathematics and Statistics
Williamstown, MA 01267

Tenure-track position in statistics, beginning fall 2002, at the rank of assistant professor; in exceptional cases, however, more advanced appointments may be considered. Excellence in teaching and research and a Ph.D. at the time of appointment are required.

Please send a vita and have sent three letters of recommendation on teaching and research to the Statistics Hiring Committee, Department of Mathematics and Statistics, Williams College, Williamstown, MA 01267. Evaluation of applications will begin on or after December 10. As an EEO/AA Employer, Williams especially welcomes applications from women and minority candidates.

WORCESTER POLYTECHNIC INSTITUTE
Mathematical Sciences Department

The Worcester Polytechnic Institute (WPI) Department of Mathematical Sciences invites applications for one or more anticipated tenure-track faculty positions in applied or computational mathematics in 2002. Candidates at all academic ranks will be considered.

An earned Ph.D. or equivalent degree is required. Successful candidates must be able to contribute strongly to both the department's research activities and its innovative, project-based educational programs. Areas of research in the department include partial differential equations with applications in fluid and continuum mechanics, composite materials, computational modeling and simulation, numerical analysis, optimization, control theory, discrete mathematics, applied probability, and applied statistics.

WPI is a private and highly selective technological university with an enrollment of 2,700 undergraduates and about 1,100 full- and part-time graduate students. Worcester, located forty miles west of Boston, offers ready access to the diverse economic, cultural, and recreational resources of the region.

The Mathematical Sciences Department has 24 tenured/tenure-track faculty and supports B.S., M.S., and Ph.D. programs in applied and computational mathematics and applied statistics. For additional information, see http://www.wpi.edu/+math/.

Qualified applicants should send a detailed curriculum vitae, a one-page statement of specific teaching and research objectives, and the names of four references with mail/e-mail addresses and telephone/fax numbers to: Mathematics Search Committee, Mathematical Sciences Department, WPI, 100 Institute Road, Worcester, MA 01609-2280.

Applications will be considered on a continuing basis beginning October 1, 2001, until the position is filled.

To enrich education through diversity, WPI is an Affirmative Action/Equal Opportunity Employer.

MICHIGAN

HILLSDALE COLLEGE
Department of Mathematics and Computer Science
Applied Mathematics Position

Applications are invited for a tenure-track position in mathematics at the assistant professor level, beginning in August 2002. Candidates are required to have a Ph.D. in mathematics with a speciality in applied mathematics and to have a strong commitment to excellence in teaching undergraduate mathematics. In order to build our expertise in applied mathematics and to complement our existing strengths, candidates must be willing to teach mathematical modelling, differential equations, numerical analysis, and vector analysis. Duties include a 12-hour (3-course) teaching load per semester, which will include all levels of undergraduate mathematics, academic advising, college service, and continued mathematical activity.

Hillsdale College, founded in 1844, is an independent, coeducational, four-year liberal arts college of 1,200 students. Hillsdale has traditionally upheld two concepts: academic excellence and institutional independence. For additional college information see our website, http://www.hillsdale.edu/.

Send a letter of application which includes a personal statement addressing the applicant's teaching philosophy and qualifications for the position, curriculum vitae, graduate transcript, a short summary of teaching evaluations, and at least three letters of recommendation to: Professor Mark J. Watson, Chair, Department of Mathematics and Computer Science, Hillsdale College, Hillsdale, MI 49242. Review of applications will begin December 15, 2001, and will continue until the position is filled. EOE.

MICHIGAN STATE UNIVERSITY
proMSc Program in Industrial Mathematics
East Lansing, MI 48824

Direct your students toward one of the professional M.Sc. programs. Industry needs business-savvy mathematicians. See http://www.sciencemasters.com/.

UNIVERSITY OF MICHIGAN
Department of Mathematics

The department has several openings at the tenure-track or tenured level. Candidates should hold the Ph.D. in mathematics or a related field and should show outstanding promise and/or accomplishments in both research and teaching. Areas of special interest are: analysis; geometry/topology; applied and interdisciplinary mathematics, including mathematical biology, computational science, probability, and actuarial or financial mathematics. However, we encourage applications from any area of pure or applied mathematics. Salaries are competitive, based on credentials. Applicants should send a CV; bibliography; descriptions of research and teaching experience; and three or four letters of recommendation, at least one of which addresses the candidate's teaching experience and capabilities, to: Personnel Committee, University of Michigan, Department of Mathematics, 2074 East Hall, Ann Arbor, MI 48109-1109. Applications are considered on a continuing basis, but candidates are urged to apply by November 1, 2001. More detailed information regarding available positions may be found on our Web page, http://www.math.lsa.umich.edu/. Inquiries may be made by e-mail to math.chair@math.lsa.umich.edu. The University of Michigan is an Equal Opportunity/Affirmative Action Employer.

NEVADA

UNIVERSITY OF NEVADA
Department of Mathematics

Applications are invited for a tenure-track assistant professorship beginning fall 2002. Minimum Qualifications: Ph.D. in a mathematical science with a specialization in the area of partial differential equations and/or numerical analysis. Candidate: must also have documented excellence in teaching and evidence of strong potential for future significant research. (At least one reference letter must provide strong evidence of good teaching.) Academic-year salary is dependent on experience and qualifications. Teaching load is approximately 6 to 8 credit hours per semester. See `http://jobs.unr.edu/` for complete position announcement and requirements, and `http://www.unr.edu/math/` for a detailed position announcement and information about our department, including research interests of the faculty.

Send curriculum vitae, research summary, and at least three letters of recommendation to: DE/NA Search Committee, Department of Mathematics/084, University of Nevada, Reno, NV 89557. Please include the Academic Employment in Mathematics Standard Cover Sheet, which may be downloaded from `http://www.ams.org/`. Review of complete applications will begin December 1, 2001. AA/EEO.

NEW HAMPSHIRE

DARTMOUTH COLLEGE
Department of Mathematics

The Department of Mathematics anticipates three tenure-track openings with initial appointment in the 2002-03 academic year. The positions are in logic/set theory, or number theory, or "applicable mathematics". The work of candidates in applicable mathematics should straddle the line of pure and applied mathematics. The successful candidate will be a researcher working in core mathematics who has a proven track record in pursuing both the theoretical development of his/her subject, as well as potential applications. Examples include (but are not limited to) number theorists with interests in cryptography or coding theory, representation theorists who work in signal processing, combinatorialists with interests in computing, probabilists with interests in statistics, as well as more classical applied mathematicians. Various projects are currently funded by NSF and DoD. Active collaborations with the medical and engineering schools, and programs in computer science and cognitive neuroscience exist. Collaborations and or appointments in Dartmouth's M.D./Ph.D. program as well as Dartmouth's Institute for Secure Technologies Studies are also possible. In exceptional cases an appointment at a higher level may be possible.

Candidates for any position must be committed to outstanding teaching at all levels of the undergraduate and graduate curriculum and must give evidence of a well-regarded research program that shows real promise for the future. Candidates with several years of experience should in addition be ready to direct Ph.D. theses.

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 four courses spread over two or three quarters. The department encourages good teaching with a combination of committed colleagues and bright, responsive students.

To apply, send a letter of application, curriculum vitae, and a brief statement of research results and interests. Also arrange for four letters of reference to be sent, at least one of which addresses teaching, and, if the applicant's native language is not English, the applicant's ability to use English in a classroom. All application materials should be addressed to Betty Harrington, Recruiting Secretary, Department of Mathematics, Dartmouth College, 6188 Bradley Hall, Hanover, NH 03755-3551. Applications completed by January 5 will receive first consideration. Dartmouth is committed to Affirmative Action and encourages applications from African Americans, Asian Americans, Hispanics, Native Americans, and women. Inquiries about the progress of the selection process can be directed to Dwight Lahr, Recruiting Chair.

DARTMOUTH COLLEGE
Department of Mathematics
6188 Bradley Hall
Hanover, NH 03755-3551

Dartmouth College is the recent recipient of an NSF/NIMH award to establish a fMRI Data Center (see `http://www.fmridc.org/`). This is a joint effort of Dartmouth's Department of Mathematics, Center for Cognitive Neuroscience, and Department of Computer Science. In conjunction with the center, the Department of Mathematics is now accepting applications for a two-year postdoctoral fellow in applied mathematics, initial appointment in the 2002-03 academic year. Fellows will be expected to teach one graduate seminar each year (in their specialty) and to help in the implementation and development of novel postprocessing tools for the center. Fellows will interact with all of the cooperating departments. The ideal applicant will have strong interdisciplinary interests and have a background in informatics, image or signal processing, or medical imaging, but applicants with strong mathematical backgrounds who are looking to become more applied and learn about data mining, medical imaging, or image processing may also be excellent candidates.

Send letter of application, résumé, graduate transcript, thesis abstract (and description of other research activities and interests if appropriate), and 3 or preferably 4 letters of recommendation (at least one should discuss teaching) to Betty Harrington at the address above. Dartmouth College is committed to Affirmative Action and strongly encourages applications from minorities and women.

DARTMOUTH COLLEGE
John Wesley Young
Research Instructorship

The John Wesley Young Research Instructorship is a two-year postdoctoral appointment for promising new or recent Ph.D's whose research interests overlap a department member's. Current departmental interests include areas in algebra, analysis, algebraic geometry, combinatorics, differential geometry, logic and set theory, number theory, probability, and topology. Teaching duties of four 10-week courses spread over two or three quarters typically include at least one course in the instructor's speciality and include elementary, advanced, and (at instructor's option) graduate courses. Nine-month salary of $43,000 supplemented by summer research stipend of $9,555 for instructors in residence for two months in summer. Send letter of application, résumé, graduate transcript, thesis abstract, description of order research activities and interests if appropriate, and 3 or preferably 4 letters of recommendation (at least one should discuss teaching) to: Betty Harrington, Department of Mathematics, 6188 Bradley Hall, Hanover, NH 03755-3551. Applications received by January 5 will receive first consideration; applications will be accepted until position is filled. Dartmouth College is committed to Affirmative Action and strongly encourages applications from minorities and women.

NEW JERSEY

INSTITUTE FOR ADVANCED STUDY
School of Mathematics

The School of Mathematics has a limited number of memberships, some with financial support for research in mathematics at the Institute during the 2002-03 academic year. Candidates must have given evidence of ability in research comparable at least with that expected for the Ph.D. degree. The special program for the year will focus on stochastic PDE and models of turbulence, and both Weinan E and John

Ball will be in residence. For a brief description of the program and information about application materials and deadline, please consult "Activities" and "How To Apply" on our home page at: http://www.math.ias.edu/.

RUTGERS UNIVERSITY - NEWARK
Assistant Professor of Mathematics

The Department of Mathematics and Computer Science invites applications for a tenure-track assistant professor position in mathematics to begin September 2002. Candidates must have a Ph.D. and a strong research record, show outstanding promise for future work, and demonstrate a commitment to effective teaching.

In addition to participating in our undergraduate and Ph.D. math programs, candidates must be prepared to teach courses and advise students in our department's undergraduate computer science program. Preference will be given to candidates with a willingness to take a leadership role in this area.

Applicants should arrange for (1) an AMS Standard Cover Sheet; (2) a curriculum vitae; (3) a research statement; and (4) at least four letters of recommendation, one of which addresses teaching, to be sent to:

Personnel Committee
Department of Mathematics
and Computer Science
Rutgers University
Newark, NJ 07102

The review process will begin January 15, 2002. Applications may be accepted until the position is filled.

Rutgers University is an Equal Opportunity/Affirmative Action Employer.

RUTGERS UNIVERSITY
Department of Mathematics

The Rutgers University mathematics department invites applications for the following positions, which may be available September 2002.

TENURE-TRACK OR TENURED POSITION. The department anticipates at least one appointment at the level of assistant professor or above. Strong candidates in all fields are encouraged to apply. Candidates must have the Ph.D., outstanding research accomplishments in pure or applied mathematics, and concern for teaching.

NSF-VIGRE POSTDOCTORAL FELLOWSHIP (non-tenure-track). This nonrenewable position includes three years of academic-year and summer support, a teaching load of one course per semester, and other special features. Restricted to citizens or permanent residents of the United States who are within 18 months of the award of their Ph.D. Candidates should show outstanding promise of research ability in pure or applied mathematics, and have concern for teaching.

HILL ASSISTANT PROFESSORSHIPS (non-tenure-track). These three-year nonrenewable positions include reduced teaching load for research. Candidates should have received the Ph.D., show outstanding promise of research ability in pure or applied mathematics, and have concern for teaching.

NON-TENURE-TRACK ASSISTANT PROFESSORSHIPS. These are three-year nonrenewable positions. Candidates should have a Ph.D., show evidence of superior teaching accomplishments, and show promise of research ability.

Applicants should send a printed résumé, with the AMS Standard Cover Sheet attached, and have sent four letters of recommendation (one of which evaluates teaching) to: Search Committee, Dept. of Math-Hill Center, Rutgers University, 110 Frelinghuysen Road, Piscataway, NJ 08854-8019. In addition, an electronic version of the AMS Standard Cover Sheet should also be submitted at the website http://www.mathjobs.org/jobs/. It is essential to fill out this cover sheet completely, including specific position(s) applied for and the AMS subject classification number of your area(s) of specialization. Rutgers is an Affirmative Action/Equal Opportunity Employer and encourages applications from women and minority-group members.

The department will begin reviewing applications for tenure-track and tenured positions November 1, 2001, and for non-tenure-track positions December 1, 2001, and will continue its review until the positions are filled. Updated details of these positions will appear on the Rutgers mathematics department Web page at http://www.math.rutgers.edu/.

WORLD SCIENTIFIC PUBLISHING CO.
1060 Main St., River Edge, NJ
Acquisition Editor

Expanding international STM publisher seeks a mathematics acquisition editor. The ideal candidate would have a Ph.D. in mathematics and be interested in publishing. Responsibilities include conferring with authors, keeping abreast of current research, and reporting directly to the editor-in-chief. Send résumé and salary requirement to World Scientific Publishing Co., 1060 Main St., River Edge, NJ 07661; fax 201-487-9656.

NEW MEXICO

THE UNIVERSITY OF NEW MEXICO
Department of Mathematics and Statistics
Albuquerque, NM

Pending approval, the department anticipates an appointment in applied analysis beginning fall of 2001 at the assistant professor level. Exceptionally well-qualified senior candidates may be considered. Minimal qualifications include a Ph.D. in mathematics or related area. Additional information is available at http://www.math.unm.edu/. Applicants should send a CV and three letters of recommendation to: Search Committee, Applied Analysis, Dept. of Math. & Stat., University of New Mexico, Albuquerque, NM 87131. We shall begin reviewing applications on November 2, 2001. EO/AA.

NEW YORK

NEW YORK UNIVERSITY
Courant Institute of Mathematical Sciences

The Courant Institute is a center for advanced training and research in the mathematical sciences. It has long been a leader in mathematical analysis, differential geometry, probability theory, applied mathematics, and scientific computation, with special emphasis on partial differential equations and their applications. Its scientific activities include an extensive array of research seminars and advanced graduate courses.

Each year a limited number of Courant Instructorships are awarded to postdoctoral scientists. These appointments carry a light teaching load of one course per semester and ordinarily are for a three-year term. These positions are primarily for recent Ph.D.'s, and candidates must have a degree in mathematics or an affiliated field.

For an application and further information, write to: Visiting Membership Committee, Courant Institute of Mathematical Sciences, 251 Mercer Street, New York, NY 10012-1185. Forms may also be obtained directly from the Web at http://www.cims.nyu.edu/information/brochure/visiting.html or by sending e-mail to vm-apply@cims.nyu.edu. Applications and supporting documents are due by December 15, 2001, for appointments to begin the following academic year.

The Courant Institute at New York University is an Equal Opportunity/Affirmative Action Employer.

NORTH CAROLINA

UNIVERSITY OF NORTH CAROLINA, CHAPEL HILL
Department of Mathematics

Applications are invited for the position of postdoctoral fellow in applied mathematics. The appointment is to begin January 1, 2002, and may be renewed through the 2003-04 academic year. Candidates for the 2002-03 academic year are also encouraged to apply now. Candidates should have received a doctorate either in mathematics, applied mathematics, or a closely related field. Applicants with a strong research promise in computational fluid dynamics or scientific computing will be given highest priority. More information on the UNC applied math group can be found at our website, http://www.amath.unc.edu/jobs/.

UNIVERSITY OF NORTH CAROLINA, CHAPEL HILL
Department of Mathematics

Applications are invited for positions as a postdoctoral fellow in the Department of Mathematics. Applicants in pure mathematics and in applied mathematics will be considered. The appointments are for two years and are normally renewable for a third year. Candidates should have received a doctorate by August 1, 2002, either in mathematics, applied mathematics, or a closely related field. Applicants with strong research promise in an area common with our current faculty will be given highest priority. More information can be found at our website at http://www.math.unc.edu/.

Applicants should send the (i) AMS Standard Cover Sheet, (ii) a vita, (iii) a description of current research and a plan for future research, (iv) four letters of recommendation, (v) the name(s) of one or more faculty at UNC who work in their general area of research.

The AMS Standard Cover Sheet should be completed online at http://www.mathjobs.org/jobs/. Applicants are encouraged to submit their entire application at this site. They can also mail their applications to one of these addresses:

Pure applicants:

Pure Search Committee
Department of Mathematics
UNC-CH
CB #3250 Phillips Hall
Chapel Hill, NC 27599-3250

Applied applicants:

Applied Search Committee
Department of Mathematics
UNC-CH
CB #3250 Phillips Hall
Chapel Hill, NC 27599-3250

Applications will be reviewed until the positions are filled. Preference will be given to applications received by January 1, 2002. UNC-CH is an EO/ADA Employer.

OHIO

THE OHIO STATE UNIVERSITY
Department of Mathematics

The Department of Mathematics of The Ohio State University expects to have available several tenure-track/tenured positions and several visiting positions, effective autumn quarter 2002. Candidates in all areas of pure and applied mathematics are invited to apply. Significant mathematical research accomplishment and evidence of excellent teaching ability are required.

The department will also have available several Hans J. Zassenhaus Assistant Professorships and Arnold Ross Assistant Professorships. These term positions are renewable annually up to a total of three years. Candidates are expected to present evidence of excellence in research and teaching.

Please send a CV and have at least three letters of recommendation sent to: Professor Peter March, Chair, Department of Mathematics, The Ohio State University, 231 W. 18th Avenue, Columbus, OH 43210.

The Ohio State University is an Equal Opportunity/Affirmative Action Employer. Women and minority candidates are encouraged to apply.

OKLAHOMA

OKLAHOMA STATE UNIVERSITY
Department of Mathematics

The department anticipates filling 2 or more tenure-track or tenured positions beginning fall 2002. 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 5 or 6 hours each 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 algebraic geometry and PDE/fluid mechanics.

The department also invites applications from recent recipients of the Ph.D. for several temporary postdoctoral positions beginning fall 2002. 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 5 or 6 hours each semester. Mathematicians with research interests close to those of the permanent faculty may receive preference.

All applicants should submit a curriculum vitae, 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, Standard Cover Sheet, and indicate their subject area using the AMS subject classification numbers. Full consideration will be given to applications received by December 1, 2001. Electronic applications are encouraged; information about this may be found at http://www.math.okstate.edu/~jobs/.

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 8-10 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.

THE UNIVERSITY OF OKLAHOMA
Department of Mathematics

Applications are invited for one or more full-time, tenure-track position(s) in mathematics, beginning August 16, 2002. The position(s) is initially budgeted at the assistant professor level, but an appointment at the associate professor level may be possible for an exceptional candidate with qualifications and experience appropriate to that rank. Normal duties consist of teaching two courses per semester, conducting research, and rendering service to the department, university, and profession at a level appropriate to the faculty member's experience. The position(s) requires an earned doctorate and research interests that are compatible with those of the existing faculty; preference will be given to applicants with potential or demonstrated excellence in research and prior successful undergraduate teaching experience. Salary and benefits are commpetitive. For full consideration, applicants should send a completed AMS cover sheet, curriculum vitae, a description of current and planned research, and have sent three letters of recommendation (at least one of which must address the applicant's teaching experience and proficiency) to:

Search Committee
Department of Mathematics
University of Oklahoma
601 Elm, PHSC 423
Norman, OK 73019-0315
phone: 405-325-6711
fax: 405-325-7484
e-mail: search@math.ou.edu

Screening of applications will begin on December 15, 2001, and will continue until the position(s) is filled.

The University of Oklahoma is an Equal Opportunity/Affirmative Action Employer. Women and minorities are encouraged to apply. OU has a policy of being responsive to the needs of dual-career couples.

PENNSYLVANIA

CARNEGIE MELLON UNIVERSITY
Department of Mathematical Sciences

The Department of Mathematical Sciences expects to appoint a postdoctoral fellow in mathematical finance, beginning in September 2002. Applicants should have a strong record of accomplishment in probability research and a serious interest in the applications of probability to finance. This will be a two-year appointment, with the possibility of a third-year extension. Recipients will teach at most two courses per year. Applicants should send a vita, list of publications, a statement describing current and planned research, and arrange to have at least three letters of recommendation sent. The deadline for applications is January 18, 2002. All communications should be addressed to: Appointments Committee, Center for Computational Finance, Department of Mathematical Sciences, Carnegie Mellon University, Pittsburgh, PA 15213. Carnegie Mellon University is an Affirmative Action/Equal Opportunity Employer.

CARNEGIE MELLON UNIVERSITY
Department of Mathematical Sciences
Tenure-Track Position
Applied Analysis

The Department of Mathematical Sciences at Carnegie Mellon University invites applications for a tenure-track position to begin September 1, 2002.

The position is in applied analysis in the areas of nonlinear partial differential equations and the calculus of variations. Preference will be given to candidates who have shown outstanding promise and/or excellent accomplishments in research in the above areas and who pursue a vigorous research program, including major contributions beyond the doctoral dissertation. Expertise in the areas of nonconvex variational problems, multiscale problems, connections between atomistic and continuum models will be preferred.

Applicants should send a curriculum vitae, list of publications, a statement describing current and planned research, and arrange to have sent at least three letters of recommendation to: Applied Analysis Appointments Committee, Department of Mathematical Sciences, Carnegie Mellon University, Pittsburgh, PA 15213. The deadline for both tenure-track and tenured applications is January 18, 2002.

The Department of Mathematical Sciences is committed to increasing the number of women and minority faculty. Carnegie Mellon University is an Affirmative Action/Equal Opportunity Employer and encourages applications from women and minorities.

CARNEGIE MELLON UNIVERSITY
Department of Mathematical Sciences
Zeev Nehari Visiting Assistant Professorship

The Zeev Nehari Visiting Assistant Professorship was established to honor the memory of Professor Nehari, who had a long and distinguished career in the Department of Mathematical Sciences. This position is available for a period of three years, beginning in September 2002, and carries a teaching load of three courses during the academic year. Applicants are expected to show exceptional research promise as well as clear evidence of achievement and should have research interests which intersect those of current faculty of the department. Applicants should send a vita, list of publications, a statement describing current and planned research, and arrange to have sent at least three letters of recommendation to the committee. The deadline for applications is January 18, 2002. All communications should be addressed to: Zeev Nehari Appointments Committee, Department of Mathematical Sciences, Carnegie Mellon University, Pittsburgh, PA 15213. Carnegie Mellon University is an Affirmative Action/Equal Opportunity Employer.

PENN STATE UNIVERSITY
COMMONWEALTH COLLEGE
Department of Mathematics

The Commonwealth College invites applications for tenure-track positions at the rank of assistant professor at two of its campuses beginning in August 2002. Tenure and promotion in the college are based on the following: innovative teaching of courses ranging primarily over the first two years of college mathematics; recognized research and scholarly contributions to mathematics and mathematics pedagogy; service to the campus, college, university, and community at large. Applicants must complete the Ph.D. degree in a mathematical science by the time the appointment begins and will be selected on the basis of their potential for achieving tenure and promotion. To learn more about the campuses and the positions, please visit the "Careers With Us" link on our home page at `http://cwchome.psu.edu/`. Applicants should submit a résumé including a list of publications, a statement on teaching and research, and the complete contact information for three references, including e-mails if possible, to:

The Pennsylvania State University
Commonwealth College
Faculty Searches
111 Old Main, Box AMS-NOTICES
University Park, PA 16802

Review of applications will begin November 1, 2001, and will continue until the positions are filled. Penn State is committed to Affirmative Action/Equal Opportunity and the diversity of its work force.

RHODE ISLAND

BROWN UNIVERSITY
J. D. Tamarkin Assistant Professorship

One or two 3-year nontenured nonrenewable appointments, beginning July 1, 2002. Teaching load: one to two courses per semester (3-6 hours per week). Candidates are required to have received a Ph.D. degree or equivalent by the start of this appointment, and they may have up to three years of academic and/or postdoctoral research experience by then.

VIGRE Postdoctoral Fellow: One 3-year nontenured nonrenewable appointment, beginning July 1, 2002. Teaching load: one course per semester (3 hours per week). The fellowship includes summer support and a $2,500/year research fund. Candidates are required to have received a Ph.D. degree by the start of this appointment, and they may have up to 18 months of academic and/or postdoctoral research experience by then. Candidates must be U.S. citizens, nationals, or permanent residents to qualify for the VIGRE fellowships, which are NSF-supported positions.

Applicants should have strong research potential and a commitment to teaching. Field of research should be consonant with the current research interests of the department. For full consideration, a curriculum vitae, an AMS Standard Cover Sheet, and three letters of recommendation must be received by December 1, 2001. All inquiries and materials should be addressed to: Junior Search Committee, Department of Mathematics, Brown University, Providence, RI 02912. To access the AMS Standard Cover Sheet, visit our website, `http://www.math.brown.edu/juniorsearch.shtml`.
E-mail inquiries can be addressed to `juniorsearch@math.brown.edu`. Brown University is an Equal Opportunity/Affirmative Action Employer and encourages applications from women and minorities.

SOUTH CAROLINA

UNIVERSITY OF SOUTH CAROLINA
Department of Mathematics

The Department of Mathematics anticipates hiring tenure-track faculty, primarily at the assistant professor rank, to begin in the 2002-03 academic year, and invites applications. The Ph.D. degree or its equivalent is required. There is also the possibility of a senior-level position for a candidate with outstanding research and funding credentials. The evaluation of applications will begin December 1, 2001; however, applications will be accepted and interviews conducted until the positions are filled. The department has strengths in applied mathematics, approximation theory, combinatorics, commutative algebra, complex variables, computational mathematics (analysis, algebra, biology), differential geometry, Fourier analysis, functional analysis, logic and model theory, number theory, partial differential equations, and topology. While applicants in all areas of mathematics will be considered, those whose interests mesh well but do not necessarily duplicate existing strengths will be given preference. Candidates with postdoctoral experience are generally preferred, although new Ph.D.'s with significant accomplishments in research are also encouraged to apply. Appointments will be consistent with the department's commitment to excellence in research and in teaching at the undergraduate and graduate levels. A complete application should include a detailed résumé with a summary of research accomplishments and goals, a completed AMS Standard Cover Sheet (see the *Notices*), and four letters of recommendation. Any of these components may be sent either in hard copy or by e-mail in the form of .pdf or .ps files to:

Manfred Stoll, Chairman
Department of Mathematics
University of South Carolina
Columbia, SC 29208
e-mail: `hiring2002\@math.sc.edu`

The University of South Carolina is an Affirmative Action/Equal Opportunity Employer.

TEXAS

LAMAR UNIVERSITY-BEAUMONT TEXAS
Chair, Department of Mathematics

Applications and nominations are invited for the position of chair of the Department of Mathematics starting with the fall 2002 semester. Candidates should possess a Ph.D. in mathematics, research credentials, teaching experience, and an established record of university and professional service appropriate for a tenured appointment at the rank of professor or associate professor.

Applications, including a vita and at least three letters of recommendation, should be sent to: Chair, Search Committee, Department of Mathematics, P.O. Box 10047, Lamar University, Beaumont, TX 77710.

Review of applications will begin December 1, 2001, and will continue until the position is filled. Information about the department and the university can be found at our website, `http://www.lamar.edu/`. Inquiries can be addressed to `department@math.lamar.edu`. Lamar University is an Affirmative Action/Equal Opportunity Employer.

TEXAS A&M UNIVERSITY
Department of Mathematics

Applications are invited for tenured and tenure-eligible faculty positions beginning fall 2002. The field is open, but we particularly seek applications from individuals whose mathematical interests would augment and build upon existing strengths both within the mathematics department as well as other departments in the university. Salary, teaching loads, and start-up funds are competitive.

For a tenured position the applicant should have an outstanding research reputation and would be expected to fill a leadership role in the department. An established research program, including success in attracting external funding and supervision of graduate students, and a demonstrated ability and interest in teaching are required. Informal inquiries are welcome.

For an assistant professorship, we seek strong research potential and evidence of excellence in teaching. Research productivity beyond the doctoral dissertation will normally be expected.

In order to expedite the application process, we request that the AMS Standard Cover Sheet be used. Applicants should arrange to send the completed form, a vita, and letters of recommendation to:

Faculty Hiring
Department of Mathematics
Texas A&M University
College Station, TX 77843-3368

Further information can be obtained from `http://www.math.tamu.edu/hiring/`.

Texas A&M University is an EOE/AA Employer, and the department encourages applications from women and minorities.

TEXAS A&M UNIVERSITY
Department of Mathematics

The department will have several visiting appointments available beginning fall 2002.

Senior positions may be for a semester or one-year period, and the number available will depend on funding.

The Visiting Assistant Professor positions are for a three-year period. They are intended for those who have recently received their Ph.D., and preference will be given to mathematicians whose research interests are close to those of our regular faculty members. Salary and teaching loads are competitive. In addition, as part of our VIGRE grant we expect to have up to four positions carrying a one-course-per-semester teaching load.

In order to expedite the application process, we request that the AMS Standard Cover Sheet be used. Applicants should send the completed form, a vita, and letters of recommendation to:

Visiting Faculty Hiring
Department of Mathematics
Texas A&M University
College Station, TX 77843-3368

For full consideration, the complete dossier should be received by January 15, 2002. Further information can be obtained from our website, `http://www.math.tamu.edu/hiring/`.

Texas A&M University is an EOE/AA Employer, and the department encourages applications from women and minorities.

VIRGINIA

UNIVERSITY OF VIRGINIA
Department of Mathematics

The Department of Mathematics invites applications for one or more tenure-track or tenured positions for the fall semester of 2002. Applicants must present evidence of outstanding accomplishment and/or promise in both research and teaching. Strong candidates at all levels and in all fields will be considered, though special attention will be given to fields which fit well with the strengths and interests of its current faculty (see the department's home page at `http://www.virginia.edu/`).

To apply, please send a letter of application, a curriculum vitae, and at least four letters of recommendation to:

Hiring Committee
Department of Mathematics
University of Virginia
Kerchof Hall
P. O. Box 400137
Charlottesville, VA 22904-4137

WEST VIRGINIA

WEST VIRGINIA UNIVERSITY
Eberly College of Arts and Sciences
Department of Mathematics

Applications and nominations are invited for up to three faculty positions starting August 16, 2002, to be part of the Institute for Math Learning. The Department of Mathematics seeks mathematicians or mathematics educators with excellent teaching skills and strong commitment to extending and developing effective, efficient ways of teaching mathematics students, generating new initiatives with the K–12 community, and aggressively competing for nationally awarded grants that would support the pedagogical dimension of the institute. We are working toward an institute that is regarded for its national leadership in innovative, effective research-based math learning models. The institute is part of the Department of Mathematics in the Eberly College of Arts & Sciences, with its own director and with operational governance that allows tenured and tenure-track faculty to be rewarded and recognized for their roles in teaching excellence and in research and scholarship associated with the goals of the institute and pedagogy associated with math learning. All applicants should have professional credentials qualifying for a tenure-track appointment at least at the rank of assistant professor. A truly outstanding individual with the capacity to provide research leadership will be considered for appointment at the rank of associate/full professor as an Eberly Professor, with benefits accorded to the Eberly Family Distinguished Professors in the Eberly College of Arts and Sciences.

West Virginia University is a land grant institution in the state of West Virginia, enrolling 22,000 students. It is a Doctoral/Research University-Extensive in the Carnegie Classification of Institutions of Higher Education, based on the complexity and breadth of the institution's mission. The Department of Mathematics has 26 full-time faculty members and approximately 30 M.S. and Ph.D. students. The department is housed in newly refurbished facilities that include networked offices and the university's mathematical library. The university is located in Morgantown, an award-winning city with a metropolitan population of 80,000. Morgantown has diverse cultural and recreational opportunities, excellent medical facilities, and a favorable location with ready access to the urban areas of Pittsburgh, PA, and Washington, DC.

Applicants should provide a letter of application including: a statement of teaching philosophy and any experience and vision related to achieving the goals of the institute; a vita; and the names and contact information of three references. Please send applications, references, and inquiries to:

Sherman D. Riemenschneider
Chair, Department of Mathematics
320 Armstrong Hall, P.O. Box 6310
West Virginia University
Morgantown, WV 26506-6310
e-mail: sherm@math.wvu.edu

Priority will be given to applications received by December 1, 2001.

West Virginia University is an Equal Opportunity/Affirmative Action Employer. Minority, disabled, and women candidates are urged to apply.

MARSHALL UNIVERSITY
Division Head, Mathematics and Applied Science

The division, one of three in the College of Science, includes 32 full-time faculty and is responsible for all instruction in mathematics and computer science. The division head is also chair of the Department of Mathematics (http://www.marshall.edu/math/), which offers baccalaureate and master's degrees. This is a twelve-month appointment with a teaching load of 3–6 credit hours per semester. Responsibilities include: recruitment and professional development of successful and effective scholars and teachers, development and implementation of an innovative curriculum, scheduling, staffing, fiscal and personnel management, fundraising, strategic planning, and outreach to the campus and community. Qualifications include: a Ph.D. in the mathematical sciences with an appreciation for the major fields of pure and applied mathematics, a documented record of scholarship and teaching that would qualify for appointment at the level of full professor, interpersonal and communication skills appropriate to a position of leadership in a university. Previous administrative experience as a program director/department chair or comparable level of responsibility is strongly preferred.

Marshall (http://www.marshall.edu/), a public comprehensive institution offering programs through the Ph.D. and M.D., is West Virginia's second-largest university, with an enrollment of 16,000. Located on the Ohio River a short drive from the state capitol in Charleston, Marshall is in the state's largest metropolitan corridor and is in the center of the tri-state region, within 100 miles of Lexington, Kentucky; and Columbus, Ohio.

Salary is commensurate with experience. Appointment will commence not later than August 1, 2002. Send letters of application; a current résumé; transcript(s) indicating the terminal degree; and the names, telephone numbers, street and e-mail addresses of at least three references to: Dr. Dan Babb, Chair, Math Div. Search Committee, c/o College of Science, Marshall University, 400 Hal Greer Blvd., Huntington, WV 25755. Letters of nomination are encouraged. Review of applications will begin December 1, 2001, and will continue until the position is filled. Women and minority candidates are strongly encouraged to apply. Marshall University is an Equal Opportunity Employer.

WISCONSIN

UNIVERSITY OF WISCONSIN-MADISON
Department of Mathematics

The Department of Mathematics anticipates openings for three positions to begin August 26, 2002, at the tenure-track (assistant professor) level. Appointment at the beginning associate professor level (tenured) will be considered for exceptional candidates, but strong preference will be given to hiring at the assistant professor level. Applications are invited in all areas of mathematics. Candidates should exhibit evidence of outstanding research potential, normally including significant contributions beyond the doctoral dissertation. A strong commitment to excellence in instruction is also expected. Additional departmental information is available on our website, http://www.math.wisc.edu/.

Applicants should send a completed AMS Standard Cover Sheet, a curriculum vitae which includes a publication list, and brief descriptions of research and teaching to:

Hiring Committee
Dept. of Mathematics, Van Vleck Hall
University of Wisconsin-Madison
480 Lincoln Drive
Madison, WI 53706-1388

Applicants should also arrange to have sent to the above address three or four letters of recommendation, at least one of which must discuss the applicant's teaching experiences and capabilities. Review of applications will begin on November 15, 2001. Applications will be accepted until the positions are filled. Additional letters will be solicited by the department for candidates who are finalists for a tenured position.

The Department of Mathematics is committed to increasing the number of women and minority faculty. The University of Wisconsin is an Affirmative Action/Equal Opportunity Employer and encourages applications from women and minorities. Unless confidentiality is requested in writing, information regarding the applicants must be released upon request. Finalists cannot be guaranteed confidentiality.

UNIVERSITY OF WISCONSIN-MADISON
Department of Mathematics

The Department of Mathematics invites applications for possible Van Vleck Visiting Assistant Professorships to begin August 26, 2002. Appointments are for a fixed term of two or three years. The usual teaching load is two courses per semester. Ordinarily only those applicants who have received their doctorate since 1999 will be considered. Promise of excellence in research and teaching is important. Preference will be given to candidates who are likely to interact well with other members of the department. The department also expects to have available one or more VIGRE Van Vleck Assistant Professorships, partially funded by an NSF VIGRE grant, with a reduced teaching load. VIGRE awards are restricted to U.S. citizens and permanent residents who have received the Ph.D. within 18 months of the start of the award.

Applicants should send a completed AMS Standard Cover Sheet, a curriculum vitae which includes a publication list, and a brief statement of research plans to:

Hiring Committee
Dept. of Mathematics, Van Vleck Hall
University of Wisconsin-Madison
480 Lincoln Drive
Madison, WI 53706-1388

Applicants should also arrange to have sent to the above address three or four letters of recommendation, at least one of which must discuss the applicant's teaching experiences and capabilities. Other evidence of good teaching will be helpful. The deadline for applications is December 15, 2001.

The Department of Mathematics is committed to increasing the number of women and minority faculty. The University of

Wisconsin is an Affirmative Action/Equal Opportunity Employer and encourages applications from women and minorities. Unless confidentiality is requested in writing, information regarding the applicants must be released upon request. Finalists cannot be guaranteed confidentiality.

For more information about the position, please consult http://www.math.wisc.edu/.

UNIVERSITY OF WISCONSIN-MADISON
Mathematical Physics/String Theory Cluster Hiring

The Departments of Mathematics and Physics anticipate openings for three positions to begin August 26, 2002, at either the tenure-track (assistant professor) or tenured (associate/full professor) level. This cluster hiring is a part of the Madison Initiative and is intended to establish a prominent research group connecting the existing groups in particle physics phenomenology in the physics department and topology/geometry in the mathematics department. Applications are especially encouraged from theorists pursuing innovative research in string theory, quantum gravity, physics with extra dimensions, quantum field theory, supersymmetry, and unification theories, as well as from mathematicians working on aspects of string theory or related topics. Successful candidates will be encouraged to participate in interdisciplinary research which will strengthen ties between the two departments. Joint appointments in the mathematics and physics departments are contemplated.

Candidates should exhibit evidence of outstanding research records, normally including achievements significantly beyond the doctoral dissertation. A strong commitment to excellence in instruction at both undergraduate and graduate levels is also expected. Applicants should send a curriculum vitae that includes a publication list, and brief descriptions of research and teaching accomplishments and goals to:

Math/Physics Cluster Hiring Committee
Dept. of Mathematics, Van Vleck Hall
University of Wisconsin-Madison
480 Lincoln Drive
Madison, WI 53706-1388

Applicants should also arrange to have sent to the above address three letters of recommendation which address the applicant's research potential and teaching experiences. Review of applications will begin on November 1, 2001. Applications will be accepted until the positions are filled. Additional letters will be solicited by the hiring committee for senior appointments.

The Departments of Mathematics and Physics are committed to increasing the number of women and minority faculty. The University of Wisconsin is an Affirmative Action/Equal Opportunity Employer and encourages applications from women and minorities. Unless confidentiality is requested in writing, information regarding the applicants must be released upon request. Finalists cannot be guaranteed confidentiality.

Additional departmental information is available on the websites http://www.math.wisc.edu/ or http://www.physics.wisc.edu/. Information about the cluster hiring initiative is available at http://wiscinfo.doit.wisc.edu/cluster/.

WYOMING

UNIVERSITY OF WYOMING
Department of Mathematics Analysis Position

Applications are invited for a tenure-track assistant professorship to begin in August 2002. Minimum requirements are (i) an earned Ph.D. in mathematics, (ii) evidence of strong research potential, and (iii) evidence of good teaching and an interest in undergraduate and graduate advising and thesis supervision. Preferred qualifications include research emphasis in complex analysis, functional analysis, operator theory, dynamical systems or other current research areas in the department (see http://math.uwyo.edu/). Teaching load is 6-9 credit hours per semester. Advising undergraduates and outreach teaching may be required. The University of Wyoming mathematics department has 19 full-time faculty and offers the B.S., M.S. and Ph.D. in mathematics and an M.S. in teaching.

Applicants should send a letter of application, a current curriculum vitae, a statement of research interests, a statement of teaching experience and interest, and arrange to have sent three letters of recommendation, with at least one discussing the candidate's teaching experience, to the Analysis Search Committee, Department of Mathematics, University of Wyoming, Laramie, WY 82071-3036. Review of completed applications will begin February 1, 2002. The University of Wyoming is an AA/EEO Employer.

UNIVERSITY OF WYOMING
Head, Department of Mathematics

The Department of Mathematics at the University of Wyoming invites applications and nominations for the position of department head. The appointment will be at the rank of professor and will be effective August 1, 2002. Minimum qualifications are: a doctorate degree in mathematics with a strong record of research and exemplary teaching that would warrant tenure at UW. Preference will be given to individuals with research interests close to those represented in the department and with an established record of leadership. Undergraduate advising and outreach teaching may be required. UW is a Carnegie-classified extensive, doctoral/research university with approximately 11,000 students. The department offers the B.S., M.S., and Ph.D. degrees in mathematics and a master of science degree in teaching. For additional details, visit the department's Web page at http://math.uwyo.edu/.

Review of completed applications will begin on January 15, 2002. Nominations and informal inquiries are encouraged; e-mail should be directed to bshader@uwyo.edu. Applicants should submit a letter explaining their interest in the position, a separate statement that describes their approach to the responsibilities of a department head, a vita, and arrange to have sent four letters of reference to be sent to: Head Search Committee, Department of Mathematics, University of Wyoming, Laramie, WY 82071-3036. UW is an AA/EEO Employer.

CANADA

UNIVERSITÉ DE MONTRÉAL
Department of Mathematics and Statistics Pure Mathematics

The Department of Mathematics and Statistics of the Université de Montréal invites applications for a tenure-track position in pure mathematics at the assistant professor level, starting June 2002. Applicants should have a Ph.D. in mathematics. Preference will be given to candidates in one of the following areas: differential equations, partial differential equations, spectral analysis, geometric functional analysis, arithmetic geometry, but every outstanding candidate in pure mathematics will be considered. The research record is of prime importance. The successful candidate must also possess excellent teaching skills. Courses are taught in French. Candidates who do not speak French must acquire an adequate knowledge of it within a reasonable period of time after the appointment. Duties include undergraduate and graduate teaching, supervision of graduate students, and research. The department coordinates with the activities of the Centre de Recherches Mathématiques (CRM). For more information on the department or the CRM, visit http://www.dms.umontreal.ca/ and http://www.crm.umontreal.ca/. The position is subject to budgetary approval. The Université de Montréal offers competitive salaries and a complete package of social benefits.

Interested candidates must submit a curriculum vitae including a concise statement of their research interests, at least three letters of reference, and copies of at most three of their most important research publications before November 15, 2001 (or until the position is filled), to: Chair, Départmente de mathématiques et de statistique, Université de Montréal, C.P. 6128, succursale Centre-ville, Montréal, Québec, Canada H3C 3J7; phone: 514-343-6743; fax: 514-343-5700; e-mail: mathstat@dms.umontreal.ca.

In accordance with Canadian immigration requirements, priority will be given to Canadian citizens and permanent residents of Canada. The Université de Montréal subscribes to an affirmative action program for women and to employment equity.

UNIVERSITÉ DE MONTRÉAL
Department of Mathematics and Statistics
NSERC University Faculty Awards Competition

The Department of Mathematics and Statistics of the Université de Montréal invites applications from talented females or aboriginal researchers, Canadian citizens or permanent residents of Canada in all areas of mathematics and statistics for the University Faculty Awards (UFA) program of NSERC. The holder will be appointed at the assistant professor level, starting June 2002. Exceptionally, an outstanding candidate at the associate professor level could be considered. Applicants should have a Ph.D. in mathematics or statistics. The research record is of prime importance. The successful candidate must also possess excellent teaching skills. Courses are taught in French. Candidates who do not speak French must acquire an adequate knowledge of it within a reasonable period of time after the appointment. Duties will include undergraduate and graduate teaching, supervision of graduate students, and research. The department coordinates with the activities of the Centre de Recherches Mathématiques (CRM). For more information on the department, the CRM or NSERC'S UFA program, visit http://www.dms.umontreal.ca/, http://www.crm.umontreal.ca/, and http://www.nserc.ca/programs/schol4_e.htm. The position is subject to budgetary approval. The Université de Montréal offers competitive salaries and a complete package of social benefits.

Interested candidates must submit a curriculum vitae including a concise statement of their research interests, at least three letters of reference, and copies of at most three of their most important research publications before October 1, 2001 (or until the position is filled), to: Chair, Départément de mathématiques et statistique, Université de Montréal, C.P. 6128, succursale Centre-ville, Montréal, Québec, Canada H3C 3J7; phone: 514-343-6743; fax: 514-343-5700; e-mail: mathstat@dms.umontreal.ca.

UNIVERSITY OF TORONTO
Department of Mathematics

The department invites applications for one or more limited-term assistant professorships which may, subject to budgetary approval, become available on either the St. George (downtown), Scarborough, or Erindale campus for a period of one to three years, beginning July 1, 2002. Duties consist of teaching and research, and candidates must demonstrate clear strength in both. Preference will be given to candidates with recent doctoral degrees. Salaries commensurate with qualifications.

Applicants should send their complete CV, including a list of publications, a short statement describing their research programme, and all appropriate material about their teaching. They should also arrange to have at least three letters of reference sent directly to:

Search Committee
Department of Mathematics
University of Toronto
100 St. George Street, Room 4072
Toronto, Canada M5S 3G3

At least one letter should be primarily concerned with the candidate's teaching.

In addition, it is recommended that applicants submit the electronic application form which is available on our WWW Employment Opportunities page, http://www.math.toronto.edu/jobs/. The position code is CLTA.

To ensure full consideration, all information should be received by December 1, 2001.

Further information about academic positions in the Department of Mathematics is available on the World Wide Web by accessing the above URL.

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 visible minority group members, women, aboriginal persons, persons with disabilities, and others who may add to the diversity of ideas.

Any inquiries about the application should be sent to ida@math.toronto.edu.

UNIVERSITY OF TORONTO
Department of Mathematics

The University of Toronto solicits applications for four tenure-stream appointments in the Department of Mathematics. The areas of research interest are partial differential equations and geometry, geometric analysis, gauge theory or symplectic topology, and algebra or number theory.

It is intended that the successful applicants will be nominated for a Canadian Research Chair at either a junior or senior level. Accordingly, candidates are expected to be outstanding mathematicians whose research and teaching will make major contributions to the quality and stature of the department.

The appointments will be made at the rank of either assistant, associate or full professor, to begin July 1, 2002. Salary commensurate with experience.

Applicants should send a complete CV, a short statement about their research program, and appropriate material about their teaching. They should also submit the names of four mathematicians who could be consulted about their work. The application should be sent directly to:

Search Committee
Department of Mathematics
University of Toronto
100 St. George Street, Room 4072
Toronto, Canada M5S 3G3

In addition, it is recommended that applicants submit the electronic application form which is available from our WWW Employment Opportunities page, http://www.math.toronto.edu/jobs/. The position code is CRC.

To ensure full consideration, the application should be received by December 1, 2001. Applications after this date will be considered until the positions have been filled.

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 visible minority group members, women, aboriginal persons, persons with disabilities, and others who may add to the diversity of ideas.

Any inquiries about the application should be sent to ida@math.toronto.edu.

UNIVERSITY OF TORONTO
Department of Mathematics

The University of Toronto solicits applications for a tenure-stream appointment in mathematics. Preference will be given to researchers in the areas of partial differential equations, stochastic differential equations, or modelling.

The appointment is at the downtown (St. George) campus at open rank, to begin July 1, 2002. Salary commensurate with experience. Candidates are expected to have demonstrated excellence in both teaching and research after the Ph.D.; in particular, a candidate's research record should show clearly the ability to make significant original and independent contributions to mathematics.

Applicants should send their complete CV, including a list of publications, a short statement describing their research program, and all appropriate material about their teaching. They should also arrange to have at least four letters of reference sent directly to:

Search Committee
Department of Mathematics
University of Toronto
100 St. George Street, Room 4072
Toronto, Canada M5S 3G3

At least one letter should be primarily concerned with the candidate's teaching.

In addition, it is recommended that applicants submit the electronic application form which is available from our WWW Employment Opportunities page, http://www.math.toronto.edu/jobs/. The position code is DE.

To ensure full consideration, this information should be received by December 1, 2001. Applications after this date will be considered until the position has been filled.

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 visible minority group members, women, aboriginal persons, persons with disabilities, and others who may add to the diversity of ideas.

Any inquiries about the application should be sent to ida@math.toronto.edu.

UNIVERSITY OF TORONTO
Department of Mathematics

The University of Toronto solicits applications for a tenure-stream appointment in mathematics. Preference will be given to researchers in the areas of low-dimensional, geometric or symplectic topology.

The appointment is at the downtown (St. George) campus at the rank of assistant professor, to begin July 1, 2002. Salary commensurate with experience. Candidates are expected to have demonstrated excellence in both teaching and research after the Ph.D.; in particular, a candidate's research record should show clearly the ability to make significant original and independent contributions to mathematics.

Applicants should send their complete CV, including a list of publications, a short statement describing their research program, and all appropriate material about their teaching. They should also arrange to have at least four letters of reference sent directly to:

Search Committee
Department of Mathematics
University of Toronto
100 St. George Street, Room 4072
Toronto, Canada M5S 3G3

At least one letter should be primarily concerned with the candidate's teaching.

In addition, it is recommended that applicants submit the electronic application form which is available from our WWW Employment Opportunties page, http://www.math.toronto.edu/jobs/. The position code is TOP.

To ensure full consideration, this information should be received by December 1, 2001. Applications after this date will be considered until the position has been filled.

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 visible minority group members, women, aboriginal persons, persons with disabilities, and others who may add to the diversity of ideas.

Any inquiries about the application should be sent to ida@math.toronto.edu.

UNIVERSITY OF TORONTO
Department of Mathematics

The University of Toronto solicits applications for a tenure-stream appointment in any area of pure or applied mathematics, with preference given to the areas of algebra and geometry.

The appointment is at the University of Toronto at Mississauga, Erindale College, at open rank, to begin July 1, 2002. Salary commensurate with experience. Candidates are expected to have demonstrated excellence in both teaching and research after the Ph.D.; in particular, a candidate's research record should show clearly the ability to make significant original and independent contributions to mathematics.

Applicants should send their complete CV, including a list of publications, a short statement describing their research program, and all appropriate material about their teaching. They should also arrange to have at least four letters of reference sent directly to:

Search Committee
Department of Mathematics
University of Toronto
100 St. George Street, Room 4072
Toronto, Canada M5S 3G3

At least one letter should be primarily concerned with the candidate's teaching.

In addition, it is recommended that applicants submit the electronic application form which is available on our WWW Employment Opportunities page, http://www.math.toronto.edu/jobs/. The position code is MAG.

To ensure full consideration, this information should be received by December 1, 2001. Applications after this date will be considered until the positions have been filled.

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 visible minority group members, women, aboriginal persons, persons with disabilities, and others who may add to the diversity of ideas.

Any inquiries about the application should be sent to ida@math.toronto.edu.

UNIVERSITY OF TORONTO
Department of Mathematics

The University of Toronto solicits applications for two tenure-stream appointments in mathematics. Preference will be given to researchers in the areas: (i) algebra, number theory and cryptography; and (ii) applied PDE's such as mathematical modelling, mathematical finance, or pattern recognition.

The appointments are at the University of Toronto at Mississauga, Erindale College, at the rank of assistant professor, to begin July 1, 2002. Salary commensurate with experience. Candidates are expected to have demonstrated excellence in both teaching and research after the Ph.D.; in particular, a candidate's research record should show clearly the ability to make significant original and independent contributions to mathematics.

Applicants should send their complete CV, including a list of publications, a short statement describing their research program, and all appropriate material about their teaching. They should also arrange to have at least four letters of reference sent directly to:

Search Committee
Department of Mathematics
University of Toronto
100 St. George Street, Room 4072
Toronto, Canada M5S 3G3

At least one letter should be primarily concerned with the candidate's teaching.

In addition, it is recommended that applicants submit the electronic application form which is available on our WWW Employment Opportunities page, http://www.math.toronto.edu/jobs/. The position codes are, respectively, (i) MANTC and (ii) MAPDE.

To ensure full consideration, this information should be received by December 1, 2001. Applications after this date will be considered until the positions have been filled.

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 visible minority group members, women, aboriginal persons, persons with disabilities, and others who may add to the diversity of ideas.

Any inquiries about the application should be sent to ida@math.toronto.edu.

UNIVERSITY OF WINDSOR
Department of Mathematics and Statistics
Tenure-Track Position in Statistics (Actuarial Science)

The University of Windsor invites applications for a tenure-track position in the Department of Mathematics and Statistics in the area of statistics at the rank of assistant professor commencing July 1, 2002.

The Department of Mathematics and Statistics currently has seventeen full-time faculty members. Research areas include statistics, operational research, algebra, analysis, and applied mathematics. There are excellent opportunities for collaboration with researchers in economics, engineering, business administration, and computer science.

The department offers M.Sc. and Ph.D. programs with concentration in applied mathematics and statistics. At the undergraduate level, we offer bachelor of mathematics programs in mathematics, mathematics and statistics, and mathematics and computer science. Also, there is an interdisciplinary bachelor of operational research program. There is a strong tradition of excellence in teaching at all levels, and several of our faculty have received distinguished teaching awards. For further information about our department, visit our website at http://www.uwindsor.ca/math/. For general information about faculty employment at Windsor, visit http://www.uwindsor.ca/facultyrecruitment/.

Qualifications for the position include completion of a Ph.D. by the date of appointment in an area of statistics closely related to actuarial science. Candidates who are close to completion of the Ph.D. are invited to apply. Preference will be given to applicants who have, or are close to, associate status in a professional actuarial society. The successful candidate will combine a strong commitment to quality teaching and excellent research potential.

The University of Windsor is committed to equity and diversity in the workplace and welcomes applications from aboriginal peoples, persons with disabilities, and members of visible minorities. Applications from women are particularly encouraged.

Applications will include: a letter of application indicating Canadian citizenship/resident status, a curriculum vitae, a statement of teaching interests, a proposed program of research, sample of scholarly work, and three current letters of reference forwarded by the referees.

To ensure full consideration for appointment for the fall term, complete applications and letters of reference should be submitted by January 25, 2002, to:

Dr. Alan Gold
Department of
Mathematics and Statistics
University of Windsor
Windsor, Ontario N9B 3P4, Canada
phone: (519) 253-3000, ext. 3017;
fax: (519) 971-3649
e-mail: mthsta2@uwindsor.ca

YORK UNIVERSITY
Applied Mathematics

Applications are invited for a tenure-track appointment at the assistant professor level in the Department of Mathematics and Statistics to commence July 1, 2002. Applications in the areas of operations research or applied discrete mathematics will be considered. The successful candidate must have a Ph.D. and is expected to have a proven record of research and superior teaching ability. Candidates will be expected to provide leadership to the undergrad OR program and to make a solid contribution to the mathematics graduate program. The selection process will begin on January 7, 2002. Applicants should arrange to send résumés and three letters of recommendation (one of which should address teaching) to: Applied Mathematics Search Committee, Department of Mathematics and Statistics, York University, 4700 Keele Street, Toronto, Ontario, Canada, M3J 1P3; fax: 416-736-5757; e-mail: appld.recruit\@mathstat.yorku.ca; http://www.math.yorku.ca/Hiring/.

In accordance with Canadian immigration requirements, Canadian citizens and permanent residents will be considered first for this position. All positions at York are subject to budgetary approval.

For many years York University has had a policy of employment equity including affirmative action for women faculty and librarians. Recently, York has included racial/visible minorities, persons with disabilities, and aboriginal peoples in its affirmative action program. Persons who are members of one or more of these three groups are encouraged to self-identify during the selection process. Please note that candidates from these three groups will be considered within the priorities of the affirmative action program only if they self-identify. The Department of Mathematics and Statistics welcomes applications from women, racial/visible minorities, persons with disabilities, and aboriginal peoples. The affirmative action program can be found on York's website at http://www.yorku.ca/, or a copy can be obtained by calling the affirmative action office at 416-736-5713.

YORK UNIVERSITY
Applied Mathematics

Applications are invited for a tenure-track appointment at the assistant professor level in the Department of Mathematics and Statistics in the area of infinite dimensional dynamical systems, with applications to population biology, neural networks, or data mining. The successful candidate must have a Ph.D. and is expected to have a proven record of research and superior teaching ability. Preference will be given to candidates who can make solid contributions to an undergraduate program in computational mathematics and to the graduate program and who can strengthen existing areas of present and ongoing research activity. The position commences July 1, 2002, and the selection process will begin on January 7, 2002. Applicants should arrange to send résumés and three letters of recommendation (one of which should address teaching) to: Dynamics Search Committee, Department of Mathematics and Statistics, York University, 4700 Keele Street, Toronto, Ontario, Canada, M3J 1P3; fax: 416-736-5757; e-mail: dynamics.recruit@mathstat.yorku.ca; http://www.math.yorku.ca/Hiring/.

In accordance with Canadian immigration requirements, Canadian citizens and permanent residents will be considered first for this position. All positions at York are subject to budgetary approval.

For many years York University has had a policy of employment equity including affirmative action for women faculty and librarians. Recently, York has included racial/visible minorities, persons with disabilities, and aboriginal peoples in its affirmative action program. Persons who are members of one or more of these three groups are encouraged to self-identify during the selection process. Please note that candidates from these three groups will be considered within the priorities of the affirmative action program only if they self-identify. The Department of Mathematics and Statistics welcomes applications from women, racial/visible minorities, persons with disabilities, and aboriginal peoples. The affirmative action program can be found on York's website at http://www.yorku.ca/, or a copy can be obtained by calling the affirmative action office at 416-736-5713.

YORK UNIVERSITY
Mathematics

Applications are invited for a tenure-track appointment at the assistant professor level in the Department of Mathematics and Statistics to commence July 1, 2002. Applications in algebra, logic, or related areas will be considered. The successful candidate must have a Ph.D. and is expected to have a proven record of research and superior teaching ability. Preference will be given to candidates who can strengthen existing areas of present and ongoing research activity. The selection process will begin on January 7, 2002. Applicants should arrange to send résumés and three letters of recommendation (one of which should address teaching) to: Pure Mathematics Search Committee, Department of Mathematics and Statistics, York University, 4700 Keele Street, Toronto, Ontario, Canada, M3J 1P3; fax: 416-736-5757; e-mail: pure.recruit@mathstat.yorku.ca; http://www.math.yorku.ca/Hiring/.

In accordance with Canadian immigration requirements, Canadian citizens and permanent residents will be considered first for this position. All positions at York are subject to budgetary approval.

For many years York University has had a policy of employment equity including affirmative action for women faculty and librarians. Recently, York has included racial/visible minorities, persons with disabilities, and aboriginal peoples in its affirmative action program. Persons who are members of one or more of these three groups are encouraged to self-identify during the selection process. Please note that candidates from these three groups will be considered within the priorities of the affirmative action program only if they self-identify. The Department of Mathematics and Statistics welcomes applications from women, racial/visible minorities, persons with disabilities, and aboriginal peoples. The affirmative action program can be found on York's website at http://www.yorku.ca/, or a copy can be obtained by calling the affirmative action office at 416-736-5713.

SINGAPORE

NATIONAL UNIVERSITY OF SINGAPORE
Department of Mathematics

The Department of Mathematics at NUS invites applications for several tenure-track and visiting positions in 2002. We will consider outstanding researchers in any field of pure and applied mathematics, particularly those in the areas of financial mathematics, scientific computing, optimization and operations research, as well as in computational biology, mathematical modeling, approximation and simulations.

Application materials should be sent to:
Search Committee
Department of Mathematics
National University of Singapore
2 Science Drive 2, Singapore 117543
Republic of Singapore
fax: +65 779 5452

and should include: (1) an American Mathematical Society Standard Cover Sheet; (2) a detailed CV including publications list; (3) a statement of research accomplishments and plan; (4) at least three letters of recommendation, including one which indicates the candidate's effectiveness and commitment in teaching. Inquiries may be sent via e-mail to search@math.nus.edu.sg.

Review of applications will begin December 15, 2001, and will continue until positions are filled. For further information about the department, please see http://www.math.nus.edu.sg/.

SOUTH AFRICA

UNIVERSITY OF CAPE TOWN
Department of Mathematics and Applied Mathematics
Professor/Associate Professor/ Senior Lecturer/Lecturer

The department is a large and dynamic organisation with over thirty faculty members. We seek to make three new appointments.

Applications are sought for posts at all levels, from lecturer to professor, in all fields. The department particularly encourages applications from candidates with research and teaching interests in one or more of formal aspects of computing, analysis, algebra, differential geometry, algebraic geometry and financial mathematics, but welcomes applications from researchers with strengths in other areas such as complex analysis, logic, number theory and dynamical systems. The department also has active research groups in topology and category theory, cosmology, biomathematics, and partial differential equations.

The remuneration packages are negotiable and include highly competitive benefits.

Please send a letter of application plus your CV (including the names, postal/e-mail addresses, telephone/fax numbers of 3 referees) to: The Staff Recruitment Office (Ref: 543), UCT, Rondebosch 7701, Cape Town, South Africa. The closing date for applications is 31 December 2001, although applications will be considered up until such time as the posts are filled. For further information, tel: +27 21 650-3003, fax: +27 21 650-2138, e-mail: mawenit@bremner.uct.ac.za,
http://www.uct.ac.za/.

TAIWAN

NATIONAL CHIAO TUNG UNIVERSITY
Department of Applied Mathematics

Applications are invited for assistant, associate, or full professor positions beginning fall 2002. All areas of pure and applied mathematics will be considered. The successful applicant should hold the Ph.D. degree in mathematics or a related field (earned by August 2002) and demonstrate strong research potential. The language of instruction is Mandarin, but in exceptional cases non-Mandarin speakers with excellent research records will be considered.

Applicants must send a letter of application, a curriculum vitae, a summary of research plans, and three letters of recommendation to:
Hiring Committee
Department of Applied Mathematics
National Chiao Tung University
Hsinchu 300, Taiwan

For full consideration the application should be received by February 15, 2002.

The department is one of the leading mathematics centers in Taiwan, featuring 25 faculty members in the areas of combinatorics, differential equations, differential geometry, dynamical systems, financial mathematics, functional analysis, Lie theory, numerical analysis, operator theory, probability theory. Visit the department's home page at http://www.math.nctu.edu.tw/ for more information.

The National Chiao Tung University is an Equal Oppurtunity Employer and does not discriminate on the basis of race, color, religion, national origin, sex, age, or disability.

PUBLICATIONS WANTED

MATHEMATICS BOOKS PURCHASED

Pure & appl. adv. & research level, any age, usable cond. Reprints OK. One box to whole libraries sought. Contact: Collier Brown or Ryan Thomas @ **Powell's Technical Bks.**, Portland, OR. Call 800-225-6911, fax 503-228-0505, or e-mail ryan.thomas@powells.com.

International Mathematics Research Notices

Web Site: http://imrn.hindawi.com

AIMS AND SCOPE

IMRN provides very fast publication of research articles of high current interest in all areas of mathematics. All articles are fully refereed and are judged by their contribution to advancing the state of the science of mathematics. Issues are published as frequently as necessary. IMRN is expected to publish 36+ issues in 2002. The articles of the IMRN are reviewed/indexed in INSPEC, Mathematical Reviews, PubSCIENCE, Science Citation Index, and Zentralblatt für Mathematik.

INSTRUCTIONS FOR AUTHORS

IMRN is devoted to advancing the state of the science of mathematics by publishing research articles of high current interest in all fields of mathematics. Articles of any length are welcome and all articles are refereed and judged for correctness, interest, originality, depth, and applicability. There are no page charges. Submissions are made by email to submit@imrn.hindawi.com. An abstract for each article should be included. A copy may also be sent to an editor. Only an acknowledgment from the editorial office officially establishes the date of receipt. Submissions not prepared using TEX should be typed or printed on one side of the page, be double-spaced (including references), have ample margins, and be accompanied by a page that lists all potentially ambiguous notations. Check contact information for submission by fax or post. When articles are accepted, production begins immediately; authors should be available to assist the editorial staff.

FORTHCOMING ARTICLES

- Asymptotics of Semiclassical Soliton Ensembles: Rigorous Justification of the WKB Approximation, *P. D. Miller*
- Braid Group Actions and Tensor Products, *Vyjayanthi Chari*
- Classification of Solutions of a Toda System in $\mathbb{R}^2$, *Jürgen Jost and Guofang Wang*
- Cyclomorphy, *Dan Voiculescu*
- Estimates for "Nonsingular" Multiplicative Character Sums, *Nicholas M. Katz*
- Estimates for Parametric Elliptic Integrands, *Tobias H. Colding and William P. Minicozzi II*
- Motivic Cohomology Groups are Isomorphic to Higher Chow Groups in any Characteristic, *Vladimir Voevodsky*
- Quantization of Slodowy Slices, *Wee Liang Gan and Victor Ginzburg*
- Reverse Bubbling and Nonuniqueness in the Harmonic Map Flow, *Peter Topping*
- Small Representations and Minuscule Richardson Orbits, *Mark Reeder*

SUBSCRIPTION INFORMATION:

Institutional subscription rates for year 2002 (36+ issues) are $1190.00 for print and online editions, $952.00 for online edition only. Please contact orders@hindawi.com for personal subscription rates, multiple year subscriptions, or purchase of back volumes. Back volumes are available starting from the volume of 1991. IMRN is also available as part of "Hindawi Mathematics Bundle" and "Hindawi Journals Bundle." Subscription information for these bundles is available at http://www.hindawi.com/subs.html.

HINDAWI Hindawi Publishing Corporation, P.O. Box 3079, Cuyahoga Falls, OH 44223, USA
Fax 1-866-446-3294 (USA, toll-free), 31-20-5248282 (Amsterdam, Netherlands)

Change of Address

Members of the Society who move or change positions are urged to notify the Providence Office as soon as possible.

Journal mailing lists must be printed four to six weeks before the issue date. Therefore, in order to avoid disruption of service, members are requested to provide the required notice well in advance.

Besides mailing addresses for members, the Society's records contain information about members' positions and their employers (for publication in the Combined Membership List). In addition, the AMS maintains records of members' honors, awards, and information on Society service.

When changing their addresses, members are urged to cooperate by supplying the requested information. The Society's records are of value only to the extent that they are current and accurate.

If your address has changed or will change within the next two or three months, please fill out this form, supply any other information appropriate for the AMS records, and mail it to:

Customer Services
AMS
P.O. Box 6248
Providence, RI 02940

or send the information on the form by e-mail to:

amsmem@ams.org or
cust-serv@ams.org

Name ______________________________

Customer code ______________________________

Change effective as of ______________________________

Old mailing address

____

____

____

New mailing address

____

____

____

New position ______________________________

If mailing address is not that of your employer,

please supply the following informations:

New employer ______________________________

Location of employer (city, state, zip code, country)

____

____

Telephone/home: ______________ **office:** ______________

Fax: ______________________________

e-mail ______________________________

Recent honors and awards

____

____

Fold here

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

BUSINESS REPLY MAIL

FIRST-CLASS MAIL PERMIT NO. 554B PROVIDENCE, RI

POSTAGE WILL BE PAID BY ADDRESSEE

Membership and Customer Services
AMERICAN MATHEMATICAL SOCIETY
P. O. Box 6248
Providence, RI 02940-9943

Fold here

Staple here

Cosponsored Conferences

AAAS Meeting to Offer Strong Mathematics Program

The 2002 Annual Meeting of the American Association for the Advancement of Science, February 14-19, in Boston, MA, will feature many outstanding expository talks by prominent mathematicians. These include the following three-hour symposia (and organizers) sponsored by Section A (Mathematics) of the AAAS:

- Robot Arm Manipulation (Robert Connelly, Cornell University)
- Articulation in Mathematics: Smoothing the Bumps from School to College (Bernard Madison, MAA)
- Bioconsensus (Fred Roberts, Rutgers University)
- Living with Data: Achieving Quantitative Literacy (Lynn A. Steen, St. Olaf College)
  Waves: Patterns and Turbulence (Walter Craig, McMaster University)
- Show Me the Data! Fiascos in Modeling and Statistics: Florida, Ford & Firestone, etc. (Leon Seitelman, University of Connecticut)
- Getting From Here to There: Mathematical Models for Movement and Aggregation of Cells and Organisms (Hans Othmer, University of Minnesota)
- Topical Talk "Hard Number Theory Problems and Cryptology" (Carl Pomerance, University of Georgia)

Other symposia that will be of interest to the mathematical community include:

Advanced Science and Mathematics in American High Schools

The New Computing I, II

Teaching and Learning in Science and Mathematics: What Does Discipline-Based Education Research Tell Us?

Mathematics and Science of Origami: Visualize the Possibilities

Equal Access to Science, Mathematics, and Technology Education Is a Human Right That Belongs to All

The above symposia are only a few of the 150 or so AAAS program offerings in the physical, life, social, and biological sciences. For details of the 2002 AAAS program, see the October 26, 2001, issue of *Science*.

AAAS annual meetings are the showcases of American science, and they encourage participation by mathematicians and mathematics educators. (AAAS acknowledges the AMS for its generous support.) In presenting mathematics-related themes to the AAAS Program Committee, I have found the committee to be genuinely interested in offering symposia on mathematical topics of current interest. Thus, Section A's Committee seeks organizers and speakers who can present substantial new material in an accessible manner to a large scientific audience. Toward this end, I invite you to attend our Section A Committee business meeting from 7:30-10:30 p.m. on Friday, February 15th, 2002, in the Yarmouth Room of the Marriott Copley Place. I invite you also to send me, and encourage your colleagues to send me, symposia proposals for future AAAS annual meetings.

—Warren Page, Secretary of Section A of the AAAS
wxpny@aol.com, *fax: 914-476-6446*

Add this Cover Sheet to all of your Academic Job Applications

How to use this form

1. Using the facing page or a photocopy, (or visit the AMS web site for a choice of electronic versions at www.ams.org/coversheet/), fill in the answers which apply to *all* of your academic applications. Make photocopies.

2. As you mail each application, fill in the remaining questions neatly on one cover sheet and include it *on top of* your application materials.

The purpose of the cover form is to aid department staff in tracking and responding to each application for employment. Mathematics departments in Bachelor's-, Master's-, and Doctorate-granting institutions are expecting to receive the form from each applicant, along with the other application materials they require.

The AMS suggests that applicants and employers visit the Job Application Database for Mathematicians (www.mathjobs.com), a new electronic resource being offered by the AMS (in partnership with Duke University) for the first time in 2001-02. The system provides a way for applicants to produce printed coversheet forms, apply for jobs, or publicize themselves in the "Job Wanted" list. Employers can post a job listing, and once applications are made, search and sort among their applicants. Note-taking, rating, e-mail, data downloading and customizable EOE funnctions are available to employers. Also, reference writers can submit their letters online. A paperless application process is possible with this system, however; employers can choose to use any portion of the service. It is hoped that departments hiring for postdoc positions, especially, will utilize the system this year. There will be no fees for any services this year. This system was developed at the Duke University Department of Mathematics, and was tested by a group of departments in 2000-01.

Please direct all questions and comments to: emp-info@ams.org.

Academic Employment in Mathematics

AMS STANDARD COVER SHEET

Last Name ______________________________

First Name ______________________________

Middle Names ______________________________

Address *through next June* ______________________ **Home Phone** ______________

____

______________________ **e-mail Address** ______________

____

Current Institutional Affiliation ______________________ **Work Phone** ______________

Highest Degree Held or Expected ______________________

Granting Institution ______________ **Date (optional)** ______________

Ph.D. Advisor ______________________

Ph.D. Thesis Title (optional) ______________________

***Indicate** the mathematical subject area(s) in which you have done research using, if applicable, the Mathematics Subject Classification printed on the back of this form or on e-MATH. If listing more than one number, list first the one number which best describes your current primary interest.*

Primary Interest ______________________

Secondary Interests *optional* ______________________

***Give a brief synopsis** of your current research interests (e.g. finite group actions on four-manifolds). Avoid special mathematical symbols and please do not write outside of the boxed area.*

____

____

Most recent, if any, position held *post Ph.D.*

University or Company ______________________

Position Title ______________________

Indicate the position for which you are applying and position posting code, if applicable

____

If unsuccessful for this position, would you like to be considered for a temporary position?

☐ Yes ☐ No If yes, please check the appropriate boxes.

☐ Postdoctoral Position ☐ 2+ Year Position ☐ 1 Year Position

***List the names, affiliations, and e-mail addresses** of up to four individuals who will provide letters of recommendation if asked. Mark the box provided for each individual whom you have already asked to send a letter.*

☐ ______________________

☐ ______________________

☐ ______________________

☐ ______________________

This form is provided courtesy of the American Mathematical Society.

This cover sheet is provided as an aid to departments in processing job applications. It should be included with your application material.

Please print or type. Do not send this form to the AMS.

2000 Mathematics Subject Classification

00 General
01 History and biography
03 Mathematical logic and foundations
05 Combinatorics
06 Order, lattices, ordered algebraic structures
08 General algebraic systems
11 Number theory
12 Field theory and polynomials
13 Commutative rings and algebras
14 Algebraic geometry
15 Linear and multilinear algebra, matrix theory
16 Associative rings and algebras
17 Nonassociative rings and algebras
18 Category theory, homological algebra
19 *K*-theory
20 Group theory and generalizations
22 Topological groups, Lie groups
26 Real functions
28 Measure and integration
30 Functions of a complex variable
31 Potential theory
32 Several complex variables and analytic spaces
33 Special functions
34 Ordinary differential equations
35 Partial differential equations
37 Dynamical systems and ergodic theory
39 Difference and functional equations
40 Sequences, series, summability
41 Approximations and expansions
42 Fourier analysis
43 Abstract harmonic analysis
44 Integral transforms, operational calculus
45 Integral equations
46 Functional analysis
47 Operator theory
49 Calculus of variations and optimal control, optimization
51 Geometry
52 Convex and discrete geometry
53 Differential geometry
54 General topology
55 Algebraic topology
57 Manifolds and cell complexes
58 Global analysis, analysis on manifolds
60 Probability theory and stochastic processes
62 Statistics
65 Numerical analysis
68 Computer science
70 Mechanics of particles and systems
74 Mechanics of deformable solids
76 Fluid mechanics
78 Optics, electromagnetic theory
80 Classical thermodynamics, heat transfer
81 Quantum theory
82 Statistical mechanics, structure of matter
83 Relativity and gravitational theory
85 Astronomy and astrophysics
86 Geophysics
90 Operations research, mathematical programming
91 Game theory, economics, social and behavioral sciences
92 Biology and other natural sciences
93 Systems theory, control
94 Information and communication, circuits
97 Mathematics education

Instructions for Applicant and Employer Forms

Applicant forms submitted for the Employment Center by the October 26 deadline will be reproduced in a booklet titled *Winter List of Applicants*. Employer forms submitted by the October 26 deadline will be reproduced for the *Winter List of Employers*.

Please use the electronic versions of Applicant and Employer forms (`http://www.ams.org/emp-reg/`). Paper forms should be submitted only by those who do not have access to the AMS website.

If submitting a paper form, please type carefully. **Do not type outside the box or beyond the lines indicated. Extra type will be omitted.**

All forms must be received by the Society by **October 26, 2001**, in order to appear in the *Winter List*. However, meeting registration (and payment of fees) is required before the forms can be processed.

00 General
01 History and biography
03 Mathematical logic and foundations
05 Combinatorics
06 Order, lattices, ordered algebraic structures
08 General algebraic systems
11 Number theory
12 Field theory and polynomials
13 Commutative rings and algebras
14 Algebraic geometry
15 Linear and multilinear algebra, matrix theory
16 Associative rings and algebras
17 Nonassociative rings and algebras
18 Category theory, homological algebra
19 K-theory
20 Group theory and generalizations
22 Topological groups, Lie groups
26 Real functions
28 Measure and integration
30 Functions of a complex variable
31 Potential theory
32 Several complex variables and analytic spaces
33 Special functions
34 Ordinary differential equations
35 Partial differential equations
37 Dynamical systems and ergodic theory
39 Difference and functional equations
40 Sequences, series, summability
41 Approximations and expansions
42 Fourier analysis
43 Abstract harmonic analysis
44 Integral transforms, operational calculus
45 Integral equations
46 Functional analysis
47 Operator theory
49 Calculus of variations and optimal control; optimization
51 Geometry
52 Convex and discrete geometry
53 Differential geometry
54 General topology
55 Algebraic topology
57 Manifolds and cell complexes
58 Global analysis, analysis on manifolds
60 Probability theory and stochastic processes
62 Statistics
65 Numerical analysis
68 Computer science
70 Mechanics of particles and systems
74 Mechanics of deformable solids
76 Fluid mechanics
78 Optics, electromagnetic theory
80 Classical thermodynamics, heat transfer
81 Quantum theory
82 Statistical mechanics, structure of matter
83 Relativity and gravitational theory
85 Astronomy and astrophysics
86 Geophysics
90 Operations research, mathematical programming
91 Game theory, economics, social and behavioral sciences
92 Biology and other natural sciences
93 Systems theory; control
94 Information and communication, circuits
97 Mathematics education

EMPLOYER FORM

MATHEMATICAL SCIENCES EMPLOYMENT CENTER

JANUARY 6–9, 2002

SAN DIEGO, CALIFORNIA

1. Forms should be accessed and submitted electronically if possible. The URL for accessing Employment Center information and forms is `http://www.ams.org/emp-reg/`.
2. Paper or electronic forms are due, along with payment and your Advance Registration/ Housing Form, by October 26 (to AMS, P. O. Box 6887, Providence, RI 02940) in order to be included in the *Winter List of Employers*.
3. Please list all potential interviewers, for reference by applicants, but pay fees only for each separate table.
4. Forms will not be processed until registration and payment of fees have been received.

EMPLOYER CODE:

Institution ______________________

Department ______________________

Mailing address ______________________

____

E-mail address (one only) ______________________

URL (or other contact info) ______________________

Name(s) of Interviewer(s) 1. ______________________

2. ______________________

3. ______________________

4. ______________________

Specialties sought ______________________

____

Title(s) of position(s) ______________________

Number of positions ____________

Starting date ________ / ________ (Month / Year)   Term of appointment ________ Years

Renewal   Tenure-track position

☐ Possible ☐ Impossible   ☐ Yes ☐ No   Teaching hours per week ______

Degree preferred ____________   Degree accepted ____________

Duties ______________________

____

____

Experience preferred ______________________

____

____

Significant other requirements, needs, or restrictions which will influence hiring decisions ____________

____

____

This position will be subject to a security clearance which will require U.S. citizenship: ☐ Yes ☐ No

THE EMPLOYER PLANS TO USE THE FOLLOWING SERVICES (check all that apply):

☐ One or more computer-scheduled Interview Tables

☐ One or more self-scheduled Interview Tables

☐ Placing this form for information only (not using a table)

APPLICANT RÉSUMÉ FORM
MATHEMATICAL SCIENCES EMPLOYMENT CENTER
JANUARY 6–9, 2002
SAN DIEGO, CALIFORNIA

1. Forms should be accessed and submitted electronically if possible. The URL for accessing Employment Center information and forms is `http://www.ams.org/emp-reg/`.
2. Paper or electronic forms are due, along with payment and your Advance Registration/ Housing Form, by October 26 (to AMS, P. O. Box 6887, Providence, RI 02940) in order to be included in the *Winter List of Applicants*.
3. Forms will not be processed until registration and payment of fees have been received.

APPLICANT CODE: Last name ________ First name ________

Mailing address (include zip code) ________

____

E-mail address (one only) ________

URL (or other contact info) ________

Specialties ________

____

(use MR classification codes plus text if possible; applicants will be indexed by first number only)

DESIRED POSITION:

Academic: ☐ Research ☐ University Teaching College Teaching: ☐ 4-year ☐ 2-year

Would you be interested in nonacademic employment? ☐ Yes ☐ No Available mo. ________/yr. ________

Computer skills ________

Significant requirements (or restrictions) which would limit your availability for employment ________

____

PROFESSIONAL ACCOMPLISHMENTS:

Significant achievements, research or teaching interests ________

____

____

____

____

Paper to be presented at this meeting or recent publication ________

____

Degree	Year (expected)	Institution
____	____	________
____	____	________
____	____	________

Number of refereed papers accepted/published ________

PROFESSIONAL EMPLOYMENT HISTORY:

	Employer	Position	Years
1.	________	________	____ to ____
2.	________	________	____ to ____
3.	________	________	____ to ____

References (Name and Institution only)

____

____

____

____

Work authorization status: (check one) ☐ U.S. Citizen ☐ Non-U.S. Citizen, authorized to work permanently in U.S. ☐ Other

This applicant will be using: ☐ ALL Employment Center services ☐ Message Center and Winter List ONLY

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/`. Programs and abstracts will continue to be displayed on the AMS website in the Meetings and Conferences section until about three weeks after the meeting is over. Final programs for Sectional Meetings will be archived on the AMS website in an electronic issue of the *Notices* as noted below for each meeting.

Irvine, California

University of California Irvine

November 10–11, 2001

Meeting #972

Western Section
Associate secretary: Bernard Russo
Announcement issue of *Notices*: September 2001
Program first available on AMS website: September 27, 2001
Program issue of electronic *Notices*: December 2001
Issue of *Abstracts*: Volume 22, Issue 4

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired

Invited Addresses

William Duke, University of California Los Angeles, *Title to be announced.*

Grigory Mikhalkin, University of Utah, *Title to be announced.*

Gigliola Staffilani, Stanford University, *Dispersive equations and almost conservation laws.*

Jonathan Weitsman, University of California Santa Cruz, *Title to be announced.*

Special Sessions

Dynamical Systems of Billiard Type, **Marek Rychlik**, University of Arizona.

Extremal Metrics and Moduli Spaces, **Steven Bradlow**, University of Illinois, Urbana-Champaign, **Claude LeBrun**, State University of New York, Stony Brook, and **Yat Sun Poon**, University of California Riverside.

Groups and Covering Spaces in Algebraic Geometry, **Michael Fried**, University of California Irvine, and **Helmut Voelklein**, University of Florida.

Harmonic Analyses and Partial Differential Equations, **Gustavo Ponce**, University of California Santa Barbara, and **Gigliola Staffilani**, Stanford University.

Harmonic Analysis and Complex Analysis, **Xiaojun Huang**, Rutgers University, and **Song-Ying Li**, University of California Irvine.

Operator Spaces, Operator Algebras, and Applications, **Marius Junge**, University of Illinois, Urbana-Champaign, and **Timur Oikhberg**, University of Texas and University of California Irvine.

Partial Differential Equations and Applications, **Edriss S. Titi**, University of California Irvine.

Quantum Topology, **Louis Kauffman**, University of Illinois at Chicago, **Jozef Przytycki**, George Washington University, and **Fernando Souza**, University of Waterloo.

Random and Deterministic Schrödinger Operators, **Svetlana Jitomirskaya** and **Abel Klein**, University of California Irvine.

Symplectic Geometry, **Jonathan Weitsman**, University of California San Diego.

Topology of Algebraic Varieties, **Eriko Hironaka**, Florida State University, and **Grigory Mikhalkin**, University of Utah.

San Diego, California

San Diego Convention Center

January 6–9, 2002

Meeting #973

Joint Mathematics Meetings, including the 108th Annual Meeting of the AMS; 85th Meeting of the Mathematical Association of America (MAA), with minisymposia and other special events contributed by the Society for Industrial and Applied Mathematics (SIAM); the 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).
Associate secretary: John L. Bryant
Announcement issue of *Notices*: October 2001
Program first available on AMS website: November 1, 2001
Program issue of electronic *Notices*: January 2002
Issue of *Abstracts*: Volume 23, Issue 1

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired
For summaries of papers to MAA organizers: Expired

AMS-MAA Program Updates

Joint Prize Session, Monday, 4:25 p.m.: The MAA prizes include the Deborah and Franklin Tepper Haimo Award for Distinguished College or University Teaching of Mathematics, the Chauvenet Prize, the Beckenbach Book Prize, and Certificates of Meritorious Service.

Professors for the Future Programs, Wednesday, 9:00 a.m.–10:30 a.m., organized by **Samuel M. Rankin III**, AMS, and **Thomas W. Rishel**, MAA. Various graduate student development and training programs, often described as Professors for the Future, have come into existence at institutions across the country. One of these is funded by the NSF and administered through the AMS and MAA. In this panel, directors of both the NSF-funded and some of the separately-funded programs will discuss their activities, looking at what works and what doesn't, and concentrating on the effects they are seeing on the continuing careers of their students.

MAA Program Updates

The Environment: A Context for Learning, Monday, 9:00 a.m.–10:30 a.m. This panel will be moderated by **Patricia Clark Kenschaft**, Montclair State University.

Mathematical Experiences for Students Outside the Classroom, Tuesday, 1:00 p.m.–3:15 p.m., organized by **Richard L. Poss**, St. Norbert College and **Tom Kelley**, Henry Ford Community College. Mathematics "happens" outside the classroom and, in fact, many math majors are drawn to the subject through an event sponsored by a Student Chapter or Math Club. This session seeks presentations by academic, industrial, business, or student mathematicians. Descriptions of nonclassroom activities could include, but are not limited to, special lectures, workshops for students, Math Days, Math Fairs, research projects for students, Career Days, recreational mathematics, problem solving activities, and student consultants. Applications should be submitted to Rick Poss (`possrl@mail.snc.edu`) by November 31, 2001. The application should include name, address, phone number, e-mail address, title of presentation, and a one-page description of the activity. Presentation time is limited and there is no guarantee that all submissions can be accepted. Applicants will be notified by December 14 whether or not their proposal has been accepted. This session is sponsored by the MAA Committee on Student Chapters.

The Mathematical Education of Teachers, Tuesday, 1:00 p.m.–2:30 p.m., organized by **Ronald C. Rosier**, CBMS. *The Mathematical Education of Teachers*, published last August by the AMS and the MAA, calls for mathematics faculty to take a more active role in the preparation of future teachers of mathematics at all levels. Two themes guide the MET document: 1) the intellectual substance in school mathematics, and 2) the special nature of mathematical knowledge needed for teaching. This session will focus upon how faculty can use the document to develop courses which can provide future teachers with a deeper understanding. The speakers include **James Lewis**, University of Nebraska; **Alan C. Tucker**, SUNY at Stony Brook; and **Glenda Lappan**, University of Michigan.

Social Events Updates

Mathematical Sciences Institutes Reception, Sunday, 5:30 p.m.–7:30 p.m. CRM, DIMACS, The Fields Institute, IMA, IPAM, MSRI, and PIMS invite you to a reception where you can talk to their representatives and learn about their current and future programs and activities (or reminisce about their past ones). The participating institutes are Centre de Recherches Mathématiques (Montréal), the Center for Discrete Mathematics and Theoretical Computer Science (New Jersey), The Fields Institute (Toronto), the Institute for Mathematics and its Applications (Minneapolis), the Institute for Pure and Applied Mathematics at UCLA (Los Angeles), the Mathematical Sciences Research Institute (Berkeley), and the Pacific Institute for the Mathematical Sciences (Vancouver).

MAA Two-Year College Reception, Monday, 5:45 p.m.–7:00 p.m., sponsored by Addison Wesley Longman.

Knitting Network, Monday, 8:15 p.m.–9:45 p.m., organized by Sarah-Marie Belcastro, Bowdoin College, and Carolyn Yackel, Indiana University. Join other mathematicians in discussing the mathematics involved in certain fiber arts, and bring along your current project.

***Mathematical Reviews* Reception:** Day and time to be announced. All friends of MR are invited to join reviewers and MR editors and staff (past and present) in celebrating the 60th anniversary of the founding of *Mathematical Reviews*. Refreshments will be served.

Accommodations

The following hotels have an environmentally friendly policy regarding linens: Marriott, Westin Horton Plaza, Clarion Bay View, Holiday Inn on the Bay, Best Western, Quality Inn, and the Comfort Inn. The Wyndham and Embassy Suites will comply with the guest's wishes if the guest makes the request.

Ann Arbor, Michigan

University of Michigan

March 1-3, 2002

Meeting #974

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: January 2002
Program first available on AMS website: January 17, 2002
Program issue of electronic *Notices*: May 2002
Issue of *Abstracts*: Volume 23, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: November 13, 2001
For abstracts: January 8, 2002

Invited Addresses

Lazlo Babai, University of Chicago, *Title to be announced.*

Netts Katz, Washington University, *Title to be announced.*

Alan Reid, University of Texas at Austin, *Title to be announced.*

Lihe Wang, University of Iowa, *Title to be announced.*

Special Sessions

Algebraic Combinatorics (Code: AMS SS H1), **Patricia Hersh**, University of Michigan, Ann Arbor, and **Brian D. Taylor**, Wayne State University.

Algebraic Topology (Code: AMS SS F1), **Robert Bruner**, Wayne State University, and **Igor Kriz**, University of Michigan, Ann Arbor.

Biological Applications of Dynamical Systems (Code: AMS SS J1), **J. M. Cushing**, University of Arizona, **Shandelle M. Henson**, Andrews University, and **Anna M. Spagnuolo**, Oakland University.

Commutative Algebra (Code: AMS SS D1), **Florian Enescu** and **Anurag K. Singh**, University of Utah, and **Karen E. Smith**, University of Michigan, Ann Arbor.

Differential Geometry (Code: AMS SS K1), **Lizhen Ji**, **Krishnan Shankar**, and **Ralf Spatzier**, University of Michigan, Ann Arbor.

Hyperbolic Manifolds and Discrete Groups (Code: AMS SS E1), **Richard D. Canary**, University of Michigan, Ann Arbor, and **Alan W. Reid**, University of Texas at Austin.

Integrable Systems and Poisson Geometry (Code: AMS SS C1), **Anthony Block**, University of Michigan, **Philip Foth**, University of Arizona, and **Michael Gekhtman**, University of Notre Dame.

Moduli Spaces (Code: AMS SS G1), **Angela Gibney**, University of Michigan, Ann Arbor.

Numerical Analysis and Applications of Partial Differential Equations (Code: AMS SS L1), **Joan Remski** and **Jennifer Zhao**, University of Michigan, Dearborn.

Quantum Topology in Dimension Three (Code: AMS SS A1), **Charles Frohman**, University of Iowa, and **Joanna Kania-Bartoszynska**, Boise State University.

Topics in Geometric Function Theory (Code: AMS SS B1), **David A. Herron**, University of Cincinnati, **Nageswari Shanmugalingam**, University of Texas, and **Jeremy T. Tyson**, SUNY at Stony Brook.

Atlanta, Georgia

Georgia Institute of Technology

March 8-10, 2002

Meeting #975

Southeastern Section
Associate secretary: John L. Bryant
Announcement issue of *Notices*: January 2002
Program first available on AMS website: January 31, 2002
Program issue of electronic *Notices*: May 2002
Issue of *Abstracts*: Volume 23, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: November 27, 2001
For abstracts: January 22, 2002
For summaries of papers to MAA organizers: To be announced

AMS Invited Addresses

Nigel J. Kalton, University of Missouri, Columbia, *Title to be announced.*

James G. Oxley, Louisiana State University, *Title to be announced.*

Montréal, Québec, Canada

Centre de Recherches Mathématiques, Université de Montréal

May 3-5, 2002

Meeting #976

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: March 2002
Program first available on AMS website: March 21, 2002
Program issue of electronic *Notices*: July 2002

Issue of *Abstracts*: Volume 23, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: January 15, 2002
For abstracts: March 12, 2002

Invited Addresses

Nicholas M. Ercolani, University of Arizona, *Title to be announced.*

Lars Hesselholt, Massachusetts Institute of Technology, *Title to be announced.*

Niky Kamran, McGill University, *Title to be announced.*

Rafael de la Llave, University of Texas at Austin, *Title to be announced.*

Special Sessions

Combinatorial Hopf Algebras (Code: AMS SS C1), **Marcelo Aguiar**, Texas A&M University, and **François Bergeron** and **Christophe Reutenauer**, Université du Québec à Montréal.

Combinatorial and Geometric Group Theory (Code: AMS SS A1), **Olga G. Kharlampovich**, McGill University, **Alexei Myasnikov** and **Vladimir Shpilrain**, City College, New York, and **Daniel Wise**, McGill University.

Function Spaces in Harmonic Analysis and PDEs (Code: AMS SS D1), **Galia D. Dafni** and **Jie Xiao**, Concordia University.

Potential Theory (Code: AMS SS B1), **Paul M. Gauthier**, Université de Montréal, **K. Gowri Sankaran**, McGill University, and **David H. Singman**, George Mason University.

Pisa, Italy

June 12–16, 2002

Meeting #977

First Joint International Meeting between the AMS and the Unione Matematica Italiana.
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: To be announced
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: To be announced
For abstracts: To be announced

Invited Addresses

Luigi Ambrosio, Scuola Normale Superiore, *Title to be announced.*

Luis A. Caffarelli, University of Texas at Austin, *Title to be announced.*

Claudio Canuto, Polytecnico of Torino, *Title to be announced.*

L. Craig Evans, University of California Berkeley, *Title to be announced.*

Giovanni Gallavotti, University of Rome I, *Title to be announced.*

Sergio Klainerman, Princeton University, *Title to be announced.*

Rahul V. Pandharipande, California Institute of Technology, *Title to be announced.*

Claudio Procesi, University of Rome, *Title to be announced.*

Special Sessions

Advances in Complex, Contact and Symplectic Geometry, **Paolo De Bartolomeis**, University of Florence, **Yakov Eliashberg**, Stanford University, **Gang Tian**, MIT, and **Giuseppe Tomassini**, Scuola Normale Superiore, Pisa.

Advances in Differential Geometry of PDEs and Applications, **Valentin Lychagin**, Newark, NJ, and **Agostino Prastaro**, University of Rome, La Sapienza.

Algebraic Vector Bundles, **Vincenzo Ancona**, University of Florence, **Mohan Kumar**, Washington University, **Giorgio Maria Ottaviani**, University of Florence, **Christopher Peterson**, Colorado State University, and **Prabhakar Rao**, University of Missouri.

Analytic Aspects of Convex Geometry, **Stefano Campi**, University of Modena, **Richard Gardner**, Western Washington University, **Erwin Lutwak**, Polytechnic University Brooklyn, and **Alijosa Volcic**, University of Trieste.

Classification Theory and Topology of Algebraic Varieties, **Fabrizio Catanese**, University of Goettingen, **János Kollár**, Princeton University, and **Shing-Tung Yau**, Harvard University.

Commutative Algebra and the Geometry of Projective Varieties, **Ciro Ciliberto**, University of Rome II, **Anthony Geramita**, University of Genoa, **Rick Miranda**, Colorado State University, and **Ferruccio Orecchia**, University of Naples.

Commutative Algebra: Hilbert Functions, Homological Methods and Combinatorial Aspects, **Aldo Conca**, University of Genoa, **Anna Guerrieri**, University of L'Aquila, **Claudia Polini**, University of Oregon, and **Bernd Ulrich**, Michigan State University.

Commutative Rings and Integer-Valued Polynomials, **Stefania Gabelli**, University of Rome III, and **Thomas G. Lucas**, University of North Carolina, Charlotte.

Complex, Contact and Quaternionic Geometry, **David E. Blair**, Michigan State University, and **Stefano Marchiafava**, University of Rome, La Sapienza.

Contemporary Developments in Partial Differential Equations and in the Calculus of Variations, **Irene Fonseca**, Carnegie Mellon University, and **Paolo Marcellini**, University of Florence.

Didattica della Dimostrazione, **Ferdinando Arzarello**, University of Turin, **Guershon Harel**, Purdue University, and **Vinicio Villani**, University of Pisa.

Dynamical Systems, **Antonio Giorgilli**, University of Milan-Bicocca, **Stefano Marmi**, Scuola Normale Superiore, Pisa, and **John Norman Mather**, Princeton University.

Elliptic Partial Differential Equations, **Angelo Alvino**, University of Naples, **Luis Caffarelli**, University of Texas, **Giorgio Talenti**, University of Florence, and **Vladimir Oliker**, Emory University.

Equazioni di Evoluzione Nonlineari, **Alberto Tesei**, University of Rome, La Sapienza.

Free Boundary Problems, **Ricardo Horacio Nochetto**, University of Maryland, College Park, and **Augusto Visintin**, University of Trento.

Geometric Properties of Solutions to PDEs, **Donatella Danielli**, Johns Hopkins University, and **Sandro Salsa**, Politecnico di Milano.

Harmonic Analysis, **Fulvio Ricci**, Scuola Normale Superiore, Pisa, and **Elias M. Stein**, Princeton University.

Higher Dimensional Algebra, **John Baez**, University of California Riverside, and **Giuseppe Rosolini**, University of Genoa.

History of Mathematics, **Piers Bursil-Hall**, Cambridge University, **Enrico Giusti**, University of Florence, and **James J. Tattersall**, Providence College.

Hyperbolic Equations, **Sergiu Klainerman**, Princeton University, and **Sergio Spagnolo**, University of Pisa.

Hyperbolic Systems of Conservation Laws, **Alberto Bressan**, SISSA, Trieste, and **Shi Jin**, University of Wisconsin.

Inverse Boundary Problems and Applications, **Giovanni Alessandrini**, University of Trieste, and **Gunther Uhlmann**, University of Washington.

Jump Processes in Option Pricing Theory, **Claudio Albanese**, University of Toronto, and **Marco Isopi**, University of Bari.

Kolmogorov Equations, **Giuseppe Da Prato**, Scuola Normale Superiore, Pisa, and **Nicolai V. Krylov**, University of Minnesota.

Logarithmic de Rham Cohomology and Dwork Cohomology, **Alan Adolphson**, Oklahoma State University, Stillwater, **Francesco Baldassarri**, University of Padua, **Arthur Ogus**, University of California Berkeley, and **Steven Sperber**, University of Minnesota, Minneapolis.

Mathematical Problems in Soft Matter Modelling, **Eugene C. Gartland**, Kent State University, and **Epifanio Virga**, University of Pavia.

Mathematical Problems in Transport Theory, **Carlo Cercignani**, Politecnico di Milano, and **Irene Gamba**, University of Texas.

Mathematical Schools: Italy and the United States at the Turn of the Twentieth Century, **Umberto Bottazzini**, University of Palermo, and **Karen Hunger Parshall**, University of Virginia.

Mathematics in Polymer Science, **Antonio Fasano**, University of Florence, and **Kumbakonam R. Rajagopal**, Texas A&M University.

Microlocal Analysis and Applications to PDE, **Daniele Del Santo**, University of Trieste, **M. K. Venkatesha Murthy**, University of Pisa, and **Daniel Tataru**, Northwestern University.

Nonlinear Analysis, **Antonio Ambrosetti**, SISSA, Trieste, **Vieri Benci**, University of Pisa, **Haim Brezis**, Rutgers University, and **Paul Rabinowitz**, University of Wisconsin.

Nonlinear Elliptic and Parabolic Equations and Systems, **Gary Lieberman**, Iowa State University, and **Antonio Maugeri**, University of Catania.

Nonstandard Methods and Applications in Mathematics, **Alessandro Berarducci**, University of Pisa, **Nigel Cutland**, University of Hull, **Mauro Di Nasso**, University of Pisa, and **David Ross**, University of Hawaii.

Operator Algebras, **Sergio Doplicher**, University of Rome, La Sapienza, and **Edward George Effros**, University of California Los Angeles.

Optimization and Control, **Roberto Triggiani**, University of Virginia, and **Tullio Zolezzi**, University of Genoa.

Partial Differential Equations of Mixed Elliptic - Hyperbolic Type and Applications, **Daniela Lupo**, Politecnico di Milano, **Cathleen S. Morawetz**, Courant Institute, NYU, and **Kevin R. Payne**, University of Milan.

Periodic Solutions of Differential and Difference Equations, **Massimo Furi**, University of Florence, and **Mario Umberto Martelli**, Claremont McKenna College.

Poisson Geometry and Integrable Systems, **Franco Magri**, University of Milan, and **Ping Xu**, Pennsylvania State University.

Quantum Cohomology and Moduli Spaces, **Angelo Vistoli**, University of Bologna, and **Aaron Bertram**, University of Utah.

Scaling Limits and Homogenization Problems in Physics and Applied Sciences, **Mario Pulvirenti**, University of Rome, and **George Papanicolaou**, Stanford University.

Semigroups of Operators and Applications, **Francesco Altomare**, University of Bari, and **Frank Neubrander**, Louisiana State University.

Semigroups, Automata and Formal Languages, **Alessandra Cherubini**, Politecnico di Milano, and **John Meakin**, University of Nebraska-Lincoln.

Simulation via Quantum Computation, **Thomas L. Clarke**, University of Central Florida, Orlando, and **Massimo Pica Ciamarra**, University of Naples.

Some Mathematics around Composites, **Robert V. Kohn**, Courant Institute, NYU, and **Vincenzo Nesi**, University of Rome, La Sapienza.

Structured Matrix Analysis with Applications, **Dario Andrea Bini**, University of Pisa, and **Thomas Kailath**, Stanford University.

The Topology of 3-Manifolds, **Ricardo Benedetti** and **Carlo Petronio**, University of Pisa, **Dale Rolfsen**, University of British Columbia, Vancouver, and **Jeffrey Weeks**, Canton, New York.

Variational Analysis and Applications, **Franco Giannessi**, University of Pisa, **Boris S. Mordukhovich**, Wayne State

University, Detroit, **Biagio Ricceri**, University of Catania, and **R. Tyrrell Rockafellar**, University of Washington.

Viscosity Methods in PDEs and Applications, **Piermarco Cannarsa**, University of Rome II, **Italo Capuzzo Dolcetta**, University of Rome, La Sapienza, and **Panagiotis Souganidis**, University of Texas at Austin.

White Noise Theory and Quantum Probability, **Luigi Accardi**, University of Rome, Tor Vergata, and **Hui-Hsiung Kuo**, Louisiana State University.

Portland, Oregon

Portland State University

June 20-22, 2002

Meeting #978

Western Section
Associate secretary: Bernard Russo
Announcement issue of *Notices*: April 2002
Program first available on AMS website: May 9, 2002
Program issue of electronic *Notices*: August 2002
Issue of *Abstracts*: Volume 23, Issue 3

Deadlines

For organizers: November 20, 2001
For consideration of contributed papers in Special Sessions: March 5, 2002
For abstracts: April 30, 2002

Special Sessions

Algebraic Geometry and Combinatorics (Code: AMS SS B1), **Eric Babson** and **Rekha Thomas**, University of Washington, and **Sergey Yuzvinsky**, University of Oregon.

Qualitative Properties and Applications of Functional Equations (Code: AMS SS A1), **Theodore A. Burton**, Southern Illinois University.

The Quintic Equation: Algebra and Geometry (Code: AMS SS C1), **Jerry Shurman**, Reed College, and **Scott Crass**, California State University, Long Beach.

Boston, Massachusetts

Northeastern University

October 5-6, 2002

Meeting #979

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: August 2002
Program first available on AMS website: August 22, 2002
Program issue of electronic *Notices*: December 2002
Issue of *Abstracts*: To be announced

Deadlines

For organizers: March 5, 2002
For consideration of contributed papers in Special Sessions: June 18, 2002
For abstracts: August 13, 2002

Invited Addresses

Lou P. van den Dries, University of Illinois, Urbana-Champaign, *Title to be announced.*

Diane Henderson, Pennsylvania State University, *Title to be announced.*

Christopher K. King, Northeastern University, *Title to be announced.*

Xiaobo Liu, University of Notre Dame, *Title to be announced.*

Madison, Wisconsin

University of Wisconsin-Madison

October 12-13, 2002

Meeting #980

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: August 2002
Program first available on AMS website: August 29, 2002
Program issue of electronic *Notices*: December 2002
Issue of *Abstracts*: To be announced

Deadlines

For organizers: March 12, 2002
For consideration of contributed papers in Special Sessions: June 25, 2002
For abstracts: August 20, 2002

Invited Addresses

Lawrence Ein, University of Illinois at Chicago, *Title to be announced.*

Eleny Ionel, University of Wisconsin, *Title to be announced.*

Mikhail Safonov, University of Minnesota, *Title to be announced.*

John Sullivan, University of Illinois, Urbana-Champaign, *Title to be announced.*

Special Sessions

Arithmetic Algebraic Geometry (Code: AMS SS A1), **Ken Ono** and **Tonghai Yang**, University of Wisconsin-Madison.

Arrangements of Hyperplanes (Code: AMS SS E1), **Daniel C. Cohen**, Louisiana State University, **Peter Orlik**, University of Wisconsin-Madison, and **Anne Shepler**, University of California Santa Cruz.

Biological Computation and Learning in Intelligent Systems (Code: AMS SS S1), **Shun-ichi Amari**, RIKEN, **Amir Assadi**, University of Wisconsin-Madison, and **Tomaso Poggio**, MIT.

Combinatorics and Special Functions (Code: AMS SS T1), **Richard Askey** and **Paul Terwilliger**, University of Wisconsin-Madison.

Dynamical Systems (Code: AMS SS P1), **Sergey Bolotin** and **Paul Rabinowitz**, University of Wisconsin-Madison.

Effectiveness Questions in Model Theory (Code: AMS SS J1), **Charles McCoy**, **Reed Solomon**, and **Patrick Speissegger**, University of Wisconsin-Madison.

Geometric Methods in Differential Equations (Code: AMS SS H1), **Gloria Mari Beffa**, University of Wisconsin-Madison, and **Peter Olver**, University of Minnesota.

Geophysical Waves and Turbulence (Code: AMS SS M1), **Paul Milewski**, **Leslie Smith**, and **Fabian Waleffe**, University of Wisconsin-Madison.

Group Cohomology and Homotopy Theory (Code: AMS SS G1), **Alejandro Adem**, University of Wisconsin-Madison, and **Jesper Grodal**, Institute for Advanced Study.

Harmonic Analysis (Code: AMS SS C1), **Alex Ionescu** and **Andreas Seeger**, University of Wisconsin-Madison.

Hyperbolic Differential Equations and Kinetic Theory (Code: AMS SS K1), **Shi Jin**, **Marshall Slemrod**, and **Athanassios Tzavaras**, University of Wisconsin-Madison.

Lie Algebras and Related Topics (Code: AMS SS N1), **Georgia Benkart** and **Arun Ram**, University of Wisconsin-Madison.

Multiresolution Analysis and Data Presentation (Code: AMS SS F1), **Amos Ron**, University of Wisconsin-Madison.

Partial Differential Equations and Geometry (Code: AMS SS D1), **Sigurd Angenent** and **Mikhail Feldman**, University of Wisconsin-Madison.

Probability (Code: AMS SS R1), **David Griffeath**, University of Wisconsin-Madison, and **Timo Seppalainen**, Iowa State University.

Ring Theory and Related Topics (Code: AMS SS L1), **Don Passman**, University of Wisconsin-Madison.

Several Complex Variables (Code: AMS SS B1), **Pat Ahern**, **Xianghong Gong**, **Alex Nagel**, and **Jean-Pierre Rosay**, University of Wisconsin-Madison.

Orlando, Florida

University of Central Florida

November 9–10, 2002

Meeting #982

Southeastern Section
Associate secretary: John L. Bryant
Announcement issue of *Notices*: September 2002
Program first available on AMS website: September 26, 2002
Program issue of electronic *Notices*: January 2003
Issue of *Abstracts*: Volume 23, Issue 4

Deadlines

For organizers: April 9, 2002
For consideration of contributed papers in Special Sessions: July 23, 2002
For abstracts: September 17, 2002

Baltimore, Maryland

Baltimore Convention Center

January 15–18, 2003

Joint Mathematics Meetings, including the 109th Annual Meeting of the AMS, 86th 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).
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: April 15, 2002
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

Baton Rouge, Louisiana

Louisiana State University

March 14–16, 2003

Southeastern Section
Associate secretary: John L. Bryant
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 14, 2002
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Bloomington, Indiana

Indiana University

April 4–6, 2003

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, 2002
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Seville, Spain

The third week in June, 2003

First Joint International Meeting between the AMS and the Real Sociedad Matematica Española (RSME).
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

Binghamton, New York

SUNY-Binghamton

October 10–12, 2003

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: March 10, 2003
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Phoenix, Arizona

Phoenix Civic Plaza

January 7–10, 2004

Associate secretary: Bernard Russo
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 2, 2003
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

Athens, Ohio

Ohio University

March 26–27, 2004

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: August 26, 2003
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Atlanta, Georgia

Atlanta Marriott Marquis and Hyatt Regency Atlanta

January 5–8, 2005

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 5, 2004
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

Joint Summer Research Conferences in the Mathematical Sciences

Mount Holyoke College
South Hadley, Massachusetts
June 7–August 1, 2002

The 2002 Joint Summer Research Conferences will be held at Mount Holyoke College, South Hadley, Massachusetts, from June 7–August 1, 2002. The topics and organizers for the conferences were selected by a committee representing the AMS, the Institute of Mathematical Sciences (IMS), and the Society for Industrial and Applied Mathematics (SIAM). Committee members at the time were Paul Baum, Laurel A. Beckett, David Brydges, Tom DiCiccio, Charles Doering, Ron Donagi, James A. Fill, Steven Hurder, Barbara L. Keyfitz, W. Brent Lindquist, Hema Srinivasan, Kenneth Stephenson, and Olof B. Widlund.

It is anticipated that the conferences will be partially funded by a grant from the National Science Foundation and perhaps others. Special encouragement is extended to junior scientists to apply. A special pool of funds expected from grant agencies has been earmarked for this group. Other participants who wish to apply for support funds should so indicate; however, available funds are limited, and individuals who can obtain support from other sources are encouraged to do so.

All persons who are interested in participating in one of the conferences should request an invitation by sending the following information to the Summer Research Conferences Coordinator, AMS, P.O. Box 6887, Providence, RI 02940; or by e-mail to wsd@ams.org **no later than March 2, 2002.**

Please type or print the following:

1. Title and dates of conference.
2. Full name.
3. Mailing address.
4. Phone numbers (including area code) for office, home, and fax.
5. E-mail address.
6. Your anticipated arrival/departure dates.
7. Scientific background relevant to the Institute topics; please indicate if you are a student or if you received your Ph.D. on or after 7/1/94.
8. The amount of financial assistance requested (or indicate if no support is required).

All requests will be forwarded to the appropriate organizing committee for consideration. In late April all applicants will receive formal invitations (including specific offers of support if applicable), a brochure of conference information, program information known to date, along with information on travel and dormitory and other local housing. All participants will be required to pay a nominal conference fee.

Questions concerning the scientific program should be addressed to the organizers. Questions of a nonscientific nature should be directed to the Summer Research Conferences coordinator at the address provided above. Please watch http://www.ams.org/meetings/ for future developments about these conferences.

Usually, lectures begin on Sunday morning and run through Thursday. Check-in for housing begins on Saturday. No lectures are held on Saturday. Check actual dates for individual conferences.

Groups, Representations, and Cohomology

Friday, June 7–Thursday, June 13

Alejandro Adem (co-chair), University of Wisconsin-Madison
Jon Carlson (co-chair), University of Georgia
Geoff Mason, University of California Santa Cruz
Brian Parshall, University of Virginia
Stephen Smith, University of Illinois at Chicago
Sarah Witherspoon, University of Massachusetts

More than a century ago, Frobenius and Schur began the study of the representation theory of finite groups. However, many open questions remain, particularly in the areas of representations over the integral rings or fields of positive characteristic. Brauer developed block theory to understand better such representations, and it proved important in solving some problems in the classification of finite simple groups. Today, block theory is a subject of intense investigation centering on the conjectures of Alperin, Broue, and Dade. Around the same time as Brauer's original work, Eilenberg and Mac Lane gave an algebraic definition of group cohomology, analogous to similar constructions in topology. The cohomology theory has emerged as a vital tool for those studying representations of finite groups. There are many fruitful interactions among mathematicians from diverse backgrounds who use group cohomology, including those who work in representation theory and algebraic topology. More recently we have seen very active interactions between homotopy theory, group actions, and modular representation theory. Topics such as stable splittings of classifying spaces, group actions on finite complexes, and homotopy representations blend algebra and topology in novel and productive ways.

The main goals of this meeting will be not only to showcase recent research accomplishments but also to foster emerging interdisciplinary connections between several related areas in algebra and topology. Participation by recent Ph.D.'s as well as advanced graduate students is particularly encouraged. The conference will also celebrate the 65th birthday of Jon Alperin (June 2002), who has been a highly influential figure in group theory, group cohomology, and representation theory.

The following broad themes will be covered at this meeting, combining perspectives from both algebra and topology: structure and representations of finite and algebraic groups; block theory and the conjectures of Alperin and Dade; categorical equivalences and the conjectures of Broué; cohomology of groups and classifying spaces; groups, actions and homotopy theory.

The invited plenary speakers include: M. Aschbacher (Caltech), D. J. Benson (University of Georgia), C. Broto (U. A. de Barcelona), M. Broué (École Normale Superieure), W. Browder (Princeton University), J. Brundan (University of Oregon), E. Dade (University of Illinois), K. Erdmann (Oxford University), E. Friedlander (Northwestern University), R. Griess (University of Michigan), J. Grodal (University of Chicago), J. C. Jantzen (University of Oregon), G. Lehrer (University of Sydney), G. Lusztig (MIT), M. Linckelman (University of Paris VII), R. Lyons (Rutgers University), U. Meierfrankenfeld (Michigan State University), R. J. Milgram (Stanford University), D. Nakano (University of Georgia), R. Oliver (Université de Paris-Nord), S. Priddy (Northwestern University), J. Rickard (University of Bristol), G. Robinson (University of Birmingham), R. Rouquier (University of Paris VII), L. Scott (University of Virginia), J. H. Smith (Purdue University), P. Webb (University of Minnesota).

For further information please visit the website maintained by the organizers at `http://www.math.wisc.edu/~adem/src.html`.

Advances in Quantum Dynamics

Sunday, June 16–Thursday, June 20

B. Mitchell Baker (co-chair), United States Naval Academy
Palle E. T. Jorgensen (co-chair), University of Iowa
Paul S. Muhly (co-chair), University of Iowa
Geoffrey L. Price (chair), United States Naval Academy

Since the appearance of the landmark papers by Murray and von Neumann on rings of operators, von Neumann algebras have been used as mathematical models in the study of the time evolution of quantum mechanical systems. Originating with the work of Stone, von Neumann, and others on the structure of one-parameter groups of unitary transformations, many researchers have made fundamental contributions to the understanding of time-reversible dynamical systems. In recent years W. B. Arveson and R. T. Powers have launched an ambitious program to analyze the highly complex structure of irreversible quantum dynamics. As interest in this subject continues to grow, mathematicians and mathematical physicists have established new connections between this and other areas of mathematics and mathematical physics. These include Brownian motion, quantum probability, and free probability. With the subject enjoying a period of increasing activity and with more and more applications on the horizon, it is a perfect time to draw together researchers and graduate students working in operator algebras, physics, or quantum probability to assess the present state of knowledge and to map out plans for future activity.

Waves in Periodic and Random Media

Sunday, June 23–Thursday, June 27

David Dobson, Texas A&M University
Alex Figotin, University of California Irvine
Peter Kuchment (co-chair), Texas A&M University
Stephanos Venakides (co-chair), Duke University

The topic of wave propagation in periodic and random linear and nonlinear media arises in physics and engineering and stems in particular from solid state physics, material science, electromagnetics, optics, and acoustics. The mathematical problems that appear in this area are of practical importance and pose high challenges to pure and applied mathematicians. They have attracted a lot of attention of researchers lately. The methods involved come from a wide range of areas of pure and applied mathematics, ranging from spectral theory to PDE, to complex analysis, to numerical methods. In order to make the discussions more focused, it is planned to specifically target (although not to limit the scope to) the following areas:

- Photonic crystals and their acoustic analogs
- Anderson localization (including localization of classical waves)
- Wave propagation in nonlinear periodic media
- Waves in mesoscopic media
- Surface waves

It is expected that the topics of the conference will be addressed from the analytic, numerical, and physics perspectives. Due to this, not only mathematicians actively working in these and adjacent areas are invited, but also prominent physicists who could communicate with mathematicians on these issues. We hope that the conference will stimulate the very much needed progress in the directions described above.

Participation of graduate students, young researchers, minorities, and women is especially encouraged.

Researchers interested in participation can obtain additional information from the conference website, `http://www.math.tamu.edu/~kuchment/SRC2002.htm` maintained by the organizers.

Graph Coloring and Symmetry

Sunday, July 21–Thursday, July 25

Karen Collins (co-chair), Wesleyan University
Danny Krizanc (co-chair), Wesleyan University
Alexander C. Russell (co-chair), University of Connecticut

The goal of this conference will be to gather together in one place researchers working in three different but synergistic areas: graph coloring and homomorphisms, symmetric functions, and graph algorithms. The workshop will focus on applications of results from the theory of symmetric functions to graph homomorphism problems and to the development of graph-coloring algorithms, and applications of tools from the theory of graph homomorphisms and graph-coloring algorithms to illuminate the theory of symmetric functions. Offering a forum where researchers in these fields can unite and share their tools, methodology, and experience, the workshop will serve both to deepen our understanding of these beautiful topics and to provide new perspectives for the participants.

Our preliminary list of hour speakers includes Lenore Cowen (Tufts University), Chris Godsil (University of Waterloo), Pavol Hell (Simon Fraser University), Richard Stanley (MIT), and Xuding Zhu (National Sun Yat-sen University). For further information, please visit the website `http://www.engr.uconn.edu/~acr/SRC/`.

Emerging Issues in Longitudinal Data Analysis

Sunday, July 28–Thursday, August 1

Jane-Ling Wang, University of California Davis
Marie Davidian, North Carolina State University
Xihong Lin, University of Michigan

With mounting advances in modern technology, more and more data are being recorded over a period of time on the same subject (or other experimental unit). Such data are often referred to as "longitudinal data" by statisticians in biomedical applications, where a small number of repeated measures over time per subject are often obtained, and as "functional data" in engineering and computational applications, where a large number of repeated measures over time per subject are available. Statistical approaches to analyze such data are also intrinsically different in the longitudinal and functional data research communities. One goal of this conference is to bring the two communities together to promote advances in both areas by allowing each to explore the alternative approaches of the other and by providing an opportunity for brainstorming on challenging problems of common interest.

Emerging new areas for the analysis of longitudinal data include: (a) nonparametric and semiparametric regression, (b) joint modeling longitudinal and survival outcomes, (c) methods for handling missing data, and (d) approaches to making causal inference. A second goal of this conference is to provide a forum for researchers in each of the four areas to debate the merits of various approaches and exploit insights from other areas to stimulate new ideas for addressing controversial issues. Moreover, it will serve as an effective educational opportunity for junior researchers who work in one of these areas and will provide a platform for them to interact with leading senior researchers.

Overall it is hoped that the conference will provide a unique opportunity for researchers to explore these areas in depth; discuss pros and cons of the existing methods; identify new research directions from different, but related, areas; and stimulate new advances and collaborations.

We envision a conference format that stimulates discussion and inspires ideas. The conference is planned to last for five days, with two days focusing on nonparametric and semiparametric regression and one day each on each of the other three topics. Each day will start with an expository lecture delivered by a keynote speaker who will provide an introduction to the topic area and discuss current status, challenges, and future directions. Keynote speakers for the four areas have been identified: Raymond Carroll and John Rice (Nonparametric and Semiparametric Regression), Anastasios Tsiatis (Joint Modeling Longitudinal and Survival Outcomes), Roderick Little (Modeling of Informatively Missing Data), and James Robbins (Causal Inference).

There will also be a case study led by a neurologist, David Benett, who will present challenges in analyzing longitudinal data from a practitioner's point of view. Additional invited speakers are:

Topic (a): L. Fahmeir (Munich), J. Fan (University of North Carolina and HK), Peter Hall (Australian National University), S. Marron (University of North Carolina), H.-G. Mueller (University of California Davis), D. Ruppert (Cornell), A. Verbyla (Adelaide University), M. Wand (Harvard), N. Wang (Texas A&M), W. Wang (Harvard), C. Wu (Johns Hopkins).

Topic (b): M. Buyse (I. Drug Development I.), P. Diggle (Lancaster University), D. Follman (National Institutes of Health), J. Ibrahim (Harvard), C. McCulloch (UCSF), J. Taylor (University of Michigan).

Topic (c): M. Kenward (London S. Hygiene Tropical Medicine), D. Lin (University of North Carolina), G. Molenberghs (Limburgs University), P. Rathouz (University of Chicago), A. Rotnitzky (Harvard), W. Guo (University of Pennsylvania). Topic (d): P. Dawid (University of London), C. Frangakis (Johns Hopkins), E. Goetghebeur (University of Ghent), J. Hogan (Brown University).

For further information please visit the website maintained by the organizers at `http://www.stat.ucdavis.edu/src/`.

San Diego Joint Meetings Advance Registration/Housing Form

Name ______________________________
(please write name as you would like it to appear on your badge)

Mailing Address ______________________________

____

Telephone ____________________ Fax ____________________

Email Address ______________________________

(Acknowledgment of this registration will be sent to the email address given here, unless you check this box: *Send by US Mail* ☐)

Badge Information: Affiliation for badge ______________________________

Nonmathematician guest badge name ______________________________ (please note charge below)

Membership
✓ all that apply

AMS ☐
ASA ☐
ASL ☐
AWM ☐
CMS ☐
MAA ☐
NAM ☐
SIAM ☐
YMN ☐

☐ **I DO NOT want my program and badge to be mailed to me on 12/14/01.**

Registration Fees

Joint Meetings	**by Dec 10**	**at mtg**	**Subtotal**
☐ Member AMS, ASL, CMS, MAA, SIAM	$185	$241	
☐ Nonmember	$287	$373	
☐ Graduate Student	$ 35	$ 45	
☐ Undergraduate Student	$ 20	$ 26	
☐ High School Student	$ 2	$ 5	
☐ Unemployed	$ 35	$ 45	
☐ Temporarily Employed	$145	$166	
☐ Developing Countries Special Rate	$ 35	$ 45	
☐ Emeritus Member of AMS or MAA	$ 35	$ 45	
☐ High School Teacher	$ 35	$ 45	
☐ Librarian	$ 35	$ 45	
☐ Nonmathematician Guest	$ 5	$ 5	
			$______

AMS Short Course: *Symbolic Dynamics & its Applications (1/4–1/5)*

☐ Member of AMS or MAA	$ 80	$100	
☐ Nonmember	$110	$130	
☐ Student, Unemployed, Emeritus	$ 35	$ 50	
			$______

MAA Short Course: *A Sampler of Applications of Graph Theory (1/4–1/5)*

☐ Member of MAA	$125	$140	
☐ Nonmember	$175	$190	
☐ Student, Unemployed, Emeritus	$ 50	$ 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 #_____

(no onsite registration for Minicourses 1 & 2)

Prices: $90 for Minicourses #1-8 and $60 for Minicourses #9-16 $______

Employment Center

Applicant résumé forms and employer job listing forms will be on e-MATH and in *Notices* in September and October.

Employer—First Table ☐ Regular ☐ Self-scheduled	$210	$300	
Employer— Each Additional Table ☐ Regular ☐ Self-scheduled	$ 60	$100	
☐ Employer—Posting Only	$ 50	N/A	
☐ Applicant (all services)	$ 40	$ 75	
☐ Applicant (Winter List & Message Ctr only)	$ 20	$ 20	
			$______

Events with Tickets

MER Banquet	$47	#___Regular	#___Veg
NAM Banquet	$47	#___Regular	#___Veg
AMS Banquet	$47	#___Regular	#___Veg

$______

Other Events (no charge)

☐ Graduate Student Reception (1/6)

Total for Registrations and Events $______

Payment

Registration & Event Total (total from other column) $______

Hotel Deposit (only if paying by check) $______

Total Amount To Be Paid **$**______

(Note: A $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)

Registration for the Joint Meetings is not required for the Short Courses, but it is required for the Minicourses and the Employment Center.

Other Information

Mathematical Reviews field of interest # __________

How did you hear about this meeting? Check one:

☐ Colleague(s) ☐ *Notices* ☐ Focus ☐ Internet

☐ I am a mathematics department chair.

☐ **Please do not include my name on any promotional mailing list.**

☐ Please ✓ this box if you have a disability requiring special services. ♿

Mail to:

Mathematics Meetings Service Bureau (MMSB)
P. O. Box 6887
Providence, RI 02940-6887
Fax: 401-455-4004
Questions/changes call: 401-455-4143 or 1-800-321-4267 x4143; mmsb@ams.org

Deadlines

For room lottery and/or résumés/job descriptions printed in the *Winter Lists*, return this form by:	**Oct. 26, 2001**
For housing reservations, badges/programs mailed:	**Nov. 7, 2001**
For housing changes/cancellations through MMSB:	**Dec. 6, 2001**
For advance registration for the Joint Meetings, Employment Center, Short Courses, MAA Minicourses, & Tickets:	**Dec. 10, 2001**
For 50% refund on banquets, cancel by:	**Dec. 21, 2001***
For 50% refund on advance registration, Minicourses & Short Courses, cancel by:	**Jan. 2, 2002***

***no refunds after this date**

San Diego 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 only be made 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. All rates are subject to a 10.5% sales tax and a California commerce fee of $0.13. Rates at hotels may be subject to an energy surcharge. Participants are not obligated to pay an energy surcharge and may use their own discretion in this decision.
Guarantee requirements: First night deposit by check (add to payment on reverse of form) or a credit card guarantee.

☐ Deposit enclosed ☐ 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	Quad 2 beds	Quad 2 beds w/cot	Suites Starting rates
	San Diego Marriott Hotel & Marina (headquarters)								
	Bay view	$176	$176	$176	$196	(king & cot) $196	$216	N/A	$650
	City view	$156	$156	$156	$176	(king & cot) $176	$196	N/A	$650
	Student	$128	$128	$128	$148	(king & cot) $148	$168	N/A	N/A
	Embassy Suites (Regular Suites)	$148	$148	$148	$168	N/A	$188	N/A	N/A
	Bay view (Suites)	$168	$168	$168	$188	N/A	$208	N/A	N/A
	Student (Suites)	$138	$138	$138	$158	N/A	$178	N/A	N/A
	Wyndham San Diego at Emerald Plaza (Regular Rooms)	$147	$147	$147	$167	(king & cot) $187	$187	N/A	$550
	Student	$137	$137	$137	$157	(king & cot) $177	$177	N/A	N/A
	Horton Grand (Regular Rooms-most rooms have one bed)	$145	$145	$145	N/A	N/A	N/A	N/A	$259
	Student	$135	$135	$135	N/A	N/A	N/A	N/A	N/A
	Bristol San Diego (Regular Rooms)	$140	$140	$140	$150	(king & cot) $160	$160	N/A	N/A
	Student	$130	$130	$130	$140	(king & cot) $150	$150	N/A	N/A
	Westin Horton Plaza (Regular Rooms)	$139	$149	$149	$169	$194	$189	$214	$500
	Holiday Inn on the Bay (Regular Rooms)	$138	$148	$148	$163	$178	$178	$193	N/A
	Bay view	$158	$168	$168	$183	$198	$198	$213	$250
	Clarion Bay View (Regular Rooms)	$138	$138	$138	$158	(king & cot) $158	$178	N/A	$209
	Student	$128	$128	$128	$148	(king & cot) $148	$168	N/A	N/A
	Best Western Bayside (Regular rooms)	$119	$119	$119	$129	$141	$129	$141	N/A
	Student	$109	$109	$109	$119	$131	$119	$131	N/A
	Quality Inn & Suites Harbor View	$109	$119	$119	$129	$144	$139	$154	N/A
	Comfort Inn	$91	$91	$91	$91	$106	$91	$106	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: ________

☐ If you are a member of a hotel frequent-travel club and would like to receive appropriate credit, please include the hotel chain and card number here: ________

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.

MAA SHORT COURSE

A SAMPLER *of* APPLICATIONS *of* GRAPH THEORY

at the
Joint Mathematics Meetings
San Diego
January 6–9, 2002

ORGANIZER: **Fred Roberts,** *Rutgers University*

The short course will survey a variety of applications of graph theory. Graph theory is an old subject which has found a vast number of exciting applications in recent years. The speakers will introduce the graph-theoretical topics needed, describe both historical and current applications, and discuss current research topics in graph theory related to the applications. Many of the topics to be covered will be amenable to discussion in the classroom as well as making for good research topics for both researchers and students. No prior knowledge of graph theory will be required.

PROGRAM:

OVERVIEW AND BACKGROUND
Fred Roberts, *Rutgers University*

APPLICATIONS TO NETWORK VISUALIZATION
Nate Dean, *Rice University*

THE GRAPH STRUCTURE OF THE WORLD WIDE WEB
Sridhar Rajagopalan, *IBM Almaden*

APPLICATIONS TO MOLECULAR BIOLOGY
R. Ravi, *Carnegie Mellon University*

APPLICATIONS TO FACILITY LOCATION
K. Brooks Reid, *Cal State University, San Marcos*

SOCIAL NETWORKS
Fred Roberts, *Rutgers University*

APPLICATIONS TO STATISTICAL PHYSICS
Peter Winkler, *Bell Labs*

Meetings and Conferences of the AMS

Associate Secretaries of the AMS

Western Section: Bernard Russo, Department of Mathematics, University of California Irvine, CA 92697; e-mail: brusso@math.uci.edu; telephone: 949-824-5505.

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: John L. Bryant, Department of Mathematics, Florida State University, Tallahassee, FL 32306-4510; e-mail: bryant@math.fsu.edu; telephone: 850-644-5805.

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** at www.ams.org/meetings/.

Meetings:

Important Information regarding AMS Meetings

Potential organizers, speakers, and hosts should refer to page 87 in the January 2001 issue of the *Notices* for general information regarding participation in AMS meetings and conferences.

Abstracts

Several options are available for speakers submitting abstracts, including an 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. To see descriptions of the forms available, visit http://www.ams.org/abstracts/instructions.html, or send mail to abs-submit@ams.org, typing help as the subject line; descriptions and instructions on how to get the template of your choice will be e-mailed to you.

Completed abstracts should be sent to abs-submit@ams.org, typing submission as the subject line. Questions about abstracts may be sent to abs-info@ams.org.

Paper abstract forms may 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. Close attention should be paid to specified deadlines in this issue. Unfortunately, late abstracts cannot be accommodated.

Conferences: (See http://www.ams.org/meetings/ for the most up-to-date information on these conferences.)

February 14–19, 2002: Annual Meeting of the American Association for the Advancement of Science (AAAS), Boston, MA.

May 20–25, 2002: 6th International Conference on Clifford Algebras and Their Applications to Mathematical Physics, Cookeville, TN.

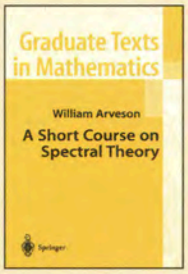
June 3–8, 2002: Abel Bicentennial Conference 2002, University of Oslo, Norway.

June 7–August 1, 2002: Joint Summer Research Conferences in the Mathematical Sciences, Mount Holyoke College, South Hadley, MA. See pages 1289-1291, this issue, for details.

SPRINGER FOR MATHEMATICS

A SHORT COURSE ON SPECTRAL THEORY

WILLIAM ARVESON, University of California, Berkeley, CA



This book presents the basic tools of modern analysis within the context of the fundamental problem of operator theory: to calculate spectra of specific operators on infinite dimensional spaces. The tools are diverse and provide the basis for refined methods that allow one to approach problems that go well beyond the computation of spectra, including the mathematical foundations of quantum physics, noncommutative k-theory, and the classification of simple C*-algebras.

2001/144 PP./HARDCOVER/$39.95
ISBN 0-387-95300-0
GRADUATE TEXTS IN MATHEMATICS, VOLUME 209

FUNDAMENTALS OF CONVEX ANALYSIS

JEAN-BAPTISTE HIRIART-URRUTY, Université Paul Sabatier, Toulouse, and **CLAUDE LEMARECHAL,** INRIA, Montbonnot, both, France

This book is an abridged version of the two volumes *Convex Analysis and Minimization Algorithms I and II.* It presents an introduction to the basic concepts in convex analysis and a study of convex minimization problems with an emphasis on numerical algorithms. This book is not a reference book to be kept on the shelf by experts who already know convex analysis; it is far more a book for the purpose of learning and teaching.

2001/267 PP., 66 ILLUS./SOFTCOVER/$49.95
ISBN 3-540-42205-6
GRUNDLEHREN TEXT EDITIONS

FINITE MÖBIUS GROUPS, MINIMAL IMMERSIONS OF SPHERES, AND MODULI

GABOR TOTH, Rutgers University, Camden, NJ

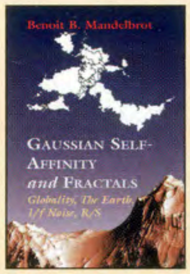
"Spherical soap bubbles", isometric minimal immersions of round spheres into round spheres, or spherical immersions for short, belong to a fast growing and fascinating area between algebra and geometry. This theory has rich interconnections with a variety of mathematical disciplines such as invariant theory, convex geometry, harmonic maps, and orthogonal multiplications. In this book, the author traces the development of the study of spherical minimal immersions over the past 30 plus years.

2001/456 PP., 32 ILLUS./HARDCOVER/$69.95
ISBN 0-387-95323-X
UNIVERSITEXT

GAUSSIAN SELF-AFFINITY AND FRACTALS

Globality, the Earth, 1/f Noise, and R/S

BENOIT MANDELBROT, IBM Research Division, Yorktown Heights, NY



Benoit Mandelbrot's pioneering research in fractal geometry has impacted many areas of mathematics, physics, finance, and other disciplines. The papers reprinted in this third volume of his *Selected Works* center on a detailed study of fractional Brownian functions, best known as the mathematical tools behind the celebrated fractal landscapes. Extensive introductory material incorporates striking new observations and conjectures. The fractal themes of "self-affinity" and "globality" are presented. This book contributes to the development of new mathematical tools and will be of use in diverse scientific communities.

2001/648 PP., 50 ILLUS./HARDCOVER/$54.95
ISBN 0-387-98993-5

PERIODIC INTEGRAL AND PSEUDODIFFERENTIAL EQUATIONS WITH NUMERICAL APPROXIMATION

JUKKA SARANEN, University of Oulu, and **GENNADI VAINIKKO,** Helsinki University of Technology, Espoo, both, Finland

2001/500 PP./HARDCOVER/$89.95
ISBN 3-540-41878-4
SPRINGER MONOGRAPHS IN MATHEMATICS

Springer
www.springer-ny.com

STOCHASTIC-PROCESS LIMITS

An Introduction to Stochastic-Process Limits and their Application to Queues

WARD WHITT, AT&T Labs-Research, Florham Park, NJ

This book provides an informal introduction to stochastic-process limits, i.e., limits in which a sequence of stochastic processes converges to another stochastic process. In addition to providing a general introduction to stochastic-process limits, the book focuses on their application to queues, i.e., probability models of waiting lines or service systems. Special attention is given to the scaling of time and space that is required for the heavy-traffic stochastic-process limits. The scaling leads to important concepts such as the averaging principle and the snapshot principle. Throughout, the book emphasizes the applied significance as well as the underlying mathematics.

2001/650 PP., 68 ILLUS./HARDCOVER/$79.95
ISBN 0-387-95358-2
SPRINGER SERIES IN OPERATIONS RESEARCH

DISCREPANCY OF SIGNED MEASURES AND POLYNOMIAL APPROXIMATION

VLADIMIR V. ANDRIEVSKII, Kent State University, Kent, OH, and **HANS-PETER BLATT,** Catholic University of Eichstätt, Germany

This book is an authoritative and up-to-date introduction to the field of analysis and potential theory dealing with the distribution of zeros of classical systems of polynomials such as orthogonal polynomials, Chebyshev, Fekete and Bieberbach polynomials, best or near-best approximating polynomials on compacts sets and on the real line. The main feature of the book is the combination of potential theory with conformal invariants, such as module of a family of curve and harmonic measure, to derive discrepancy estimates for signed measures if bounds for their logarithmic potentials or energy integrals are known *a priori*.

2001/464 PP., 36 ILLUS./HARDCOVER/$79.95
ISBN 0-387-98652-9
SPRINGER MONGRAPHS IN MATHEMATICS

ORDER TODAY!

CALL: 1-800-SPRINGER **FAX:** (201)348-4505 **WRITE:** Springer-Verlag New York, Inc., Dept. S4112, PO Box 2485, Secaucus, NJ 07096-2485 **VISIT:** Your local technical bookstore **E-MAIL:** orders@springer-ny.com **INSTRUCTORS:** Call or write for info on textbook exam copies
YOUR 30-DAY RETURN PRIVILEGE IS ALWAYS *GUARANTEED!*

11/01 **Promotion #S4112**

0002-9920(200111)48:10;1-5