Developments in Chaotic Dynamics
page 1318

John Nash and "A Beautiful Mind"
page 1329

Pricing of Scientific Publications: A Commercial Publisher's Point of View
page 1333

1998 Fields Medals
page 1358

1998 Nevanlinna Prize
page 1361

Statistics of Chaos (See page 1328)
K-Theory for Operator Algebras
Revised Edition
Bruce Blackadar
This first paperback printing has been revised and expanded and contains an updated reference list. This book develops K-theory, the theory of extensions, and Kasparov's bivariant KK-theory for C*-algebras. Special topics covered include the theory of AF algebras, axiomatic K-theory, the Universal Coefficient Theorem, and E-theory. Although the book is technically complete, motivation and intuition are emphasized. Many examples and applications are discussed. Mathematical Sciences Research Institute Publications 5 1998 c.352 pp. 0-521-63532-2 Paperback $29.95

Higher Order Operational Techniques in Semantics
Andrew D. Gordon and Andrew M. Pitts, Editors
The book surveys and introduces techniques such as contextual equivalence, applicative bisimulation, logical relations, improvement relations, explicit models of memory management, and labeling techniques for confluence properties. It treats a variety of higher order languages, based on functions, processes and objects, with and without side effects, typed and untyped. Researchers and graduate students will find this book valuable reading. Publications of the Newton Institute 12 1998 400 pp. 0-521-63168-8 Hardback $59.95

Hausdorff Measures
Second Edition
C. A. Rogers
This new edition has a foreword by Kenneth Falconer outlining the developments in measure theory since this book first appeared. Based on lectures given by the author at University College London, this book is ideal for graduate mathematicians with no previous knowledge of the subject, but experts in the field will also want a copy for their shelves. Cambridge Mathematical Library 1998 c.200 pp. 0-521-62491-6 Paperback $29.95

A Primer of Infinitesimal Analysis
J. L. Bell
In this book, basic calculus, together with some of its applications to simple physical problems, are presented through the use of a straightforward, rigorous, axiomatically formulated concept of “zero-square”, or nilpotent infinitesimal. The book also contains a historical and philosophical introduction, a chapter describing the logical features of the infinitesimal framework, and an Appendix sketching the developments in the mathematical discipline of category theory that have made the refounding of infinitesimals possible. 1998 122 pp. 0-521-62401-0 Hardback $29.95

Geometry and Interpolation of Curves and Surfaces
Robin J. Y. McLeod and M. Louisa Baart
The authors start with simple interpolation, including splines, and extend this in an intuitive fashion to the production of conic sections. They then introduce projective coordinates as tools for dealing with higher order curves and singular points. They present many applications and concrete examples, including parabolic interpolation, geometric approximation, and the numerical solution of trajectory problems. In the final chapter, they apply the basic theory to the construction of finite element basis functions and surface interpolants over nonregular shapes. 1998 416 pp. 0-521-32153-0 Hardback $80.00

Orthonormal Systems and Banach Space Geometry
Albrecht Pietsch and Jörg Wenzel
Using harmonic analysis as a starting point, classical inequalities and special functions are used to study orthonormal systems leading to an understanding of the advantages of systems consisting of characters on compact Abelian groups. Probabilistic concepts such as random variables and martingales are employed and Ramsey’s theorem is used to study the theory of super-reflexivity. The text yields a detailed insight into concepts including type and cotype of Banach spaces, B-convexity, super-reflexivity, the vector-valued Fourier transform, the vector-valued Hilbert transform and the unconditionality property for martingale differences (UMD). Encyclopedia of Mathematics and its Applications 70 1998 c.554 pp. 0-521-62462-2 Hardback $85.00

Asymptotic Statistics
A. W. van der Vaart
In addition to most of the standard topics of an asymptotics course, including likelihood inference, M-estimation, the theory of asymptotic efficiency, U-statistics, and rank procedures, the book also presents recent research topics such as semiparametric models, the bootstrap, and empirical processes and their applications. Cambridge Series in Statistical and Probabilistic Mathematics 3 1998 c.400 pp. 0-521-49603-9 Hardback $64.95

World Wide Asset and Liability Modeling
William T. Ziemba and John M. Mulvey, Editors
The underlying theme of this volume is how to invest assets over time to achieve satisfactory returns subject to uncertainties, various constraints and liability commitments. The papers utilize several approaches and integrate a number of techniques as well as discussing a variety of models that have either been implemented, are close to being implemented or represent new innovative approaches that may lead to future novel applications, that is, financial engineering. Publications of the Newton Institute 10 1998 c.320 pp. 0-521-57187-1 Hardback $95.00
Hyperbolic Equations and Frequency Interactions

Luis Caffarelli and Weinan E, Courant Institute, New York University, Editors

How waves, or “frequencies”, interact in nonlinear phenomena has been a central issue in many of the recent developments in pure and applied analysis. It is believed that wavelet theory—with its simultaneous localization in both physical and frequency space—and its lacunarity—will be a fundamental new tool in the treatment of the phenomena.

Included in this volume are write-ups of the “general methods and tools” courses held by Jeff Rauch and Ingrid Daubechies. Rauch’s article discusses geometric optics as an asymptotic limit of high-frequency phenomena. He shows how nonlinear effects are reflected in the asymptotic theory. In the article “Harmonic Analysis, Wavelets and Applications” by Daubechies and Gilbert the main structure of the wavelet theory is presented. Also included are articles on the more “specialized” courses that were presented.

This Summer Session brought together students, fellows, and established mathematicians from all over the globe to share ideas in a vibrant and exciting atmosphere. This book presents the compelling results.

IAS/Park City Mathematics Series, Volume 5; 1999; 466 pages; Hardcover; ISBN 0-8218-0592-4; List $69; All AMS members $55; Order code PCMS/NST811

Complex Geometric Analysis in Pohang

Kang-Tae Kim, Pohang University of Science and Technology (POSTECH), Korea, and Steven G. Krantz, Washington University, St. Louis, MO, Editors

This volume comprises the proceedings of a conference on the geometric analysis of several complex variables held at POSTECH in June 1997. The conference was attended by scientists and students from around the globe.

Each of the five plenary speakers at the conference gave a short course on a topic of current interest in the field. The lecture write-ups contain cogent and accessible information intended for a broad audience. The volume also includes a tutorial in several complex variables given by Kim and Krantz at the conference.

This tutorial is geared toward helping the novice to understand the rest of the material in the book.

Contemporary Mathematics, Volume 222; 1999; 256 pages; Softcover; ISBN 0-8218-0957-1; List $55; Individual member $33; Order code CONM/222; NST811

Randomization Methods in Algorithm Design

Panos Pardalos and Sanguthevar Rajasekaran, University of Florida, Gainesville, and José Rolim, University of Geneva, Switzerland, Editors

Randomization has played an important role in the design of both sequential and parallel algorithms. Major topics covered in the book include randomization techniques for linear and integral programming problems, randomization in the design of approximate algorithms for combinatorial problems, randomization in parallel and distributed algorithms, practical implementation of randomized algorithms, de-randomization issues, and pseudorandom generators. This volume focuses on theory and implementation aspects of algorithms involving randomization. It would be suitable as a graduate or advanced graduate text.

DIMACS: Series in Discrete Mathematics and Theoretical Computer Science, Volume 43; 1999; 318 pages; Hardcover; ISBN 0-8218-0916-4; List $69; Individual member $41; Order code DIMACS/43; NST811

Prospects in Mathematics

Invited Talks on the Occasion of the 250th Anniversary of Princeton University

Hugo Rossi, Mathematical Sciences Research Institute, Berkeley, CA, Editor

In celebration of Princeton University’s 250th anniversary, the mathematics department held a conference entitled “Prospects in Mathematics”. The purpose of the conference was to speculate on future directions of research in mathematics.

This collection of articles provides a rich panorama of current mathematical activity in many research areas. From Gromov’s lecture on quantitative differential topology to Witten’s discussion of string theory, new ideas and techniques transformed the audience of international mathematicians.

1999; 154 pages; Hardcover; ISBN 0-8218-0975-X; List $29; All AMS members $23; Order code PIM-ROSSINT811

Mirror Symmetry I

Shing-Tung Yau, Harvard University, Cambridge, MA, Editor

This volume is an updated edition of Essays on Mirror Manifolds, the first book of papers published after the phenomenon of mirror symmetry was discovered. The two major groups who made the discovery reported their papers here.

Greene, Plesser, and Candelas gave details on their findings; Witten gave his interpretation which was vital for future development. Vafa introduced the concept of quantum cohomology. Several mathematicians, including Katz, Morrison, Wilson, Roan, Tian, Hübsch, Yau, and Borcea discussed current knowledge about Calabi-Yau manifolds. Ferrara and his coauthors addressed special geometry and $N = 2$ supergravity. Robek proposed possible mirrors for Calabi-Yau manifolds with torsion. This collection continues to be an important book on this spectacular achievement in algebraic geometry and mathematical physics.

Titles in this series are co-published with International Press, Cambridge, MA.

AMS/International Press Studies in Advanced Mathematics, Volume 9; 1998; 444 pages; Hardcover; ISBN 0-8218-0655-3; List $49; All AMS members $39; Order code AMS/IP; NST811

All prices subject to change. Charges for delivery are $3.00 per order. For optional air delivery outside of the continental U.S., please include $5.50 per item. Prepayment required. Order from: American Mathematical Society, P.O. Box 6248, Providence, RI 02940-6248, USA. For credit card orders, fax 1-401-455-4046 or call toll free 1-800-321-AMS (4267) in the U.S. and Canada, 1-401-455-4000 worldwide. Or place your order through the AMS bookstore at www.ams.org/bookstore. Residents of Canada, please include 7% GST.
NEW TEXTBOOKS

The Geometry of Domains in Space
S.G. Krantz, Washington University, St. Louis, MO & H.R. Parks, Oregon State University, Corvallis, OR

This comprehensive treatise on domains (in space) emphasizes the growing interaction between analysis and geometry. Wherein classical analysis on Euclidean space is based on the study of the classical groups, the modern setting, which is the focus of this work, treats the subject of domains in space. The authors cover a wide array of topics and detail basic analytic ideas in the theory of convexity. The book provides a clear, self-contained, and systematically developed exposition for which only a good working knowledge of multivariable calculus and linear algebra is required.

Contents: 1 Elementary Topics ⊃ 2 Domains with Smooth Boundaries ⊃ 3 Measures ⊃ 4 Sobolev Spaces ⊃ 5 Smooth Mappings ⊃ 6 Convexity ⊃ 7 Steiner Symmetrization ⊃ 8 Topics Related to Complex Analysis ⊃ 9.1 Metrics on the Collection of Subsets of Rp ⊃ 9.2 The Constants Associated to Euclidean Space

Birkhäuser Advanced Texts $59.50 (tent.)

Basic Ergodic Theory
Second Edition
M. G. Nadkarni, University of Mumbai, India

This introduction to ergodic theory gives a slow pace presentation and can be read by anyone with a background in basic measure theory and metric topology. New features in the second edition: basic topics of ergodic theory are treated at the descriptive set-theoretic level, where they are presented; treatment of topics centering around the Glimm–Effros theorem: a section on rank one automorphisms; a brief discussion of the ergodic theorem due to Wiener and Wintner.

... admirably broad in scope. The exposition is clear. The examples have been chosen with great care... it is easy to recommend this book for students as well as anyone who would like to learn about the descriptive approach to ergodic theory.

— Mathematical Reviews

(From a review of the first edition)

Birkhäuser Advanced Texts $45.00 (tent.)

Scaling Limits and Models in Physical Processes
C. Cercignani, Politecnico di Milano, Italy & D. Serfing, University of Minnesota, Minneapolis

This introductory text in two parts treats scaling limits and modelling in equations of mathematical physics. The first part is concerned with basic concepts of the kinetic theory of gases and also features a very readable historic survey of the field. The second part treats the role of integrable systems for modelling weakly nonlinear equations which contain the effects of both dispersion and nonlinearity.

DMV, Volume 28

$39.50 (tent.)

Spectral Theory of Dynamical Systems
M. G. Nadkarni, University of Mumbai, India

This book introduces some basic topics in the spectral theory of dynamical systems, but also includes advanced topics such as a theorem due to H. Helson and W. Parry, and another due to B. Host. It describes Ornstein's family of mixing rank one automorphisms with construction and proof and discusses systems of imprimitivity, and their relevance to ergodic theory. The book also treats Baire category theorems of ergodic theory and considers Blass products which are used to describe the spectral types and eigenvalues of rank one automorphisms. This is the first book devoted exclusively to this subject, moving from introductory material to some topics of current research.

Birkhäuser Advanced Texts $59.50 (tent.)

Green Sale

From October 1 until December 31, 1998, we offer up to 30% on more than 85 excellent Mathematics titles.

Look in the mail for your copy of the Green Sale catalog, or request a copy at 1-800-777-4643.

Please use Promotion Number Y395

Green Sale 1998

JUST RELEASED

Chebyshev Splines and Kolmogorov Inequalities
S. Bagdasar, The Ohio State University, Columbus, OH
$118.00 (tent.)

Contributions to Operator Theory in Spaces with an Indefinite Metric
The Heinz Langer Anniversary Volume
I. Gohberg, Tel Aviv University, Israel; M.A. Kaashoek, Free University, Amsterdam, The Netherlands & R. Meinikken, University of Utrecht, Germany (Eds.)
$150.00 (tent.)

European Congress of Mathematics, Volumes I & II
Budapest, July 22-26, 1996
A. Balog & G.O.H. Katona, boys, Hungary Academy of Sciences, Budapest, Hungary; A. Recski, Technical University of Budapest, Hungary & D. Szász, Hungarian Academy of Sciences, Budapest, Hungary (Eds.)
$199.00 each

Generalized Polygons
H. Van Maldeghem, University of Gent, Belgium
$138.00 (tent.)

Topological Field Theory, Primitive Forms and Related Topics
M. Kashiwara, Kyoto University, Japan; A. Matsuuo, Nagoya University, Japan; K. Saito, Riken University, Japan & I. Satake, Osaka University, Japan (Eds.)
$79.00

Birkhäuser
Boston • Basel • Berlin

TO ORDER

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

Please mention promotion Y395 when ordering.

Prices are valid in North 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 132, CH-4010 Basel, Switzerland. Phone +41-61-305-0700; Fax +41-61-306-8792 or E-mail orders@birkhauser.ch
Feature Articles

Developments in Chaotic Dynamics
Lai-Sang Young

This article reports on some developments since the 1960s in the subject of hyperbolic dynamics, using billiards and Hénon attractors as illustrative examples.

John Nash and “A Beautiful Mind”
John Milnor

Sylvia Nasar has written a biography of Nobel laureate John Nash. Milnor gives a brief review of this book and then adds some commentary about Nash’s scientific work.

Pricing of Scientific Publications: A Commercial Publisher’s Point of View
Edwin F. Beschler

The author discusses factors that play a role in pricing in the commercial publishing business, seeing profit as the reward for the investment that makes innovation and risk-taking possible and seeing profit as a relatively small contributor to the price spiral.

Memorial Article

Samuel Eilenberg (1913–1998)
Hyman Bass, Henri Cartan, Peter Freyd, Alex Heller, and Saunders Mac Lane

Communications

Interviewing for a Job in Academia
Thomas Hull, Michael A. Jones, and Diana M. Thomas

Borcherds, Gowers, Kontsevich, and McMullen Receive Fields Medals
Alyn Jackson

Peter Shor Receives Nevanlinna Prize
Alyn Jackson

From the AMS

AMS E-mail Support for Frequently Asked Questions

AMS Standard Cover Sheet

Departments

Editorial
Commentary
Mathematics People
Mathematics Opportunities
For Your Information
Reference
Mathematics Calendar
New Publications Offered by the AMS
Publications of Continuing Interest
Classifieds
Membership Forms
Meetings and Conferences
Table of Contents
Editorial

Improving the Job Search

Graduate students, looking for a job after graduation, often seek advice from within their own universities. Too often, that advice misses the mark. Advice from the thesis advisor may reflect personal experience that is no longer applicable, or it may reflect career goals differing from those of the student. Advice from other graduate students may be based on inaccurate conventional wisdom.

The result is a scattershot approach in which the student sends identical letters and documentation to as many schools as possible. But this approach is the complete opposite of what professional career counselors recommend in other situations. Therefore the Notices is pleased to publish an article in this issue by three recent PhDs who describe how they used a highly individualized approach that generated multiple interviews and job offers.

The details of their approach will not apply to every situation. There is no simple algorithm for success. Indeed, the most important lesson to be learned from this article—by T. Hull, M. A. Jones, and D. Thomas—is that it pays to put effort into a search for a position suited to the applicant's own particular talents and interests.

In times of job shortages we sometimes forget that the goal is not just a job, but a position that will be a step toward a satisfying and productive career in mathematics. For some that may be a postdoctoral fellowship or a position at a research university; for others it may be a position at a department that emphasizes teaching rather than research; and for others it may be a position in industry. Of course, mixtures of these settings also occur. Whatever the circumstances, thesis advisers and graduate students alike need useful information about the job process.

Hull, Jones, and Thomas were seeking jobs whose emphasis was on teaching, and their article details how they zeroed in on jobs suitable for them. For all types of positions in mathematics, the employment page of the AMS Web site is a good source of useful information; in particular, links to various articles about mathematics employment are available at http://www.ams.org/employment/employ.html#articles.

However, finding good matches becomes extremely difficult when departments have to deal with many hundreds of applications. Is the present kind of process really necessary? Some may argue that it is a step toward a satisfying and productive career in mathematics. For some that may be a postdoctoral fellowship or a position at a research university; for others it may be a position at a department that emphasizes teaching rather than research; and for others it may be a position in industry. Of course, mixtures of these settings also occur. Whatever the circumstances, thesis advisers and graduate students alike need useful information about the job process.

Hull, Jones, and Thomas were seeking jobs whose emphasis was on teaching, and their article details how they zeroed in on jobs suitable for them. For all types of positions in mathematics, the employment page of the AMS Web site is a good source of useful information; in particular, links to various articles about mathematics employment are available at http://www.ams.org/employment/employ.html#articles.

However, finding good matches becomes extremely difficult when departments have to deal with many hundreds of applications. Is the present kind of process really necessary? Some may argue that it is a step toward a satisfying and productive career in mathematics. For some that may be a postdoctoral fellowship or a position at a research university; for others it may be a position at a department that emphasizes teaching rather than research; and for others it may be a position in industry. Of course, mixtures of these settings also occur. Whatever the circumstances, thesis advisers and graduate students alike need useful information about the job process.

Hull, Jones, and Thomas were seeking jobs whose emphasis was on teaching, and their article details how they zeroed in on jobs suitable for them. For all types of positions in mathematics, the employment page of the AMS Web site is a good source of useful information; in particular, links to various articles about mathematics employment are available at http://www.ams.org/employment/employ.html#articles.

However, finding good matches becomes extremely difficult when departments have to deal with many hundreds of applications. Is the present kind of process really necessary? Some may argue that it is a step toward a satisfying and productive career in mathematics. For some that may be a postdoctoral fellowship or a position at a research university; for others it may be a position at a department that emphasizes teaching rather than research; and for others it may be a position in industry. Of course, mixtures of these settings also occur. Whatever the circumstances, thesis advisers and graduate students alike need useful information about the job process.

Hull, Jones, and Thomas were seeking jobs whose emphasis was on teaching, and their article details how they zeroed in on jobs suitable for them. For all types of positions in mathematics, the employment page of the AMS Web site is a good source of useful information; in particular, links to various articles about mathematics employment are available at http://www.ams.org/employment/employ.html#articles.

However, finding good matches becomes extremely difficult when departments have to deal with many hundreds of applications. Is the present kind of process really necessary? Some may argue that it is a step toward a satisfying and productive career in mathematics. For some that may be a postdoctoral fellowship or a position at a research university; for others it may be a position at a department that emphasizes teaching rather than research; and for others it may be a position in industry. Of course, mixtures of these settings also occur. Whatever the circumstances, thesis advisers and graduate students alike need useful information about the job process.

Hull, Jones, and Thomas were seeking jobs whose emphasis was on teaching, and their article details how they zeroed in on jobs suitable for them. For all types of positions in mathematics, the employment page of the AMS Web site is a good source of useful information; in particular, links to various articles about mathematics employment are available at http://www.ams.org/employment/employ.html#articles.

However, finding good matches becomes extremely difficult when departments have to deal with many hundreds of applications. Is the present kind of process really necessary? Some may argue that it is a step toward a satisfying and productive career in mathematics. For some that may be a postdoctoral fellowship or a position at a research university; for others it may be a position at a department that emphasizes teaching rather than research; and for others it may be a position in industry. Of course, mixtures of these settings also occur. Whatever the circumstances, thesis advisers and graduate students alike need useful information about the job process.

Hull, Jones, and Thomas were seeking jobs whose emphasis was on teaching, and their article details how they zeroed in on jobs suitable for them. For all types of positions in mathematics, the employment page of the AMS Web site is a good source of useful information; in particular, links to various articles about mathematics employment are available at http://www.ams.org/employment/employ.html#articles.

However, finding good matches becomes extremely difficult when departments have to deal with many hundreds of applications. Is the present kind of process really necessary? Some may argue that it is a step toward a satisfying and productive career in mathematics. For some that may be a postdoctoral fellowship or a position at a research university; for others it may be a position at a department that emphasizes teaching rather than research; and for others it may be a position in industry. Of course, mixtures of these settings also occur. Whatever the circumstances, thesis advisers and graduate students alike need useful information about the job process.

Hull, Jones, and Thomas were seeking jobs whose emphasis was on teaching, and their article details how they zeroed in on jobs suitable for them. For all types of positions in mathematics, the employment page of the AMS Web site is a good source of useful information; in particular, links to various articles about mathematics employment are available at http://www.ams.org/employment/employ.html#articles.

However, finding good matches becomes extremely difficult when departments have to deal with many hundreds of applications. Is the present kind of process really necessary? Some may argue that it is a step toward a satisfying and productive career in mathematics. For some that may be a postdoctoral fellowship or a position at a research university; for others it may be a position at a department that emphasizes teaching rather than research; and for others it may be a position in industry. Of course, mixtures of these settings also occur. Whatever the circumstances, thesis advisers and graduate students alike need useful information about the job process.

Hull, Jones, and Thomas were seeking jobs whose emphasis was on teaching, and their article details how they zeroed in on jobs suitable for them. For all types of positions in mathematics, the employment page of the AMS Web site is a good source of useful information; in particular, links to various articles about mathematics employment are available at http://www.ams.org/employment/employ.html#articles.

However, finding good matches becomes extremely difficult when departments have to deal with many hundreds of applications. Is the present kind of process really necessary? Some may argue that it is a step toward a satisfying and productive career in mathematics. For some that may be a postdoctoral fellowship or a position at a research university; for others it may be a position at a department that emphasizes teaching rather than research; and for others it may be a position in industry. Of course, mixtures of these settings also occur. Whatever the circumstances, thesis advisers and graduate students alike need useful information about the job process.

Hull, Jones, and Thomas were seeking jobs whose emphasis was on teaching, and their article details how they zeroed in on jobs suitable for them. For all types of positions in mathematics, the employment page of the AMS Web site is a good source of useful information; in particular, links to various articles about mathematics employment are available at http://www.ams.org/employment/employ.html#articles.

However, finding good matches becomes extremely difficult when departments have to deal with many hundreds of applications. Is the present kind of process really necessary? Some may argue that it is a step toward a satisfying and productive career in mathematics. For some that may be a postdoctoral fellowship or a position at a research university; for others it may be a position at a department that emphasizes teaching rather than research; and for others it may be a position in industry. Of course, mixtures of these settings also occur. Whatever the circumstances, thesis advisers and graduate students alike need useful information about the job process.

Hull, Jones, and Thomas were seeking jobs whose emphasis was on teaching, and their article details how they zeroed in on jobs suitable for them. For all types of positions in mathematics, the employment page of the AMS Web site is a good source of useful information; in particular, links to various articles about mathematics employment are available at http://www.ams.org/employment/employ.html#articles.
In My Opinion

Spending (Non-)Profits

A not-for-profit corporation organized for scientific and educational purposes, like the American Mathematical Society, can be exempt from federal taxation as long as, in the words of the Internal Revenue Code, "no part of the net earnings of [it] inures to the benefit of any private shareholder or individual." In the financial statements of a nonprofit corporation, the annual revenue it receives for the goods and services it provides minus the annual expenses incurred in providing them is called operating income if it is non-negative (or operating loss if it isn't) instead of net earnings. Ideally annual operating income for a nonprofit would be zero, but since the problems of overshooting, or inadvertently collecting more revenue than expenses, are generally easier to solve than undershooting, or spending more than is taken in, most nonprofits budget for and try to achieve modest positive operating income. The AMS is no exception. For example, the Society went on record on this point in November 1997, saying that "the Society [should] budget positive operating income each year in the low range," leaving it to the treasurer and associate treasurer each year to define "low range".

Even well-managed and expertly led organizations can occasionally be caught unaware by unexpected events, like loss of a key customer or failure of an important piece of capital equipment on the negative side, or finding themselves with surprisingly successful products or in an unusually robust economy on the positive side. Again the AMS is no exception. In the last few years, the Society has unexpectedly found itself achieving significantly more than its budgeted operating income; see the Treasurer's Report for details. The treasurer also reports there on investment returns and other revenue which is not operating income.

Many factors contribute to the AMS's positive operating income: the Society's professional leadership and staff, the success of products like MathSciNet and the enhanced book publishing program, and the generally favorable U.S. economic environment. These are likely to continue to benefit the AMS for years to come.

Here is a partial list of things which the Society has been able to do because of this situation: it has introduced consortium pricing, bringing MathSciNet to many smaller institutions at reduced rates; it has introduced international institutional membership, bringing reduced journal subscription rates to academic libraries outside North America; and it has introduced special dues for new individual members, cutting their dues by half for their first five years of membership. It has also been able to reward its hard-working staff.

We still need to bear in mind, however, exactly where the revenue comes from. Some of those dollars come from individual mathematicians, and many more from their institutions' library budgets. It would be wonderful if over-budget positive operating income came from selling outdated copies of the Combined Membership List to tobacco companies, but in fact it, like the rest of the money, comes from resources transferred from the mathematical community.

The Society collects about $2.1M annually in dues: $1.4M from individuals, and the balance from institutions. It collects about $0.5M annually in individual meeting registrations, and it takes in about $14.2M annually in publications, including about $4.7M in subscriptions, $3.2M in book sales, and $5.8M from Math Reviews Data Access Fees. Presumably it is not necessary to remind Notices readers and Society members that AMS publications and member services are high quality and fairly priced; the community is getting good value for its money. Nonetheless, leaving any of those resources in the community in the first place is like making a grant of the equivalent amount. I think it should be a priority.

This comes out sounding rather unusual when stated as a goal: I want to measure success by the revenue not collected, the operating income not earned. And I certainly do not mean to encourage meeting that goal by weak marketing and inefficient production of inferior products. Rather, the Society should always be asking itself how it can continue to deliver quality publications and services while at the same time continually reducing expenses. (Would it be cheaper to do our fulfillment from Colorado Springs, say, or our printing in Matamoros?) All of the management techniques of for-profit corporate America—downsizing, outsourcing, maybe even profit sharing—should be in the AMS arsenal. And I would like to see the AMS matching expense reductions with price reductions on subscriptions, dues, and meeting registrations. At the very least, in my opinion, reducing prices (that is, leaving resources in the community) is my first choice when it comes to spending any operating income windfall.

—Andy Magid
Associate Editor
Developments in Chaotic Dynamics

Lai-Sang Young

Dynamical systems as a mathematical discipline goes back to Poincaré, who developed a qualitative approach to problems that arose from celestial mechanics. The subject has expanded considerably in scope and has undergone some fundamental changes in the last three decades. Today it stands at the crossroads of several areas of mathematics, including analysis, geometry, topology, probability, and mathematical physics. It is generally regarded as a study of iterations of maps, of time evolutions of differential equations, and of group actions on manifolds.

This article is about an area of dynamical systems called hyperbolic dynamics or chaotic dynamics. The concept of hyperbolicity, which we will define shortly, was used by Hedlund and Hopf in their analysis of geodesic flows on manifolds with negative curvature. A systematic study of hyperbolic systems began in the 1960s when Smale outlined in his 1967 Bulletin of the AMS article [Sm] a program for the geometric theory of dynamical systems. Another viewpoint, namely, the ergodic theory or probability approach to hyperbolic dynamics, was introduced several years later by Sinai and Ruelle. These ideas have developed over the last thirty years into a very rich theory, one that has changed the qualitative theory of ordinary differential equations and helped shape modern ideas about chaos.

In this article I would like to report on some developments since the 1960s. This, however, is very far from a survey. I hope that by focusing on a couple of examples and a small sample of ideas I can convey to the general mathematics community a sense of some of the progress that has been made.

We begin with the meaning of hyperbolicity. For definiteness let us confine ourselves to discrete time dynamical systems, that is, to systems generated by the iteration of self-maps of manifolds (as opposed to continuous time systems or flows). A linear map $T : \mathbb{R}^n \to \mathbb{R}^n$ is called hyperbolic if none of its eigenvalues lies on the unit circle. A nonlinear map $f$ is said to have a hyperbolic fixed point at $p$ if $f(p) = p$ and $Df(p)$ is a hyperbolic linear map. Hyperbolic fixed points are therefore either attracting (corresponding to when all the eigenvalues of $Df(p)$ are inside the unit circle), repelling (when they are all outside of the unit circle), or of saddle type (when some are inside and some are outside). The idea of a hyperbolic invariant set as introduced in [Sm] is a globalization of the idea of a hyperbolic fixed point.

Let $f : M \to M$ be a diffeomorphism of a Riemannian manifold, and let $\Lambda \subset M$ be a compact invariant set, i.e., $f^{-1}(\Lambda) = \Lambda$. We say that $f$ is hyperbolic on $\Lambda$ if the tangent space at each point $x \in \Lambda$ is the direct sum of two subspaces, one of which is expanded and the other contracted by $Df$. One requires also that these subspaces vary continuously with $x$ and that they be respected by $Df$. When the expanding (or contracting) subspaces are trivial, it can be shown that $\Lambda$ is the union of a finite number of periodic orbits. The more interesting situation is when both subspaces are nontrivial. In this case orbits are locally saddle-like, and both the structure of $\Lambda$ and the dynamics on
A can be quite complicated. A prototypical example of a nontrivial hyperbolic invariant set is Smale's horseshoe (see Figure 1).

An important characteristic of hyperbolicity when both subspaces are nontrivial is dynamic instability, meaning that the orbits of most pairs of nearby points diverge exponentially fast in both forward and backward times. Translations, rotations, local isometries, or fixed points with multipliers equal to 1 are among the simplest examples of nonhyperbolic behavior. Two terminologies introduced in the 1960s that we will encounter later in this article are Anosov diffeomorphisms, which refers to maps that are hyperbolic on the entire manifold $M$, and Axiom A, a condition satisfied by maps that are hyperbolic on certain essential parts of $M$. (We will not need to know its precise definition.)

The 1970s brought new outlooks and new challenges. With the aid of computer graphics, researchers became increasingly aware of the abundance of examples whose dynamics are dominated by expansions and contractions but which do not meet the rather stringent requirements of Axiom A. Two famous examples are the Lorenz ("butterfly") attractors and Hénon mappings. About the same time, a version of hyperbolicity with considerably weaker assumptions emerged following the works of Oseledec and Pesin. We will discuss this in more detail later, but suffice it to say now that in this weaker version "expansions and contractions everywhere" on a compact set is replaced by "asymptotic expansions and contractions almost everywhere". Some old results continue to hold in this more general setting (it is a bit like extending theorems for continuous functions to measurable ones), and new phenomena have been discovered. In light of these developments we will refer to the definition of hyperbolicity we gave earlier as uniform hyperbolicity to distinguish it from more general notions, which I will refer to loosely as nonuniform hyperbolicity.

This article is about nonuniformly hyperbolic systems, with emphasis on their ergodic theory. I would like to focus on the following two directions of progress: the development of a general theory and the application of hyperbolic techniques to specific examples. I will select two sample results from each one of these directions and discuss some of the ideas behind the theorems. The two applications I have chosen are billiards and Hénon attractors. For the general theory part, my two topics are (1) Lyapunov exponents, entropy, and dimension; and (2) correlation decay and central limit theorem.

Let me try to put things in perspective before continuing. Since the time of its conception, hyperbolic theory has developed in many different directions; the ergodic theory of nonuniformly hyperbolic systems is one of them, and this is the topic I have chosen to write about. Other important topics that I will not touch upon include partial hyperbolicity, bifurcation theories, one-dimensional dynamics, real and complex (to the degree that expanding properties are involved) group actions and geometry, etc. Within the topic of ergodic theory of hyperbolic systems I have also made choices that are clearly biased toward my own interests, although I hope that the results I am presenting are not an unreasonable sample.

**Billiards**

A billiard flow is the motion of a point mass in a bounded domain $\Omega \subset \mathbb{R}^2$ or $\mathbb{T}^2$ where $\partial \Omega$ is the union of a finite number of smooth curves. The point moves at unit speed and bounces off $\partial \Omega$ according to the usual laws of reflection: that is, the angle of incidence is equal to the angle of reflection. There is a natural section to this flow given by the surface $M = \partial \Omega \times [-\frac{\pi}{4}, \frac{\pi}{4}]$ which corresponds to collisions with $\partial \Omega$. It is convenient to think of $p = (x, \theta) \in M$ as represented by an arrow with footpoint at $x \in \partial \Omega$ and making an angle $\theta$ with the normal pointing into $\Omega$ (see Figure 2). We consider the Poincaré map or first return map $f$ from this section to itself and call it the billiard map for the domain $\Omega$. It is straightforward to check that $f$ leaves invariant the probability measure $\mu = c \cos \theta \, dx \, d\theta$ where $c$ is the normalizing constant, i.e., $\mu(f^{-1}E) = \mu(E)$ for every Borel measurable set $E \subset M$ and $c$ is chosen so that $\mu(M) = 1$.

Not all billiards have hyperbolic properties. In the case where $\Omega$ is an ellipse, for example, it is an exercise to see that the envelope of every (infinite) billiard trajectory is an ellipse or a hyperbola having the same foci as $\Omega$ (Figure 2(a)). One could

---

Figure 1. The horseshoe map: $B$ is a square; $f$ stretches $B$ in the horizontal direction, compresses it in the vertical direction, and bends the resulting rectangle into the shape of a horseshoe; the two shaded vertical strips are mapped onto the shaded horizontal strips, and the hyperbolic invariant set $\Lambda = \cap_{i=-\infty}^{\infty} f^i(B)$ is a Cantor set.

---

1 The figures for this article were created by William Cowieson, graduate student at UCLA.
Figure 2. Examples of nonhyperbolic billiards.

Figure 3. Dispersing billiards.

thus picture $M$ as being foliated by simple closed curves left invariant by the action of $f$, which "rotates" points around within each curve. This kind of dynamics is called quasi-periodic; it has a very different flavor from hyperbolic dynamics. In the case of a polygonal domain (Figure 2(b)), it is also easy to see that $f$ does not expand or contract distances.

Sinai was the first to investigate rigorously billiards with hyperbolic properties. He studied in [S2]

billiards of dispersing type corresponding to when $\partial \Omega$ is the union of a finite number of "concave" pieces. (Concave boundaries, by convention, refer to boundary curves whose center of curvature at each point lies outside of $\Omega$.) Two standard examples of billiards of this type are billiards on the 2-torus with a finite number of "scatterers" made up of disjoint convex regions (Figure 3(a)) and those on planar domains as shown in Figure 3(b).

Let us observe why billiard maps associated with dispersing billiards have hyperbolic properties. A tangent vector $v$ at $p \in M$ can be represented by a curve in $M$, which in turn can be thought of as a parametrized family of arrows containing the one corresponding to $p$. We distinguish between families of arrows that are divergent and those that are convergent and note that divergent families correspond to a sector, or a cone, in the tangent space to $M$ at $p$. Since divergent families of rays become even more divergent upon being reflected off a concave boundary piece (see Figure 5(a)), we see that $Df$ maps the cone corresponding to divergent rays at $p$ strictly into that at $f(p)$ (see Figure 4). Finding a continuous family of cones in tangent spaces that are mapped strictly into themselves by $Df$ is a standard way of proving uniform hyperbolicity: it shows that projectively, at least, $Df$ behaves like a hyperbolic linear map.

A few words of caution are in order here. First, billiard maps such as those in Figure 3(a) are discontinuous. Consider a trajectory of the point mass that meets $\partial \Omega$ tangentially. Trajectories slightly to the left and to the right of this one will run into different components of $\partial \Omega$ (see Figure 5(b)). Second, billiard maps have unbounded derivatives (see Figure 5(c)). These properties make them considerably more complicated than Anosov diffeomorphisms.

An important breakthrough in the study of billiards is the following theorem of Sinai, which can be viewed as lending support to Boltzmann's Ergodic Hypothesis, a hypothesis that is part of the foundation of statistical mechanics.

**Theorem** [S2]. Dispersing billiards are ergodic.

For a measure-preserving transformation, ergodicity means that there are no invariant sets having intermediate measure. The proof of Sinai's theorem is far too involved to be given here, but I would like to try to explain the idea of the proof, assuming that the discontinuity curves were not there, and to indicate what problems they cause.

Suppose now that $f$ is Anosov, i.e., uniformly hyperbolic (without discontinuities) on the entire manifold, and suppose that $f$ preserves a probability measure $\mu$ equivalent to the volume element. By Birkhoff's Ergodic Theorem we know that for every $L^1$ function $\varphi$, the trajectory averages $\frac{1}{n} \sum_{i=0}^{n-1} \varphi \circ f^i$ converge $\mu$-a.e. and that the limit is equal to $\int \varphi \, d\mu$ if $(f, \mu)$ is ergodic. To prove er-
godicity, then, it suffices to check that these limit functions are constant almost everywhere; in fact, it suffices to do this for continuous \( \varphi \). Our proof follows an idea due to Hopf. It uses the fact that for an Anosov diffeomorphism, the contracting and expanding directions can be integrated to form a pair of invariant foliations. The leaves of these two foliations are called stable and unstable manifolds. Now, for two points \( x \) and \( y \) on the same stable manifold, since \( d(f^n x, f^n y) \to 0 \) as \( n \to \infty \), it follows that their trajectory averages must tend to the same limit as \( n \to \infty \). This argument in backward time gives a similar conclusion for points on the same unstable manifold. Since locally stable and unstable manifolds form a Cartesian coordinate system (topologically, at least), it seems as if it would follow immediately that the limit function, which is constant on both stable and unstable manifolds, would be locally constant. The validity of this argument actually relies on the absolute continuity of the foliations, a fairly subtle property that says that the holonomy maps of these foliations carry sets of Lebesgue measure zero on transversals to sets of Lebesgue measure zero. It is a fact that the stable and unstable foliations of Anosov diffeomorphisms are absolutely continuous if \( f \) is \( C^2 \), and hence "local ergodicity" is proved. To prove that the limits of trajectory averages are globally constant a.e. requires a separate argument that we will omit.

Back with billiard maps, the discontinuity curves "chop up" the stable and unstable curves, making some of them arbitrarily short. This destroys the local product structure which is essential in our proof of local ergodicity in the last paragraph. A great deal of work has to be done to overcome this.

We remark that in addition to ergodicity more refined statistical properties of these and other billiards have been studied by Sinai, Bunimovich, Chernov (see, e.g., [BSC]), and others. We will return to some of these properties later in the article.

We saw from the examples above that the geometry of \( \Omega \) influences strongly the dynamical properties of the billiard map. It is not the case, however, that hyperbolic behavior is limited to concave boundaries. Convex boundaries, such as those in the stadium studied by Bunimovich (see Figure 6), can also produce hyperbolicity if certain conditions are met. This is because even though nearly parallel rays first become convergent upon reflection, they diverge after focussing, and expansion for the billiard map results if, before the next collision, these rays have diverged more than they have converged.

One could in fact prove that the billiard map associated with the stadium has some weak saddle-like behavior almost everywhere. This is called nonzero Lyapunov exponents. It means more precisely that almost everywhere on \( M \) there is a splitting of the tangent space into two invariant directions \( E^u \) and \( E^s \) so that for \( v \in E^u \), \( |Df^n v| = e^{n\lambda} \) for some \( \lambda > 0 \) as \( n \to \infty \), and the same holds for \( v \in E^s \) with \( \lambda < 0 \). Note that the hyperbolicity here is very nonuniform: billiard trajectories that are nearly perpendicular to the two straight sides, for example, will bounce back and forth for a long time without diverging, and in the meantime \( v \in E^u \) will not expand. Geometric conditions on billiard domains \( \Omega \) that give rise to nonzero Lyapunov exponents are formulated in [W].

Finally, we remark that billiards are in some sense low-dimensional models of interactions of large numbers of hard balls in, for example, 3-space. We refer the reader to [Sz] for an exposition on what is known about these systems and close this section with a report on the latest development: it has been announced very recently by Simányi and Szász that with no restriction on the number of balls, systems of finitely many balls in a torus with typical mass distributions have now been proved to have nonvanishing Lyapunov exponents.

![Figure 5. Properties of dispersing billiards.](image)

![Figure 6. The stadium.](image)
Hénon Attractors

The Hénon maps are a 2-parameter family of diffeomorphisms of the plane given by

\[ T_{a,b}(x, y) = (1 - ax^2 + y, bx). \]

In certain parameter ranges \( T_{a,b} \) is known to have an attractor. An attractor is an invariant set \( \Omega \) with the property that it attracts all nearby orbits: that is to say, for any starting point \( z \) near \( \Omega \) the orbit of \( z \) will in time be drawn toward \( \Omega \). The equations above were first investigated numerically in 1977 by the astronomer Hénon, who observed that they have attractors with very complicated dynamics. Many numerical studies were carried out in the late 1970s and early 1980s; analytically these maps remained intractable until quite recently. We would like to consider here the following two questions: (1) Are the Hénon attractors chaotic, and what do we mean by that? (2) What do computer plots such as those in Figure 7 really represent? (1) and (2) are general questions not at all particular to the Hénon maps, but we will use this family to illustrate some of the underlying issues. For definiteness we consider only parameter values with \( a < 2 \) and close to 2, and \( b \) very small. These are the parameters studied by Benedicks and Carleson; they represent a very small fraction of the parameters for which attractors are known to exist.

We begin with some elementary geometric facts. Let \( T = T_{a,b} \) with \( (a, b) \) fixed. From the equations of \( T \) it follows easily that \( T \) maps vertical lines to horizontal lines and sends horizontal lines to parabolas (see Figure 8). Observe also that \( T \) strongly contracts area, with \( |\det(DT)| = b \). It is not hard to show that away from the \( y \)-axis, say outside of the region \( \{|x| > \sqrt{b}\} \), the dynamics is essentially uniformly hyperbolic of saddle type: nearly horizontal tangent vectors are mapped by \( DT \) to nearly horizontal vectors, and they grow exponentially after a while. Horizontal segments near the \( y \)-axis, however, are mapped to the turns of parabolas. Thus when an orbit gets near the \( y \)-axis, directions of expansion and contraction may get mixed up and hyperbolicity may be spoiled.

Another elementary fact is that \( T \) has a compact invariant set \( \Omega \) located near \([-1, 1] \times \{0\} \); \( \Omega \) is an attractor in the sense that there is an open set \( U \subset \mathbb{R}^2 \) containing it, with the property that for every \( z \in U \), \( \det(DT^n(z), \Omega) = 0 \) as \( n \to \infty \). The maximal set with this property is called the basin of \( \Omega \); it is an open and relatively large set, whereas \( \Omega \), being a compact invariant set of an area contracting map, has Lebesgue measure 0. It is not hard to prove that \( \Omega \) is not a uniformly hyperbolic or Axiom A attractor.

Consider now the dynamics on \( \Omega \). There are two competing scenarios. The first is that most orbits tend eventually to attract periodic cycles, which are also called periodic sinks. To see why this may be the case, recall that \( |\det(DT)| \) is very small. If for some \( z \), \( T^n(z) \) comes near \( z \) and \( DT^n(z) \) is contracting in all directions, then the Contraction Mapping Theorem gives a periodic sink of period \( n \). Newhouse observed some time ago that this happens easily near tangencies of stable and unstable manifolds. He showed, in fact, that under certain conditions one typically expects to find infinitely many sinks [N].

A counterscenario is that the dynamics on \( \Omega \) is predominantly hyperbolic of saddle type and the resulting dynamic instability gives rise to a rather “chaotic” picture. (“Chaotic” is used as a descriptive word here; to my knowledge it has no accepted mathematical definition.) The reasoning is as follows. If \( b \) is small, then the strip \( \{|x| \leq \sqrt{b}\} \) is very narrow, and the orbit of an arbitrary point \( z \) is likely to spend most of its time outside of this strip where the map is uniformly hyperbolic of saddle type. Now let us not be so naive as to believe that a visit to the region \( \{|x| \leq \sqrt{b}\} \) once in a long while cannot do any harm; consider, for instance, the matrix product \( A_{2N} \cdots A_1 A_0 \) where

\[ A_i = \begin{pmatrix} 2 & 0 \\ 0 & -2 \end{pmatrix} \quad \text{for all } i \neq N \quad \text{and} \quad A_N = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}. \]

It is not unreasonable, however, to think that while cancellations of this type can and do occur to

Figure 7. This is the computer plot of a single orbit of length 5000 for the map \( (x, y) \to (1 - 1.4x^2 + 0.3y, x) \), the original map studied by Hénon. The overall appearance of the picture does not seem to depend on the choice of initial condition provided it is chosen from certain regions of the plane. This particular picture is generated using the initial condition \( (x, y) = (0, 0) \).
When an orbit gets near \( m \), the dimension is quite substantial.

For most parameters \((a, \beta)\) it is not known which one of these scenarios occurs, nor is it clear that both cannot coexist on different parts of \( \Omega \); the picture is simply extremely complicated. It is known that sinks exist for an open set of parameters. Numerics as well as intuitive thinking favor the "chaotic" regime in certain parameter ranges, but cancellations of the type in the last paragraph are not easy to deal with. In 1991 Benedicks and Carleson published a 100-page paper [BC] in which they proved that there is a positive measure set of parameters for which the "chaotic" scenario prevails. In [BC] a scheme for tracking the cumulative derivative \( DT^n \) is devised and \( ||DT^n|| \) is shown to grow exponentially for many points in the attractor. This work is a breakthrough in hyperbolic dynamics, for even though their analysis is carried out only for the Hénon maps, it has potential applications in other situations. Their scheme is too involved for me to outline here, but I would like to give a much simplified version of it, namely, for the case \( b = 0 \), which corresponds to the 1-dimensional map \( f_0(x) = 1 - ax^2 \), \( x \in [-1, 1] \).

Suppose we wish to prove the exponential growth of \( ||f^n|| \) for arbitrary points in \([-1, 1]\). Clearly the problem here is the critical point 0. When an orbit gets near 0, its cumulative derivative experiences a sharp drop. A fruitful idea, first used by Collet and Eckmann, is to impose a condition of the type \( |f^n| |f(0)| \geq \lambda^n \) for some \( \lambda > 1 \). This, together with some control on how fast the critical orbit is allowed to approach 0, easily gives the following estimates: For \( x \) near 0, \( |f^n(x)| \sim |x| \) and \( |f(x) - f(0)| \sim x^2 \), so the orbit of \( f(x) \) will stay near the orbit of \( f(0) \) for \( n \) times where \( n \) is determined by \( \lambda^n x^2 \sim 1 \). Hence \( |f^n(x)| \sim |x| \lambda^n \sim |x|^{-1} \sim \lambda^{n/2} \) and the small derivative at \( x \) is fully compensated for after \( n \) iterates. The conditions imposed on the critical orbit have been shown to hold for a positive measure set of \( a \)'s. The scheme of Benedicks and Carleson has a similar flavor, but with angles as well as lengths to control the increase in complexity from one to two dimensions is quite substantial.

Let us turn now to the second question. A standard way of making a computer picture of the Hénon attractor is to pick an initial condition in the basin of the attractor and to plot the first few thousand iterates of its orbit. (Initial conditions are typically taken from the basin and not necessarily from the attractor itself, because, as we recall, \( \Omega \) is a measure zero set and it is hard to know exactly which points lie in it.) Since the plotted orbit limits on the attractor, one often assumes that the resulting plot is "the picture" of the attractor (see Figure 7). This leads naturally to the following question: We know that orbits of the Hénon map are not all the same: some are periodic, others are not; some come closer to the turns than others. We also know from experience that (for a fixed \( T \)) one gets essentially the same picture independent of the choice of initial condition. Is there a mathematical explanation for this?

We do not pretend to have an answer for this intriguing and very important question, but use it instead to motivate the idea of Sina
- - Ruelle-Bowen or SRB measures. Our computer picture can be thought of as the picture of a probability measure which gives mass \( \frac{1}{n} \) to each point in an orbit of length \( n \). Let \( \delta_z \) denote point mass at \( z \). If there is a measure \( \mu \) with the property that \( \frac{1}{n} \sum_{i=0}^{n-1} \delta_{T^i z} \rightarrow \mu \) for "most" choices of initial conditions \( z \), that would explain why our pictures tend to look similar. Now this measure \( \mu \), if it exists, would have to have the following very special property: like all invariant probability measures, it must be supported on \( \Omega \), but somehow \( \mu \) has the ability to influence orbits starting from various parts of the basin, including points that are far away from the support of \( \mu \).

The conditions imposed on the critical orbit have been shown to hold for a positive measure set of \( a \)'s. The scheme of Benedicks and Carleson has a similar flavor, but with angles as well as lengths to control the increase in complexity from one to two dimensions is quite substantial.

Let us turn now to the second question. A standard way of making a computer picture of the Hénon attractor is to pick an initial condition in the basin of the attractor and to plot the first few thousand iterates of its orbit. (Initial conditions are typically taken from the basin and not necessarily from the attractor itself, because, as we recall, \( \Omega \) is a measure zero set and it is hard to know exactly which points lie in it.) Since the plotted orbit limits on the attractor, one often assumes that the resulting plot is "the picture" of the attractor (see Figure 7). This leads naturally to the following question: We know that orbits of the Hénon map are not all the same: some are periodic, others are not; some come closer to the turns than others. We also know from experience that (for a fixed \( T \)) one gets essentially the same picture independent of the choice of initial condition. Is there a mathematical explanation for this?

We do not pretend to have an answer for this intriguing and very important question, but use it instead to motivate the idea of Sina
- - Ruelle-Bowen or SRB measures. Our computer picture can be thought of as the picture of a probability measure which gives mass \( \frac{1}{n} \) to each point in an orbit of length \( n \). Let \( \delta_z \) denote point mass at \( z \). If there is a measure \( \mu \) with the property that \( \frac{1}{n} \sum_{i=0}^{n-1} \delta_{T^i z} \rightarrow \mu \) for "most" choices of initial conditions \( z \), that would explain why our pictures tend to look similar. Now this measure \( \mu \), if it exists, would have to have the following very special property: like all invariant probability measures, it must be supported on \( \Omega \), but somehow \( \mu \) has the ability to influence orbits starting from various parts of the basin, including points that are far away from the support of \( \mu \).

**Theorem [BY].** For a positive Lebesgue measure set of parameters \((a, \beta)\), the Hénon map \( T = T_{a,b} \) admits an invariant probability measure \( \mu \) on its attractor \( \Omega \) with the following properties:

1. \( f \) has a positive Lyapunov exponent \( \mu \)-a.e.;
2. \( \mu \) is supported on \( \Omega \);
Lyapunov Exponents, Entropy, and Dimension

We now shift to the part on general theory. To motivate our results in this section, we consider first a simple-minded way of building fractals from a single template.

Figure 9(a) shows a template consisting of a larger ball with three smaller balls inside. In Figure 9(b) we put a scaled-down copy of this template on each of the three smaller balls, constructing nine balls that are another size smaller. This procedure is repeated in Figure 9(c) on each of the nine balls, and so on. Continuing ad infinitum and taking the intersection, we obtain a fractal which is nothing other than a standard Cantor set.

All this can be said in the language of dynamical systems. Let us call the large ball in the template $B$ and the smaller balls $B_i$. Let $f : \cup B_i \rightarrow B$ be such that it maps each $B_i$ affinely onto $B$. Then $\Lambda = \cap_{n=0}^{\infty} f^{-n}(\cup B_i)$. It is natural to try to relate the fractal dimension of $\Lambda$ to the characteristics of its generating dynamical system. Assume for simplicity that all the $B_i$’s have the same radii. Consider $\lambda := \log(\text{radius } B/\text{radius } B_i)$ and $h := \log \#(B_i)$. To understand the relation among $h$, $\lambda$, and the Hausdorff dimension $\delta$ of $\Lambda$, we fix one of these numbers, vary a second, and observe the effect on the third. This is illustrated in Figure 10. From Figures 10(a) and (b) it seems intuitively clear that if we decrease $\lambda$ while keeping $h$ fixed, then $\delta$ goes down; likewise Figures 10(b) and (c) should convince us that if we increase $h$ while keeping $\lambda$ fixed, then $\delta$ goes up.

To turn these observations into a theorem that holds for all diffeomorphisms (the derivative of which varies from point to point), one possibility is to consider averaged quantities. This leads to the introduction of an invariant measure. We consider for the rest of this section a pair $(f, \mu)$, where $f$ is a $C^2$-diffeomorphism of a compact Riemannian manifold $M$ and $\mu$ is an $f$-invariant Borel probability measure on $M$.

We have encountered the idea of Lyapunov exponents before. Here is a more systematic discussion. Let $v$ be a tangent vector at $x$. We call $\lambda = \lambda(x,v)$ the Lyapunov exponent at $x$ in the direction of $v$ if $|DF^n(x)v| \sim e^{\lambda n}$ as $n \rightarrow \infty$. There is a matrix version of the ergodic theorem due to Oseledec that tells us that $\lambda(x,v)$ is well defined for every $v$ at $\mu$-a.e. $x$. In fact, at $\mu$-a.e. $x$ there is a decomposition of the tangent space into a direct sum of subspaces $E_1(x) \oplus \cdots \oplus E_r(x)$ with the property that $\lambda(x,v)$ is constant for all $v$ in $E_i(x)$; this common value of $\lambda(x,v)$ is denoted $\lambda_i(x)$. The decomposition into $\oplus E_i(x)$ is in a sense a generalization of the decomposition into eigenspaces for a single linear map. It is easy to see that $\lambda_i(x) = \lambda_i(fx)$, so that if $(f, \mu)$ is ergodic, then these numbers are constant $\mu$-a.e. and the asymptotic properties of $DF^n$ can
be summed up in a finite set of numbers \( \lambda_1 > \lambda_2 > \cdots > \lambda_r \) with multiplicities \( m_1, \ldots, m_r, m_i = \dim E_i \).

The translation of this linear theory into a nonlinear one describing the action of \( f \) in neighborhoods of typical trajectories was carried out by Pesin, who proved among other things that at \( \mu \)-a.e. \( x \), there is an unstable manifold passing through \( x \). This manifold, denoted \( W^u(x) \), is tangent at \( x \) to \( E^u(x) := \oplus_{\lambda_i > 0} E_i(x) \) and is characterized by \( \{ y \in M : d(f^{-n}x, f^{-n}y) \to 0 \text{ as } n \to \infty \} \). Analogously there is a stable manifold tangent to the stable subspace at almost every point.

While Lyapunov exponents measure geometrically how fast orbits diverge, the metric entropy of \( (f, \mu) \), written \( h_\mu(f) \), measures complexity in the sense of randomness and information. This notion was introduced by Kolmogorov and Sinai around 1959. Roughly speaking, it measures the amount of uncertainty one faces when attempting to predict future behaviors of orbits based on knowledge of their pasts. The formal definition of \( h_\mu(f) \) is a little hard to give in this limited space, so let me define it instead via the Shannon-Brieman-McMillan Theorem. Let \( \alpha \) be a finite partition of our manifold \( M \). For \( n \geq 0 \) we let \( \alpha^n \) be the partition whose elements are sets of the form \( \alpha^n(x) := \{ y \in M : f^lix \text{ and } f^iy \text{ belong in the same element of } \alpha \text{ for all } l \leq i \leq n \} \). For simplicity let us assume that \( (f, \mu) \) is ergodic. Then the Shannon-Brieman-McMillan Theorem says that there is a number \( h \) which we will take to be the definition of \( h_\mu(f) \) such that if \( \alpha \) is a sufficiently fine partition, then for all sufficiently large \( n \), neglecting a set of small \( \mu \)-measure, we may think of \( M \) as made up of \( \sim e^{\alpha n} \) elements of \( \alpha^n \) each having \( \mu \)-measure \( \sim e^{-nh} \).

For a more precise statement we refer the reader to a standard ergodic theory text, but for our purposes it suffices to think of \( e^{\alpha n} \) as the rate of growth in complexity of \( f \), counting only orbits that are “typical” with respect to \( \mu \).

Since Lyapunov exponents and metric entropy both reflect properties of the invariant measure, they can be related only via notions that pertain to the measure. Let \( \nu \) be a Borel probability measure on a compact metric space \( X \), and let \( B(x, r) \) denote the ball of radius \( r \) about \( x \). We say the dimension of the measure \( \nu \), \( \dim(\nu) \), is well defined and is equal to \( \alpha \) if for \( \nu \)-a.e. \( x \), \( \nu B(x, r) \sim r^\alpha \) as \( r \to 0 \). The relation between \( \dim(\cdot) \) and Hausdorff dimension \( (HD) \) is that if \( \dim(\nu) = \alpha \), then \( \inf \{ HD(Y) : Y \subseteq X, \nu(Y) = 1 \} = \alpha \).

Before giving the full statement of our theorem, it is instructive to consider first the special case where \( f \) has a single Lyapunov exponent \( \lambda > 0 \) (such an \( f \) is necessarily noninvertible, but that is fine). Let

\[
B(x, c; n) := \{ y \in M : d(f^kx, f^ky) < \varepsilon \text{ for all } 0 \leq k \leq n \}.
\]

Then

\[
B(x, c; n) \sim B(x, e^{-\lambda n}),
\]

and a small modification of the Shannon-Brieman-McMillan Theorem tells us that

\[
\mu B(x, c; n) \sim e^{-\lambda n}.
\]

Putting these two lines together gives

\[
\mu B(x, c) \sim r^\lambda,
\]

which proves that \( \dim(\mu) \) exists and is related to \( h \) and \( \lambda \) by \( h = \lambda \cdot \dim(\mu) \).

The argument above relies on the fact that we are able to generate dynamically sets that approximate round balls. When there is more than one positive Lyapunov exponent, this is impossible and the proofs become considerably more involved. In the theorem below, \( f \) is allowed to be any \( C^2 \)-diffeomorphism and \( \mu \) any invariant Borel probability measure. Recall that \( E_i \) is the subspace corresponding to the Lyapunov exponent \( \lambda_i \). The conditional measures of \( \mu \) on unstable manifolds are denoted \( \mu|W^u \), and \( \alpha^+ := \max(a, 0) \).

**Theorem.** Assume for simplicity that \( (f, \mu) \) is ergodic. Then corresponding to each \( \lambda_i \) there is a number \( \delta_i \) with \( 0 \leq \delta_i \leq \dim E_i \) such that

a. \( h_\mu(f) = \sum \lambda_i \delta_i \),

b. \( \dim(\mu|W^u) \) exists and is equal to \( \sum \lambda_i > 0 \delta_i \).

Moreover, if \( \lambda_i \neq 0 \) for any \( i \), then

c. \( \dim(\mu) \) exists and is equal to \( \dim(\mu|W^u) + \dim(\mu|W^s) \).
The numbers $\delta_i$ have geometric interpretations as partial dimensions of $\mu$ in the directions of $E_i.$ With this in mind, the dimension formula in part (a) can be understood as saying that in general, $h = \bar{\lambda} \cdot \delta$ where $\bar{\lambda}$ and $\delta$ are the Lyapunov exponent and partial dimension vectors. Parts (a), (b), and the “$$\leq$$” part of (c) of this theorem are proved by Ledrappier and the author [LY]. The reverse inequality in (c) is proved in a recent preprint by Barreira, Pesin, and Schmeling.

We remark that the dimension formula above can be viewed as a refinement of two very important results proved earlier: Ruelle’s Inequality, which says that $h_\mu(f) \leq \int \Sigma \dim E_i \, d\mu$ [R2], and Pesin’s Formula, which says that equality holds when $\mu$ is equivalent to the Riemannian measure [P]. Since the gap in Ruelle’s Inequality can be viewed as an indication of the amount of “dissipation” in a dynamical system, the dimension of an invariant measure has that interpretation as well. For a more detailed survey of this topic see [ER].

### Correlation Decay and Central Limit Theorem

In this last section we consider sequences of observations from dynamical systems and treat them as random variables in probability. More precisely, let $f : M \to M$ be a dynamical system, $\mu$ an invariant probability measure, and $\phi : M \to \mathbb{R}$ a function which we think of as a quantity that can be measured or observed (for example, temperature in an experiment). We regard the sequence of functions

$$\phi, \quad \phi \circ f, \quad \phi \circ f^2, \quad \ldots, \quad \phi \circ f^n, \quad \ldots$$

as random variables on the underlying probability space $(M, \mu)$ and ask how they compare qualitatively with genuinely random stochastic processes (such as outcomes from flipping a coin).

In this context, the Strong Law of Large Numbers, which says that $\frac{1}{n} \sum_{i=0}^{n-1} \phi \circ f^i$ converges to $\int \phi \, d\mu$ almost surely, holds when $(f, \mu)$ is ergodic; this is simply the Birkhoff Ergodic Theorem, which we have encountered many times. One could also ask if the Central Limit Theorem holds: that is to say, for $\phi$ with $\int \phi \, d\mu = 0$ we may ask if

$$\frac{1}{\sqrt{n}} \sum_{i=0}^{n-1} \phi \circ f^i \xrightarrow{\text{distr}} \mathcal{N}(0, \sigma)$$

for some $\sigma > 0$ where $\mathcal{N}(0, \sigma)$ is the normal distribution (or bell-shaped curve) with variance $\sigma^2.$

Another standard question concerns the correlation between $\phi$ and $\phi \circ f^n$ for large $n.$ More precisely, if

$$\Phi(n) := \left| \int (\phi \circ f^n) \phi \, d\mu - \left( \int \phi \, d\mu \right)^2 \right|,$$

then one could ask if $\Phi(n)$ tends to zero as $n$ tends to infinity and at what speed. For example, if $\Phi(n) \sim e^{-\alpha n}$ for some $\alpha > 0$ independent of $\phi,$ then this is a property of the dynamical system $(f, \mu)$ and we say $(f, \mu)$ has exponential decay of correlations. Similarly, if $\Phi(n) \sim n^{-\alpha}$ for some $\alpha > 0,$ then we say $(f, \mu)$ has polynomial decay; and so on.

These are, I believe, very important questions. Current techniques do not permit us to deal with them for completely general dynamical systems. Thus, following the theme of this article, we will limit ourselves to maps that geometrically have a great deal of expansion and contraction on large parts of their phase spaces. This (not so rigorously defined) class includes Axiom A diffeomorphisms as well as the examples discussed earlier. We take the view here that only properties that hold on positive Lebesgue measure sets are observable. Accordingly, if a system is “conservative,” i.e., if $f$ preserves a measure equivalent to Lebesgue measure, then this will be the measure of interest to us. If a system is “dissipative” (meaning not conservative), then we will take $\mu$ to be an SRB measure if one exists, for as we saw in the section on Hénon attractors these are the measures that reflect the properties of Lebesgue measure in dissipative systems. Since relatively little is known about the existence of SRB measures in general, this existence question will be our first and foremost challenge with regard to dissipative systems.

Our next remark has to do with the ergodic and mixing properties of $(f, \mu).$ Mixing is a stronger condition than ergodicity: it says that for every pair of Borel sets $A$ and $B,$ $\mu(f^{-n}A \cap B) \to \mu(A)\mu(B)$ as $n \to \infty.$ Some of our questions make sense only if $(f, \mu)$ is mixing, which is essentially equivalent to the assertion that the function $\Phi(n)$ above tends to zero as $n \to \infty.$ Even though not all $(f, \mu)$ are ergodic or mixing, there is a theorem due to Pesin and Ledrappier saying that if $(f, \mu)$ is smooth or is SRB and if $f$ has no zero Lyapunov exponents $\mu$ a.e., then $(f, \mu)$ is made up of at most a countable number of ergodic components, each one of which is mixing up to a finite cycle (see, e.g., [P]). Thus our questions are always relevant on each mixing component.

Finally, it is not hard to see that in deterministic settings such as ours the speed of mixing can be arbitrarily slow if we do not impose some regularity on our test functions. Thus $\phi$ will always be assumed to be Hölder continuous.

For the class of dynamical systems under consideration, the situation can be summarized as follows: For Anosov diffeomorphisms and Axiom A attractors, SRB measures always exist, correlation decay is exponential, and the Central Limit Theorem always holds (see, e.g., [R1]). Outside of the Axiom A category, much of the progress up until recently has been focused on individual classes of examples, and these examples suggest that many
distinct behaviors are possible. For instance, there are examples on the boundary of Axiom A that do not admit SRB measures; others do, but have polynomial decay.

In the remainder of this article I would like to report on some recent work that attempts to study systematically the statistical properties above. My goals are (1) to give verifiable conditions for these properties and (2) to relate them to the geometry of the map. These conditions are formulated in terms of recurrence times or renewal times and are defined for an object whose construction requires some degree of hyperbolicity. I will begin with a description of this object. For simplicity of exposition, allow me to temporarily treat \( f \) as though it were an expanding map, omitting details in connection with collapsing along local stable manifolds for systems with contracting directions. The idea is as follows: Pick an arbitrary set \( \Lambda \) with reasonable properties and with \( m(\Lambda) > 0 \) where \( m \) is Lebesgue measure. Think of \( \Lambda \) as a reference set, and regard \( \Lambda' \subset \Lambda \) as having "renewed" itself or "returned" to \( \Lambda \) at time \( n \) if \( f^n \) maps \( \Lambda' \) diffeomorphically onto \( \Lambda \). We run the system until almost all points of \( \Lambda \) have returned, decomposing \( \Lambda \) into a disjoint union of subsets \( \{\Lambda_i\} \), each returning at a different time. Let \( R \) be the return-time function. We claim that the statistical properties of \( f \) are to a large extent reflected in the asymptotics of the sequence \( m(\Lambda > n) \).

To be sure, the results below are not precisely stated. One important analytic ingredient that we have left out is the control of nonlinearities, which is essential for maintaining a certain degree of "independence" for the dynamics between returns to the reference set. Referring the reader to [Y1] and [Y2] for details, we state:

**Theorem.** Let \( f, \Lambda, m, \) and \( R \) be as above.

a. If \( \int f \circ m < \infty \), then \( f \) leaves invariant a probability measure \( \mu \) that is smooth or SRB; \( \mu \) is unique if we require \( (f, \mu) \) to be ergodic with \( \mu(\Lambda) > 0 \).

b. If, in addition, \( \gcd(\mathbb{R}) = 1 \), then \( (f, \mu) \) is mixing.

c. If \( m(\Lambda > n) < Cn^\theta \) for some \( \theta < 1 \), then correlation decay is exponential.

d. If \( m(\Lambda > n) = O(n^{-\alpha}) \) for some \( \alpha > 1 \), then \( \alpha \)-dependence is exponential.

e. If \( R \) is as in (d) and \( \alpha > 2 \), then the Central Limit Theorem holds.

The theorem above relates the statistical properties of \( f \) to the tail of its recurrence times. We claim that the latter is closely connected with the speed with which arbitrarily small pieces of unstable manifolds grow to a fixed size. This is because in order to return to the reference set \( \Lambda \) in our renewal construction an unstable disk must grow to the size of \( \Lambda \), and it is not hard to see that once it has reached a certain size it will return within a fixed number of iterates. The speed of growth of unstable manifolds varies from system to system; this is where the geometry of the map enters. For example, if \( f \) is uniformly hyperbolic, then the diameter of every sufficiently small unstable disk grows by a definite factor with each iteration. For maps that are not uniformly hyperbolic, if the source of its nonhyperbolicity can be identified and its mechanism known, then the degree to which this growth is stunted can be understood in terms of the action of the "bad set".

What we have proposed is a generic scheme for obtaining statistical information for dynamical systems with some hyperbolic behavior. This scheme has been implemented for a number of well-known examples. We finish by illustrating how it works for billiards on \( \mathbb{T}^2 \) with convex scatterers (see the section on billiards, Figure 3a in particular). For these billiards, discontinuities in the map are the only hindrance to uniform growth of unstable curves. This suggests that we examine closely the discontinuity set. Under an additional assumption on the billiard called "finite horizon" this set is known to be made up of a finite number of smooth curves, some of which meet at certain points. An easy but crucial fact is that no more than \( Kn \) branches of the discontinuity set of \( f^n \) can meet in one point, \( K \) depending only on the configuration of scatterers on our billiard table. This observation is due to Bunimovich. In \( n \) iterates, then, the image of a sufficiently short unstable curve has at most \( Kn + 1 \) components, while its total length grows by a factor of \( \lambda^t \) for some \( \lambda > 1 \). On average, therefore, exponential growth prevails. The preceding discussion translates, after some work, into the estimate \( m(\Lambda > n) < Cn^\theta \), and we conclude from the theorem above that the Central Limit Theorem holds and the speed of correlation decay is \( e^{-\alpha n} \). For more details see [Y1]. The CLT result is first proved in [BSC].

**References**


Applying Mathematics

TWO- AND THREE-DIMENSIONAL PATTERNS OF THE FACE
Peter W. Hallinan, Gaile Gordon, A. L. Yuille, Peter Giblin, and David Mumford
1998; Hardcover; ca. 300 pages; ISBN 1-56881-087-3; ca. $48.00

The human face is perhaps the most familiar and easily recognized object in the world, yet both its three-dimensional shape and its two-dimensional images are complex and hard to characterize. This book develops the vocabulary of ridges and parabolic curves, of illumination eigenfaces and elastic warpings for describing the perceptually salient features of a face and its images. The book explores the underlying mathematics and applies these mathematical techniques to the computer vision problem of face recognition, using both optical and range images.

WAVELETS: A PRIMER
Christian Blatter
1998; Hardcover; ca. 200 pages; ISBN 1-56881-095-4; $34.95

Based on a short course for mathematicians and engineers given at the ETH Zürich, this book cuts to the point by providing the basic mathematics before moving on to a summary of wavelet techniques from the continuous wavelet transform to multiresolution analysis and spline wavelets. It is an ideal book for self-study or a short course on a popular subject.

MODELING AND SIMULATION
Hartmut Bossel
1994; Hardcover; 504 pages; ISBN 1-56881-033-4; with 3.5" diskette; $65.00

This book provides an introduction and comprehensive reference to modeling and simulation techniques using computers. It emphasizes applications to economics and the environmental sciences and contains a disk with simulation software (SIM-PS) and 50 system models.

About the Cover
Recently subdivision techniques have been developed for the numerical approximation of both invariant manifolds and invariant measures of dynamical systems (cf. the article above by L.-S. Young). These techniques allow us to extract geometric and statistical information from complicated or chaotic dynamical systems.

For the cover image we have considered the Lorenz system (with a nonstandard set of parameter values). The object shown is a covering of a two-dimensional unstable manifold, and the coloring scheme illustrates the density of an invariant measure supported on this set (yellow (high density)→red→green→blue (low density)).

The image was created using the software GAIO (M. Dellnitz and O. Junge, University of Bayreuth) and the visualization platform GRAPE (Universities of Bonn and Freiburg). More detailed information and references may be obtained at http://www.uni-bayreuth.de/departments/math/~mdellnitz/.

—Michael Dellnitz

NOTICES OF THE AMS VOLUME 45, NUMBER 10

John Nash and "A Beautiful Mind"

John Milnor

John Forbes Nash Jr. published his first paper with his father at age seventeen. His thesis, at age twenty-one, presented clear and elementary mathematical ideas that inaugurated a slow revolution in fields as diverse as economics, political science, and evolutionary biology. During the following nine years, in an amazing surge of mathematical activity, he sought out and often solved the toughest and most important problems he could find in geometry and analysis. Then a mental breakdown led to thirty lost and painful years, punctuated by intermittent hospitalization, as well as occasional remission. However, in the past ten years a pronounced reawakening and return to mathematics has taken place. Meanwhile, the importance of Nash's work has been recognized by many honors: the von Neumann Prize, fellowship in the Econometric Society and the American Academy of Arts and Sciences, membership in the U.S. National Academy of Sciences, culminating in a Nobel Prize.

A Beautiful Mind

Sylvia Nasar's biography, A Beautiful Mind,¹ tells this story in carefully documented detail, based on hundreds of interviews with friends, family, acquaintances, and colleagues, as well as a study of available documents. Indeed, she is a highly talented interviewer and in some cases seems to un-earth material far beyond what one might expect. She gives detailed descriptions of the deliberations, not only for the 1958 Fields Medals, where Nash had been one possible candidate, but even for the 1994 Nobel Prize in Economics—deliberations that were so explosive that they led to a radical restructuring of the prize and a complete change in the nominating committee. In general her sources are carefully identified, but in these particular cases they remain anonymous.

Although Nasar's training was in economics rather than mathematics, she is able to provide background, rough descriptions, and precise references for all of Nash's major work. Also, she gives a great deal of background description of the places and persons who played a role in his life. (Mathematical statements and proper names are sometimes a bit garbled, but the astute reader can usually figure out what is meant.) Thus we find fascinating information about the history of Carnegie Tech, Princeton, the Rand Corporation, MIT, the Institute for Advanced Study, and the Courant Institute, and also information about many well-known and not so well-known mathematical personalities. The discussion leads into many interesting byways: her description of MIT is interwoven with a discussion of the McCarthy era, while her description of the Rand Corporation and of von Neumann leads to a discussion of the relation of game theory to cold war politics. (Von Neumann, who advocated a preemptive strike against the Soviet Union, may have been the original model for Kubrick's Dr. Strangelove.)

Any discussion of Nasar's book must point out a central ethical dilemma: This is an unauthorized biography, written without its subject's consent or

Nash’s mathematical activity was accompanied by a tangled personal life, which Nasar describes in great detail. This material is certainly of interest to a wide audience. (Oliver Sacks, quoted in the publisher’s blurb, writes that the book is “extraordinarily moving, remarkable for its sympathetic insights into both genius and schizophrenia.”) Inevitably, however, the publication of such material involves a drastic violation of the privacy of its subject. The book is dedicated to Alicia Nash, first his wife and later his steadfast companion, whose support through impossible difficulties has clearly played a major role in his recovery.

**Nash’s Scientific Work**

Pure mathematicians tend to judge any work in the mathematical sciences on the basis of its mathematical depth and the extent to which it introduces new mathematical ideas and methods, or solves long-standing problems. Seen in this way, Nash’s prize work is an ingenious but not surprising application of well-known methods, while his subsequent mathematical work is far more rich and important. During the following years he proved that every smooth compact manifold can be realized as a sheet of a real algebraic variety, introduced powerful and radially new tools to prove the far more difficult $C^\infty$-isometric embedding theorem in high dimensions, and made a strong start on fundamental existence, uniqueness, and continuity theorems for partial differential equations. (Compare [K1] and [M] for some further discussion of these results.)

However, when mathematics is applied to other branches of human knowledge, we must really ask a quite different question: To what extent does the new work increase our understanding of the real world? On this basis, Nash’s thesis was nothing short of revolutionary. (Compare [N21], as well as [U].) The field of game theory was the creation of John von Neumann and was written up in collaboration with Morgenstern. (One much earlier paper had been written by Zermelo.) The von Neumann-Morgenstern theory of zero-sum two-person games was extremely satisfactory and certainly had application to warfare, as was amply noted by the military. However, it had few other applications. Their efforts to develop a theory of $n$-person or non-zero-sum games for use in economic theory were really not very useful. (Both Nash and the reviewer participated in one experimental study of $n$-person games [N10]. As far as I know, no such study has ever been able to detect much correlation between von Neumann-Morgenstern “solutions” and the real world.)

Nash in his thesis was the first to emphasize the distinction between cooperative games, as studied by von Neumann and Morgenstern (roughly speaking, these are games where the participants can sit around a smoke-filled room and negotiate with each other), and the more fundamental noncooperative games, where there is no such negotiation. In fact, the cooperative case can usually be reduced to the noncooperative case by incorporating the possible forms of cooperation into the formal structure of the game. Nash made a start on the cooperative theory with his paper [NS] on the Bargaining Problem, to some extent conceived while he was still an undergraduate. (A related, much earlier study is due to Zeuthen.) As one remark in this paper, Nash conjectured that every cooperative game should have a value which expresses “the utility to each player of the opportunity to engage in the game.” Such a value was constructed by Shapley a few years later.

However, the major contribution, which led to his Nobel Prize, was to the noncooperative theory. Nash introduced the fundamental concept of equilibrium point: a collection of strategies by the various players such that no one player can improve his outcome by changing only his own strategy. (Something very much like this concept had been introduced by Cournot more than a hundred years earlier.) By a clever application of the Brouwer Fixed Point Theorem, he showed that at least one equilibrium point always exists. (For more detailed accounts, see [OR], [M].)

Over the years the developments from Nash’s seemingly simple idea have led to fundamental changes in economics and political science. Nasar illustrates the dollars and cents impact of game-theoretic ideas by describing “The Greatest Auction Ever” in 1994, when the U.S. government sold
off large portions of the electromagnetic spectrum to commercial users. A multiple-round procedure was carefully designed by experts in the game theory of auctions to maximize both the payoff to the government and the utility of the purchased wavelengths to the respective buyers. The result was highly successful, bringing more than $10 billion to the government while guaranteeing an efficient allocation of resources. By way of contrast, a similar auction in New Zealand, without such a careful game-theoretic design, was a disaster in which the government realized only about 15 percent of its expected earnings and the wavelengths were not efficiently distributed. (In one case, a New Zealand student bought a television station license for one dollar!)

One totally unexpected triumph of equilibrium theory has been its application to population genetics and evolutionary biology. Based on the pioneering work of Maynard Smith, game-theoretic ideas are now applied to the competition between different species or within a species. (Compare [MS], [IHS], [W]. A more precise form of this theory, popularized by Dawkins [D1], holds that the competition is rather between individual genes). There has also been an interesting reverse flow of ideas from evolution back to economics. According to Binmore (in [W]):

Despite Nash's remarks in his thesis about a possible evolutionary interpretation of the idea of a Nash equilibrium, attention at the time was focused almost entirely on its interpretation as the only viable outcome of careful reasoning by ideally rational players. Fortunately, Maynard Smith's book Evolution and the Theory of Games directed game theorists' attention away from their increasingly elaborate definitions of rationality. After all, insects can hardly be said to think at all, and so rationality cannot be so crucial if game theory somehow manages to predict their behavior under appropriate conditions. Simultaneously the advent of experimental economics brought home the fact that human subjects are no great shakes at thinking either. When they find their way to an equilibrium of a game, they typically do so using trial-and-error methods.

[3] Here Binmore does not refer to biological evolution, but rather to a dynamic process in which repeated plays of a game converge to an equilibrium. Unfortunately, this discussion from Nash's thesis does not appear in his published work.
In all of the applications one very important corollary must be emphasized: Although equilibrium theory, as developed by Nash and his successors, seems to provide the best-known description of what is likely to happen in a competitive situation, an equilibrium is not necessarily a good outcome for anyone. In contrast to the classical economic theory of Adam Smith, where free competition leads to best-possible results, and in contrast to classical Darwinian theory, where natural selection always leads to improvement in the species, the actual dynamics of unregulated competition can be disastrous. We all know that political conflict between nations can lead to an arms race, which is bad for everyone concerned, and in extreme cases can lead to totally unnecessary war. Similarly, in evolutionary theory an arms race within a species or between competing species over geological periods of time can be extremely detrimental. Indeed, it seems perfectly conceivable that natural selection may sometimes lead to a dead end and eventual extinction. Here is a mildly exaggerated version of an example which goes back to Darwin. (Compare [D3], [D4].) Suppose that an amorous peahen will always choose the peacock with the most splendid tail. This must lead to an evolutionary arms race during which the tails get progressively larger, until the males become so clumsy that they cannot escape from predators.

Similar comments apply to economic theory. In this case, one hopes that carefully chosen government regulation can modulate the negative effects of unbridled competition and lead to a better outcome for all concerned. However, the question as to just who will do the careful choosing is of course a matter of politics and leads to an even more complicated problem for equilibrium theory.

References


4 According to Darwin, “As natural selection works solely by and for the good of each being, all corporeal and mental endowments will tend to progress towards perfection.” However, he also expressed a contrary view. Compare the discussion of “why progress does not rule the history of life” in Gould [G1]. Unfortunately, there has been much unnecessary misunderstanding and bad feeling between those like Maynard Smith who work with theoretical models for evolution and those like Gould [G2] who emphasize that the real world is more complicated than any model.

5 Compare [DK], [D2]. When interpreting the phrase “arms race” for an evolutionary contest, remember that reproductive success is more important than battle prowess. The best evolutionary strategy is often to “make love, not war”.


Historical correction: I claimed in [M] (quoted by Nasar, p. 68) that Nash’s ideas on desingularizing algebraic varieties date back to the early 1950s. In fact, the correct dates are 1963–64 (Nasar, Chapter 42). Nash’s construction was probably first published by Nobile [No] in 1975.
When Jack Cade, a rebel vowing to lead the people in opposition to Shakespeare’s King Henry VI, declared that he would “apparel them all in one livery, that they may agree like brothers,” one of his loyal supporters proposed as a beginning, “The first thing we do, let’s kill all the lawyers.” Some members of the library community have responded in kind to recommendations by some mathematicians for homogenization of the scientific publishing process, in particular through the “one livery” of \TeX and other digital information technology tools, with a plea to return scientific publication to the “circle of the academy”. To some of us this sounds like “First, let’s hang all the commercial publishers.”

This mildly provocative literary parallel may not carry the startling effect of “Mathematics Journals Should Be Electronic and Free”, which appeared in the opinion column of the Notices, but I offer it as a tone setter for a view from the other side of the noose. The argument is made by Branin and Case in their Notices article [1] that “commercialism” is at the core of the current serials crisis and that scholarly books as well as journals would be more efficiently managed and less expensive if published by nonprofit publishers, i.e., the “circle of the academy” as opposed to commercial publishers. The charge carries several counts, discussion of which forms the core of this article.

Branin and Case have laid out the problem with admirable clarity and thoroughness. They have touched upon many related issues and have referred to much of the relevant literature. I will not in this article attempt to rebut their facts, but rather their main conclusion. The price tags on scientific literature have been rising and will probably continue to do so. The reasons are complex and involve a growing body of literature, an increasingly complex communications system, and differences of opinion about how scientific research communication should be funded. I will address only the narrow question of how commercial publishing’s profits relate to the problem. In the following I construe the “academy” referred to above as being all nonprofit publishers, mainly professional societies, universities, university presses, various ad-hoc consortia of scholars, and even individuals with personally created and maintained Web pages, the common bond being the absence of a “profit” factor in the pricing equation.
The point of view of the article is that of one member of the world of commercial publishing. This point of view, by virtue of the competitive nature of commerce, is perhaps more idiosyncratic and personal than what might be expected from a librarian, an individual scientist, a director of a funding program, an executive director of a society, or a head of a university press—all entities having more in common with their individual groups than do commercial publishers with each other. The chief exception of course is that we all need to operate our businesses at a profit. This view is expressed with some sense of discomfort, engendered by years of a common understanding that sharing information on pricing issues with one's competitors not only was bad business but also was possibly in violation of antitrust laws. Nevertheless, I feel strongly about the crucial role that commercial publishing has played over the past half century in the development of scientific publication in the United States and disagree with the notion that improvements will come about by withdrawal from the arena of the trained publishing personnel found there and the investments that are available.

The Charges

There are two major counts to the charges against commercialism and for-profit publishers:

COUNT ONE: Profits made by commercial publishers are the fuel for rising prices.

COUNT TWO: The superstructure of commercial publishing generates unnecessary cost, whereas the technology is available to create less expensive and more efficient researcher-to-reader channels of communication without publisher intervention.

There is a third count charging that the commercial publishers' need to protect their profits leads them to restrict availability of information by setting prices that are unaffordable and by placing other limitations on usage. This is a complex and contentious issue and will not be addressed in any detail in this article. I will, however, make one comment. Publishers by nature try to maximize their market penetration, not place restrictions on it. They invest resources to do this, and they must indeed protect those investments. The technology exists to download all types of information freely, whether text, graphics, audio, video, or any other imaginable form, and to subsume that material into forms of the downloader's choosing. All publishers, whether commercial or not, share the need to exercise some limitations on this ability, whether to protect revenue or maintain integrity of the material. Commercial publishers do not seek ways to prohibit access but to be paid fairly and honestly for their investment in packaging it.

In brief, the claim behind the charges is that if scientific publication was removed from the commercial arena and returned to the "circle of the academy", costs would be significantly reduced, prices would decline, and access by individuals would be simpler and more affordable. As an active editor (i.e., one who reads and edits manuscripts) and an ex-publisher in the commercial world, I take issue with much of all three counts. The reasons for the crisis are varied and complex, and if commercial publishing is part of the problem, it is also a part of the solution. Both history and a close examination of the dynamics of publishing will, I believe, support that statement. The simple facts are that publishing costs money whether directly or indirectly, that someone must be responsible for paying those costs, and that our real need is to determine who that will be and how it can be done. In other words, a central question in science publishing is, and always has been, how the support money flows rather than whether or not it should flow. Costs can be hidden, but they cannot be wished away.

On Count One the profession has to plead guilty to the charge that profits do contribute to rising prices, as do the surpluses that all publishers, profit and nonprofit alike, require to cover their overheads. But I intend to argue that profits are a relatively minor part of the problem. On Count Two I feel no need for a plea. The charge is simply wrong and should be dismissed.

Before going further, let me dispatch a straw man implied in my opening. Complete homogenization of the publication process will not happen, and there is no authority on earth with the power to remove scientific publishing from the commercial scene to the "academy". To be sure, SOME of everything that is predicted and seen as desirable will happen. Free journals will be established and will be available for some period of time. Marginally edited and controlled journals will come into existence where there is a perceived need, and some will serve their purpose and survive. Some commercial journals will spiral themselves out of existence in the price/subscription struggle and either close down, be adopted elsewhere, or be replaced by alternative media. None of the editors and authors who provide the intellectual input or the librarians who provide the core of subscriptions are captive to the publisher. They all have choices, but the scientific community has too much vested interest, both at an institutional and personal level, to want to see the commercial publishing industry withdraw completely. At the institutional level the community can ill afford to refuse private investment in the scientific communication system, since this implies, among other things, a limitation on choices. On the individual level numerous individual editors derive professional satisfaction, support for related ac-

---

1 I use "scientist" to mean scientist or mathematician in this article.
tivities, and in a few cases some personal income from their editing activities. All of these are legitimate returns for the exercise of professional expertise and editorial skills and are justifiable as returns for teaching, consulting, or writing. And they are an integral part of the cost of publishing.

Some History

The Commercial Publishing Industry

It may be instructive to consider how the commercial publishing industry became involved in scholarly publishing in America in the first place. In the early part of the century almost all serious scholarly scientific publishing in the United States was in the hands of the societies and university presses—the "academy" to which we refer\(^2\). Their capabilities were inadequate to handle the growing mass of publications arising from that era, and they were unable to provide the speed and acceleration of publishing schedules that were demanded. Thus the community turned to commercial publishers, in particular to those of European genesis, mostly founded by publishers who immigrated to the United States along with the wartime wave of scientists and scholars. Then, as now, they were a diverse group who brought to the profession of science publishing their imagination, enthusiasm, and individual perceptions. They considered themselves to be members of the scientific community even more than they identified themselves with the mainstream of commercial publishing. They created channels of publication that would not have existed otherwise. They provided a freedom of choice about what and how to publish, thus giving voice to many who, in a more controlled setting, would not have been heard. Perhaps the profession would have been better off without some of these voices. But who among us can make that judgment, even in hindsight, much less in the middle of our fast and furious "research and publish" society? The fact is that they identified needs, invested in scientific publishing, and were rewarded for it.

The Funding Agencies

In addition, the reality of publishing costs was recognized by funding agencies and various institutions that supported scientific research, resulting in their commitment to support the distribution of information as well as its creation. This support took the form of subsidies to libraries, publication grants, page charges, and the like. The idea was to make all information easily and cheaply available without regard to its comparative "popularity." The cost of this distribution was considered a legitimate part of support for scientific research, and it led to an era of health and prosperity in the publishing industry, as well as to the physical growth of the literature. Indeed some of us, while basking in this growth through the 1960s and 1970s, bemused ourselves with such lunchtime ruminations as to what happens when the most recent wing of the MIT library abuts the most recent wing of the Harvard library. This was not a truly serious and short-term concern, but a useful visual model for the implications of growth. In the days of which I speak the "electronic solution" was only a dim gleam in someone's eye and the physical storage problem loomed large, at least with respect to capital expenditures on expanding space. The "microform solution," though still a partial solution, never proved the panacea that was hoped.

Will History Be Reversed?

If reversion of science publishing to the academy cannot be realized by fiat, will the academic community, as individuals, gradually effect such a change by resigning as editors of commercial journals, declining to submit papers to them, and denying even paid-for facilities for editorial offices within universities? This suggestion has been made by a number of individuals, but there seems to be yet no empirical evidence that this will happen en masse. Should it happen, it would mean a return to a universe of fewer editorial programs, fewer individuals making publishing decisions based on their own tastes and interests—in short, fewer choices for both authors and buyers. Concomitantly it would remove a primary source of investment. It is difficult to see how this would be in the best interests of the scientific community.

I retain complete faith that under any system, however it came about, that places restrictions on commercial publishing of scientific research, it would not be long before an impatient scientific group—very possibly representing a subspecialty of mathematics—would approach a publisher or respond to an approach by a publisher with a proposal similar to one heard often over the years: "We know there are too many journals, and we know the economics are not favorable, but the needs of this community are not being filled, and we have set up this publication, but our institution will fund it only for a short time, so we need a partner in the enterprise. So here's our plan!" And a new journal, or book series, or other publishing context will be born outside the academy. Publishing is, and should be, a rebellious profession.

The Pricing Process

Those of us who have spent their careers in the commercial publishing field—and this may be true of all publishing settings—can attest to the fact that the most vociferous, often bruising, arguments that take place are centered on the question of pricing and print run. Questions of what to publish, how to publish it, and how to market it, though

\(^2\)Some notable exceptions existed, such as the MacMillan Company's publication of the first volumes of The Physical Review.
often spirited, rarely generate the heat of the price/print run debate. Egos are bruised, friendships destroyed, vendettas established, illusions shattered—and in the end pragmatic decisions are made that are miles away from the often suspected “what-the-market-will-bear” attitude.

Journal Pricing

Let us talk about some of the practical considerations that guide journal price setting. Although the basis will be the print media with which I have been familiar over the years, I believe that most cost savings from a reduced need for hard copy will be more than offset by other costs to support electronic systems. Even the university presses are under this kind of financial pressure, as noted for example in [2], where the author cites a number of rising cost factors such as paper, postage, creation of electronic versions, new hardware and software, and staff training. At the same time she cites the fact that universities are lessening their support for editorial costs and offices and libraries are not supporting the experimental electronic journals that are being demanded by the community.

The arithmetic of a pricing calculation is almost embarrassingly simple and perhaps even obvious. Nevertheless, I will say some words about it since it lies at the heart of how a commercial publisher views pricing, which is in a very pragmatic manner. Over the years, the economic model that produced in the 1960s a $20 subscription price for a new quarterly mathematics journal and in the 1990s a $200 subscription price for a similar item has changed very little, and the same debate takes place in the various “publishing committees” that meet in a publishing house and make such decisions. Antitrust considerations make it difficult to provide supporting evidence. However, we can risk stating a basic simple formula:

\[(EC + PC + MC)/ES = CS,\]

where \(EC\) = editorial cost, \(PC\) = production cost, \(MC\) = marketing cost, \(ES\) = expected number of subscriptions in five years, and \(CS\) = cost per subscription. This is the “fixed” cost that must be recovered on average for each subscription. It remains to determine the potential for individual subscriptions, subsidiary rights income, and anything else that might impact total revenue, including potential income from electronic subscriptions. By the same token, it must consider the impact on cost if the electronic version is to be free! It has been generally standard practice to hold the initial price for at least the first three years of publication, regardless of subscription level, and sometimes for up to five years, engendering losses that must be made up in time. It is an investment containing the risk of never being recovered or of making a profit only in the long run. Even though all the categories of cost may change significantly in their makeup, they will still exist and will still be required investment factors. Each journal with which I have been personally involved over the past ten years has encountered a different configuration of additional costs related to electronic delivery, and in no case was the new format in place long enough to attain a cost/revenue balance. One graphic example of the dilemma was described by a committee of the American Astronomical Society in 1995 as they looked at extending the *Astrophysical Journal Letters* to an electronic version. It is important to realize that the production of an electronic version of a journal requires additional steps that are not required in production of a paper version. This statement and other details about costs for electronic journals can be found in [3]. It calls into question the assumption that new electronic capabilities will dramatically reduce costs. There seems to me no evidence yet that this can be done AND sustained over time.

In the growth years of the 1960s and 1970s, when a mathematics journal of sufficient quality (guaranteed by a first-class editorial board and a publisher with good editorial support services) could easily attain 1,000 subscribers worldwide within a five-year period, the pricing decision was relatively easy. The individual publisher needed essentially to apply to the formula above its own overhead factor—something that obviously differs widely in absolute percentages as well as interpretation of what “overhead” means—in order to reach a subscription price that would generate the required revenue. In the 1980s and 1990s, when that “guaranteed” figure has dropped to 300 or lower and the overhead factor has increased to include funds to keep up with technological development, it is not difficult to see how the revenue-to-cost ratio changes and results in the need for higher prices.

Prices for succeeding years are adjusted to the actual number of subscribers once a maximum is judged to have been reached, a point that can be 5–7 years after inception. A formula found in [4] for predicting journal price increases is, though somewhat simplistic, still serviceable for a journal that appears to have reached its equilibrium in subscriptions. It is based on historical data indicating that for a scholarly research journal, 70% of its costs are fixed. On average, 75%-90% of its income is derived from subscriptions, the rest coming from offprints, reprints, back volume sales, and advertising. The price increase formula must therefore include a ratio of lost (or gained) subscriptions to total achieved subscriptions to date and a ratio of fixed costs to total costs. (For a fuller description of the calculation, see [5].) One of the questions we cannot answer at this point is whether this formula, minus the cost of paper, printing, binding, postage, and storage, plus costs for technological support, will still apply. My conjecture is that
it will still be used in much the same way as today, continuing to contribute some objectivity to what will always be a subjective and market-aware decision.

**Book Pricing**

Book pricing is also a topic of great importance, though of less uniform impact than the more centralized journal pricing question. Those of us who have published mainly at the upper-graduate to research level know that a book and journal program are intimately linked, a legacy perhaps of the European tradition mentioned above. Many editors and publishers believe that a book program cannot exist at the research level without a supporting journal program. Sales of scientific monographs continue to decline, helped in the decrease by librarians' need to transfer funds from the book budget to the journal budget, and those sales take place over a long period of time. Responsibility to authors and potential users dictate that such books must be kept in print, albeit in low quantities, for many years. This was at one time a minor problem involving mainly some marginal warehousing cost, until the landmark Thor Power Tool decision required commercial publishers to begin carrying full inventory costs for any books not pulped and pay relevant taxes while these items sit undisturbed for many years [6]. The result has been to force ever smaller print runs, putting pressure on unit cost and therefore, regardless of the specific pricing formula used, on the price as well. There are more universally accepted formulas for book pricing than for journal pricing, even though each publisher seems to develop its own variation. A publisher's own variation is usually referred to as "The Calculation". Whatever the form of the equation, it must include the same variables—fixed production costs, variable printing and binding costs, royalties, dealer discounts, overheads for marketing and administration, and profit margin. For determining print quantities, there is a well-known formula called the "Optimal Print Quantity", (OPQ) that relates the price and print run. A variation of the OPQ, as found in [7], is

\[ N_{opt} = \frac{P[R + N(p + w) + O]}{SD} \]

where

- \( N_{opt} \) = Optimum Print Quantity
- \( P \) = 1.00 + percentage of profit expected
- \( R \) = fixed production costs (sometimes increased to allow for reprints and inventory costs)
- \( N \) = total number of copies actually printed (some percentage is not available for sale)
- \( p \) = unit manufacturing cost
- \( w \) = unit order processing cost (varies with single and multiple quantity sales)
- \( O \) = overhead (calculated as a percentage of net income, depending on publisher's method of accounting)
- \( S \) = list price
- \( D \) = net income (calculated as a percentage of list that allows for dealer discount and royalty, usually about 55-60%)

I need hardly say that the mathematical model leaves much to be desired for an exact calculation. Many of the variables are more than a little fuzzy, and the need to vary both price and print run simultaneously is a source for much imaginative thinking. I include it more as an indication that publishers do look quantitatively at their pricing decisions. However, these formulas are used more as benchmarks or first approximations than as decision tools. The nonarithmetical factors at this point loom large and depend greatly on the individual editor's vision of the book and that editor's ability to convince marketing and administration.

How will the price of a book be set when the typical monograph is available on a Web site? Such books are less likely than journal papers to be read in their entirety on screen or even printed out on individuals' printers, since they can easily extend to 500-600 pages, whereas printing out anything over 50-60 pages would seem problematical. Even a 200-page book (printed on one side of a piece of paper and unbound, perhaps with some color illustrations?) is currently a nontrivial downloading task, to avoid which the individual might be willing to pay a reasonable amount of cash to have the service provided.

**Count One: Profits Are the Culprit**

The first count of the charges is that this pricing process, in the interests of the commercial publishers' profits, is a major underlying factor in the current library crisis. If profit could be removed from the pricing equation, would prices not decrease significantly? I do not think so. Although some items of any publisher's list are indeed profitable, there is ample evidence that most publications are only marginally profitable. Remove profit from an individual calculation and in most cases the formulas discussed in the pricing process will not change by much. Remove all journals from the commercial setting and invest them in the nonprofits, and in short order all the costs, all the development investment, and even many of the people involved would migrate to the "academy" and continue the dynamic practically unchanged. The "profit" would be subsumed by various needs of the institutions assuming responsibility. They would be no more able to support administrative and development costs on a purely "break-even-journal-by-journal" basis than can commercial publishers. I would predict that:
If profit could be removed from the pricing equation, would prices not decrease significantly? I do not think so.

The robust rate of publication of scientific monographs and advanced texts should be mentioned as an important part of the commercial publisher’s contribution to diversity in the literature. Such publications form an integral part of a journal publishing program and arguably would not exist without such an umbrella of journals. That the scientific monograph is “dead” has been bruited about for the past ten or more years. Yet in the pages of this endangered species exist distillations and surveys of some of the most important work being done, expressed from the individual point of view that one person has brought to the field, and a potential inspiration to readers who become interested in the subject. It is more often the commercial publisher who is willing and able to publish such books, since decisions can be made that are not subject to the same constraints as societies or university presses. If a commercial publisher decides to take a chance on an unknown author or a book of undetermined or peripheral interest, the punishment may be bad reviews of that book and probably (but not always) low sales. Such books are looked at with increasing skepticism by nonprofit publishers, and authors are referred to a commercial publisher, quite the reverse of previous days when the nonprofits were assumed to exist for the convenience of their sponsoring institutions. Thus many useful books are more likely to see the light of day in a diversified, commercially competitive publishing industry, populated by a wide range of editors and publishing intuitions, than in a restricted “academy only” setting. Centralization of decision making and removal of choices lead to control by some elite, and I doubt that anyone is arguing for that.

Where the Revenue Comes from and Where Some of the Profits Go

All the costs involved with publication have to be recovered through pricing and on a shrinking customer base. It is undeniable that this has led publishers with large agglomerations of journals and wide-ranging programs to push up prices of many journals and books that could individually be lower-priced if not loaded with that publisher’s expenses and overheads. On the other hand, a significant portion of that overhead is devoted to overall quality maintenance and system development that must be maintained even with a shrinking subscriber base. To be sure, some of the journals published by the larger companies like Elsevier, Kluwer, Springer-Verlag, and Academic Press are individually overpriced. Even smaller publishers are not immune from the need to spread overheads and share costs over a program rather than journal by journal. But if a product is continually priced beyond its value, it will eventually price itself out of the market. If, however, it maintains its value, then the question becomes how the customer can afford it, and this raises the question of who is to be responsible for paying the bill. I will return to this question in a later section.

When more funds were available for support of publication, less profit was required to take advantage of new ideas and new technology. Wide distribution of publications resulted in sufficient revenue flow to support the creative skills of both academia and industry in fashioning solutions to the publications problem. As technology became more complex and sophisticated and the amount of information became more massive and complex, prospective solutions to the problems—e.g., the Red Sage project of Springer-Verlag, Bell Labs, and the University of California at San Francisco and the Tulip project of Elsevier with eleven universities [8, 9]—were possible only because there

1. The same cadre of designers, copy editors, \TeX\ formatters, proofreaders—all those people who will NOT be made obsolete by the increased ability of authors to deliver coded text—will be making their living doing what they have always done. Publishing is a very labor-intensive business. Even the editors, marketers, executives, and other personnel of the industry would eventually surface as employees of the nonprofits. Many people in various nonprofit publishing institutions began their careers and received their training in the commercial world and have carried over entrepreneurial, competitive, and market-sensitive attitudes, along with personal dedication to a profession of meaning to them. People like this are needed, and they will find their profession wherever it exists.

2. The need for continuing innovation and experimentation with new knowledge and technology would still exist. It would require continuing investment of both money and time, and there is a limit to the amount of hidden subsidy and volunteer time that can be expected. Investment funds from the commercial sector would not be there and would have to be found elsewhere. Where? Additions to research grants? Society member dues? Perhaps from consumers through increasing subscription prices or charges for services? The dynamics of cost versus income will not be defeated by removal of one factor, called profit, and replacement by another, called perhaps “development costs” or some other euphemism.
were profits to be invested. A basic principle of free enterprise is that where profits are taken out, investment must be returned if the enterprise is to grow and remain healthy. Without those profits, and in the face of diminishing funding support, investment would be impossible. To look at profit without consideration of how it is reinvested shortchanges the whole idea of entrepreneurial business and free-market dynamics as an engine of social and economic good.

If all this publication was relegated to the "academy", what would be the gain? I have maintained above that costs involved for editorial work, technological development, distribution (whether hard copy or electronic) will remain. It is easy to realize economies of scale when increasing print runs to the thousands for individual titles. It is more difficult when increasing the number of titles, each of which requires some professional attention. The rate of growth in sponsored research will continue to generate more publishable material, and the material will require publishing services, the new technology notwithstanding. As the mass of publication increases, investment will also need to increase, and someone somewhere will have to pay the bill. To a great degree the various segments of the community that care about scientific communication differ only on who that someone should be. The bottom line for society remains the same.

In preparation for this article I browsed through the last two years' issues of the Newsletter on Serials Pricing [10], and I highly recommend it to anyone interested in the complex problems we are discussing. I have used it as a source for a number of references that might have originally appeared elsewhere because it is such an easy "one-stop-shopping" site for many of the items of interest here. And it is free, which should please almost all readers. As examples of the ambiguity of many arguments about pricing, the reader will find a perfectly sensible complaint from Robin Kirby about the pricing of his favorite journal, Topology, which is a commercial publication. He compares it with the new e-journal Geometry and Topology, which is published by the University of Warwick and supplied free. But he goes on to point out hidden subsidies in the form of computer and staff support that make the journal possible, begging the question of what happens in the future if that subsidy no longer exists [11]. In addition, the reader will find a well-stated and spirited defense by Karen Hunter of Elsevier of the relationship between price and size for chemistry journals such as Tetrahedron. Her comments are in response to a previous Pricing Newsletter concerning Elsevier's recently launched Inorganic Chemistry Communication, complaining that although it had an excellent editorial board and the price was reasonable, there is no telling what the price will become in twenty years. Hunter's argument is somewhat weakened by generalities implying that price is always directly related to size, which in the case of a highly specialized, low-circulation journal is often not as clear as all that [12]. I offer these references as examples of the complexity of the cost/income problem and the ambiguity that exists in all arguments on one side of commercial publishing or the other.

When attacked with charges that put the entire blame for the cost of science publishing on the commercial publishing companies, it is not surprising that a spirited entrepreneurial defense will be mounted. Speaking as a private individual, I wish Elsevier had taken a less aggressive stance in their 1998-2000 pricing proposal as detailed in [13]. The basic proposal as presented there was 7.5% over the regular subscription price for access to the electronic versions of all Elsevier journal titles (including those not now currently subscribed to), a 9% increase in each of the next two years with a no-cancellation clause, and a 10% discount for electronic versions in lieu of print subscriptions.

On a related issue, and while I am uncharacteristically naming names, I wish that Gordon and Breach had not undertaken their famous lawsuit [14], in which they challenged the validity of a study done by the American Institute of Physics. At issue were price comparisons based on such factors as cost per page or per 1,000 characters or cost per character divided by impact factor as measured in citation counts. I think they are both examples of wrong decisions for reasons that had a basic validity at the time. Nevertheless, the industry as a whole and the cause of scientific communication have benefited from Elsevier's development investment and from the debate that Gordon and Breach generated over how we measure value. Publishers from midsize to small have received the benefit of these companies' actions, even the ones with which I as an individual have the luxury of disagreeing. On the other hand, smaller publishers are also required by the new dynamics of publishing to follow industry leaders without necessarily having the underlying support and expertise to do so. These publishers often fight a successful battle against allowing new costs to impact prices radically and thus accept a minuscule or nonexistent profit in hopes that future costs will be lower, the

But if a product is continually priced beyond its value, it will eventually price itself out of the market.
publications will survive, and they will be able to perpetuate their business. Many readers of this article who are journal editors will recognize their own publishers among this group and can attest to yearly analyses of page allotments, changing editorial and production costs, and the impact on price of these costs and the impact on subscriptions of those prices.

Thus, on Count One, as admitted earlier, the profession has to plead guilty to the charge that profits do contribute to rising prices. In a free enterprise system this is no crime. And some of this profit returns to the community as investment without which other funding would have to be found. From where is it to come? “Commercialism” is simply the wrong target, and “profit” is not the main culprit.

**Count Two: Added Value**

The value added by publishers is being judged by our critics as unnecessary. Cannot much publishing be done WITHOUT the involvement of a publisher, commercial or otherwise? Is this not just adding unnecessary costs and overhead? Is the technology not adequate to handle smaller and smaller “publishing units”, down to the self-publishing level where the author IS the publisher and provides personally all the “value added” that is required—the ultimate homogenization? Some argue that the value added by publishers is becoming less important, others that without such value added the literature will explode into an incoherent mass of unprocessed data. The former attitude is inherent in the new LANL Mathematics E-print Archive [15], in which authors are encouraged to deposit their articles as they have prepared them, necessarily without regard to whether they have been refereed, edited, or provided with any value other than what the author has written. This should be an interesting experiment with input of the myriads of variations on $\LaTeX$ and $\TeX$. My opinion as a hands-on manuscript editor who has proofread $\LaTeX$ output is that anything can happen in the transfer from the author’s system to the publisher’s. My suspicion is that, as valuable as the Archive is likely to be, it will become palpable proof that editing intervention is required.

Experience even in trade publishing, as widely discussed in the popular press, indicates that literature will not stand alone on a person-to-person basis. The general level of writing skills in our students is seen to be eroding, and the removal of professional support to maintain standards will in due course negatively affect our level of discourse and the precision with which science and mathematics must express themselves. It is relatively simple to conjecture technological solutions that will handle most editorial problems. But it will be some years before authoring systems have been devised that can do such things as correct spelling, grammar, and context; check bibliographic databases to identify references properly; firmly codify notation so that ambiguities are “automatically” resolved; and handle other such refinements as creating identification systems that will uniquely mark a “piece of information” as to who first published it, who refereed it, who commented on it, who amplified it, etc. A control system will continue to be required continuously, from conception of a journal to organization of the editorial board, establishing of standards for acceptance of papers, application of editorial rules, and marketing of the product to the people who need it. (I leave aside two questions: What might be meant by “a journal” when “one universal journal with infinite branches” is conjectured? What may come to be meant by “marketing” when audiences are permanently and totally connected to everything they need?) The skills required are professional ones, demanding training and experience, and their punitious application is essential to a high standard of publishing. Silvio Levy has made some cogent observations on this point in [16]. In particular he attests to the fact that the practicalities of publishing would be much more difficult without a publisher and that the quality of the product would not be as good without editorial input.

And who can better provide this input than publishers who have, as business people, chosen to invest time and money in an enterprise that has an undeniable public good? It is to be expected that in the process some publishers will make an undue profit on some of the products. However, it is rarely the case that pricing decisions, which are generally reached through excruciatingly detailed discussions among editorial, marketing, and finance, focus solely on the question of how to maximize the profit from any one publication. Rather, discussions revolve about how one can, in the context of one’s own economic model, price this publication so that it fairly reflects its costs and will be acceptable to the market. The arguments tend to be objective and pragmatic, guided by the formulas discussed earlier but informed by knowledge of the individual publication and its value.

So to Count Two, as I stated earlier, I feel no need for a plea. The charge is simply wrong and should be dismissed. More efficiencies must indeed be realized and technological tools must be used. But it will not alter costs to shift them from one venue to another.

**Who Should Be Responsible for Paying the Bill?**

Commercial publishers deserve a return on their investments in scientific publishing. The enterprise of scientific communication has been furthered by its participation. Brannin and Case in their cited article quote the consultant Al Henderson to the effect that if library budgets matched
the growth of research expenditures, there would be no crisis. If funding agencies perceived that wide availability of information was still worth supporting, then it would be possible for the commercial publishing industry to provide more material at lower cost; i.e., it could continue with the job it is trained to do and be a vital support of the scientific community. Such a perception might be strengthened if scientific societies exercised their considerable influence in support of library funding.

In the absence of such direct funding, what is the responsibility of the institutions where scientists and researchers work? We do not consider it unreasonable that the institution must pay to maintain the physical plant, paint the walls, repair the heating system, shovel the snow from the sidewalks, buy telephone systems, build cafeterias, etc. Why should it not also pay to support library collections, the intellectual part of the physical plant that has been one of the most fundamental measures of the true greatness of any university? Does the faculty need easy access to as many resources as possible? Should the people who provide those resources not profit reasonably from their activities in doing so? Is the maintenance of adequate literature collections not as clear a responsibility as fresh paint? Indeed, much research money goes to commercial organizations who manufacture equipment, produce computers and chemicals, service communication systems, provide amenities for conferences, and provide a host of other commercial, profit making activities. It is difficult to see why the publishing industry should be singled out for criticism of making a profit on its conduct of business. It seems to me that library collections should be seen as a responsibility of the university and that the funding sources should recognize this and make the money available for the librarian to exercise free choice in deciding how it will be used. The amount involved, as large as it has become, is still only a fraction of that committed to research, and the percentage increases chronically less than the increase for central administration.

The suggested alternatives to recognizing costs and paying them involve a shift of responsibility from direct payment to such strategies as hidden subsidies and more volunteer input, all in the interests of holding prices below the true value of the product.3

Steven Weintraub's 1998 letter to the Notices [19] deplores the loss of typing services in many mathematics departments. It lends authority to a comment I have heard, but whose source I do not know, that Donald Knuth, the creator of \TeX, has succeeded in converting a generation of mathematicians into typesetters. We cannot blame Knuth for this unintended side effect of his magnificent creative achievement, but it does exemplify some of the smoke screen that obscures questions of who is really responsible for what. Perhaps in this age when businesses outsource all sorts of services to the user—data entry into ATM machines, self-service at the gas pump, build-yourself furniture—we are all fair game. But do we really want to put research money into paying professional scientists to do what professional publishers and publication support people are trained to do? What then is the actual cost?

If my contention above is correct that the main point on which many of us differ is the question of who is to bear the expense of providing cheap or free information to individuals, then it is fair to pursue this question of where the responsibility lies. Scientific publishing, both for profit and for nonprofit, is rife with free labor contributed by hundreds, perhaps thousands, of academics who see this as part of their responsibility to the profession. Inherent in the "return to the academy" argument is that this will continue and that it ought to. I wonder if that point is so clear. Would it not be fairer for the expected savings from technology to be used to help support those editors who are the guarantors of a quality literature? I do not go so far as to suggest a paid referee system, although even there I can conjure an honorarium system that recognizes the individual's sacrifice of time and resources for the good of all. This time is currently paid for by the individual contributing it. In a new model, should payment not come from the revenue of the journal? Again, it is a matter of who takes the responsibility for support. Who pays the bill?

---

3 For some historical background on the shifting of financial responsibilities, see Albert Henderson's article [17] commenting in 1995 on the 1989 Report of the ARL Serials Price Project [18]—an earlier attempt to march the commercial publishers to the gallows.
Summary
The commercial publishing industry shares the scientific community's concerns over the prices of scholarly publications. The viability of the industry depends on the health of the scientific communication system. But publishing companies must generate sufficient revenues to pay costs and overheads and return a reasonable profit to the owners to reward their investment. No industry that is not a monopoly can live indefinitely on a policy of overpricing, and the dynamics of publishing will always mitigate against domination by monopolies. Competitive pressures will always exist, even when so-called captive markets are at issue. In this respect, all publishers, commercial or nonprofit, have more in common than may be apparent and are subject to more of the same economic pressures than implied by much current argument. The competitive marketplace will right itself in ways that no authority can dictate.

So I return to the central question of where the money comes from, how it flows, and where it goes. This is a societal issue, not a "commercialization" problem. It is unfair, and ultimately futile, to label commercial publishers as the culprit. This is attested to by the fact that none of these commercial enterprises would be possible without the willing cooperation of the academics who make up our editorial and advisory boards and the support of the community for their efforts. Indeed, many of these journals exist because those academics and the groups around them realized that their aims for their professions could not be achieved entirely through the academy, but required the imagination and entrepreneurship of an establishment-defying, risk-taking commercial publisher to push the boundaries.

Acknowledgements
I would like to thank Albert Henderson for reading a draft of this article, providing some historic information, and sharpening some of my points. I would also like to express my appreciation to Tony Knapp for advising me on the organization of the article and for his patient editing of my prose. The opinions are my own.

References
[1] J. J. Brandin and Mary Case, Reforming scholarly publishing in the sciences: A librarian perspective, Notices Amer. Math. Soc. 45 (1998), 475-486. (As mentioned in my introduction, this is a well-researched and thoughtful article that covers many of the complex problems that have been created by growth in the literature and the various issues relating to its cost and ownership.)

[2] S. Whisler, The economic realities of journal publishing, Pricing Newsletter 172.3 (1997). (The author of this communication is with the University of California Press and responds to a previous communication entitled Why are librarians talking to publishers? as an example of why librarians and publishers NEED to talk with each other. She details the many financial pressures that her journals are under and the need for understanding that their problems are shared by everyone.)


[4] D. W. King, D. D. McDonald, and N. K. Roderer, Scientific journals in the United States: Their production, use, and economics, Hutchinson Ross, Stroudsburg, PA, 1981. (This was a landmark study of the entire spectrum of journal publishing in which statistics on costs, circulations, usage, growth rates, and other relevant parameters were compiled for perhaps the first time on such a wide basis. It continues to be a standard reference and a source of useful and reliable information for the period it covers.) See also C. Tenopir and D. W. King, Trends in scientific scholarly journal publishing in the United States, Journal of Scholarly Publishing 28 (1997), which contains a considerable update of this study.

[5] A. Henderson, Forecasting changes in periodicals prices, The Serials Librarian 21 (1992), 33-43. (This article discusses the various indexes that librarians can use to project price increases and thus make appropriate adjustments in their budget requests. It also discusses factors impacting on foreign and new periodicals.)

[6] Thor Power Tool Company, Petitioner-Appellant vs. Commissioner of Internal Revenue, Respondent-Appellee, U.S. Court of Appeals, Seventh Circuit, No. 76-1476, September 29, 1977, or Thor Power Tool Company v. Commissioner, 439 US 522 (1979). (The Supreme Court ruled that an inventory writedown was not allowed where it was based on subjective estimates rather than objective evidence and the inventory items continue to be held for sale at their original prices. Although this ruling was not initially meant to apply to publications, it swept them into the net.)

[7] H. S. Bailey Jr., The Art and Science Book of Publishing, Ohio University Press, Athens, 1990. (This book was first published by Princeton University Press in 1970 and is still considered to be one of the classic treatises on how publishing actually works, whether profit or nonprofit. The author was head of Princeton University Press for many decades.)

[8] Red Sage final report, http://www.springer-ny.com/press/red sage/. (The primary goal of the Red Sage project was to develop an understanding of the issues associated with electronic delivery of primary journals to scientists in their working environments.)

[9] TULIP (The University Licensing Project), http://www.acn.net/au/resources/ip/tulip/htm. (This was a cooperative research project in which Elsevier Science Publishers and eleven universities, each with strength in the physical and engineering sciences, tested systems for networked delivery and use of journals. Several Web sites have full information, e.g., http://www.acn.net/au/resources/ip/tulip/htm)
The Newsletter on Serials Pricing is free and can be subscribed to by sending a message to listproc@unc.edu saying "SUBSCRIBE PRICES [YOUR NAME]". Back issues from its inception in 1989 to the present are archived at http://www.lib.unc.edu/prices/ and at http://www.mathdoc.ujf-grenoble.fr/NSPI.html.

R. Kirby, Letter to Elsevier officers, Pricing Newsletter 199.1 (1997). (In addition to the comparison between a commercial journal and an electronic journal, the author of this article supports the concept of preprint servers, makes some comparisons of journals by cost per page, and predicts "so where you (the commercial publishers) see boom, I see bust.")

K. Hunter, Comparing serial prices, Pricing Newsletter 208.1 (1998). (The author raises the rhetorical question of whether it would seem more palatable to librarians if a large weekly journal should be divided into thirteen separate quarterly, thus reducing efficiency but winning the statistical battle by reducing dramatically the individual cost per title.)

E. Mobley, Meeting with the president of Elsevier, Pricing Newsletter 197.3 (1997). (This meeting was held between the president of Elsevier and the president of Purdue University, accompanied by a number of administration and faculty members. It was prompted by Purdue's announced decision to cancel $600,000 worth of subscriptions rather than accept the offer made by Elsevier and described in the article.)

A. Henderson, Lawful misconduct, and M. Brodsky, Valuable analysis, appearing as parts of an article entitled Decade-long legal battle focused on journal cost, impact, The Scientist 12 (1998), 7-8. (This article provides condensed views from both sides of the lawsuit brought by Gordon and Breach against the American Institute of Physics, which dragged on for a decade. As of January 1998 Gordon and Breach had won their battle in the French courts, but lost it in the United States. Henderson uses this article to challenge the physics societies to use their influence to reform allocations of resources to libraries. The article refers the interested reader to the Web site http://barschall.stanford.edu/ for a complete history.)

G. Kuperberg, D. Morrison, and R. Palais, Mathematics journals should be electronic and freely accessible, Notices Amer. Math. Soc. 45 (1998), 845. (This opinion article is by the Steering Committee for the Archive and is written to encourage its use as widely as possible.)

S. Levy, Remarks on math journals and libraries, Pricing Newsletter 202.1 (1998). (This is a written version of remarks made at a panel discussion during the January 1998 annual meeting of the AMS. The author makes the point that the issue of journal prices is independent of whether the journal is electronic or paper and focuses on our current system of tenure and promotion decisions as at least part of the fuel for the growth in number of publications.)

A. Henderson, Solving the paradoxes of journal prices: An editor's response to the serials crisis, CBE Views 18 (1995), 31-35. (Albert Henderson is a consultant to publishers and editor of the Publishing Research Quarterly. He has written widely on the "Serials Crisis" and in this article urges the participation of publishers, librarians, and university administrators in sharing information and seeking solutions together.)

S. Weintraub, Departments should provide manuscript typing, Notices Amer. Math. Soc. 45 (1998), 7. (This letter dealt with just this one issue, which seems to be a ubiquitous development in mathematics departments.)
Samuel Eilenberg
(1913–1998)

Hyman Bass, Henri Cartan, Peter Freyd, Alex Heller, and Saunders Mac Lane

Samuel Eilenberg died in New York, January 30, 1998, after a two-year illness brought on by a stroke. He left no surviving family, except for his wide family of friends, students, and colleagues, and the rich legacy of his life's work, in both mathematics and as an art collector.

"Sammy", as he has long been called by all who had the good fortune to know him, was one of the great architects of twentieth-century mathematics and definitively reshaped the ways we think about topology. The ideas that accomplished this were so fundamental and supple that they took on a life of their own, giving birth first to homological algebra and in turn to category theory, structures that now permeate much of contemporary mathematics.

Born in Warsaw, Poland, Sammy studied in the Polish school of topology. At his father's urging, he fled Europe in 1939. On his arrival in Princeton, Oswald Veblen and Solomon Lefschetz helped him (as they had helped other refugees) find a position at the University of Michigan, where Ray Wilder was building up a group in topology. Wilder made Michigan a center of topology, bringing in such figures as Norman Steenrod, Raoul Bott, Hans Samelson, and others. Saunders Mac Lane's invited lecture there on group extensions precipitated the long and fruitful Eilenberg-Mac Lane collaboration.

In 1947 Sammy came to the Columbia University mathematics department, which he twice chaired and where he remained till his retirement. In 1982 he was named a University Professor, the highest faculty distinction that the university confers.

Sammy traveled and collaborated widely. For fifteen years he was a member of Bourbaki. His collaboration with Steenrod produced the book Foundations of Algebraic Topology, that with Henri Cartan the book Homological Algebra, both of them epoch-making works. The Eilenberg-Mac Lane collaboration gave birth to category theory, a field that both men nurtured and followed throughout their ensuing careers. Sammy later brought these ideas to bear in a multivolume work on automata theory. A joint work on topology with Eldon Dyer may see posthumous publication soon.

Among his many honors Sammy won the Wolf Prize (shared in 1986 with Atle Selberg), was awarded several honorary degrees (including one from the University of Pennsylvania), and was elected to membership in the National Academy of Sciences of the USA. On the occasion of the honorary degree at the University of Pennsylvania in 1985, he was cited as "our greatest mathematical stylist".

The aesthetic principles that guided Sammy's mathematical work also found expression in his passion for art collecting. Over the years Sammy gathered one of the world's most important collections of Southeast Asian art. His fame among certain art collectors overshadows his mathematical reputation. In a gesture characteristically marked by its generosity and elegance, Sammy in 1987 donated much of his collection to the Metropolitan Museum of Art in New York, which in turn was thus motivated to contribute substantially to the endowment of the Eilenberg Visiting Professorship in Mathematics at Columbia University.

—Hyman Bass
Henri Cartan

Samuel Eilenberg died in New York on January 30, 1998, after spending two years in a state of precarious health. I would like to write here of the mathematician and especially of the friend that I gradually discovered in the course of a close collaboration that lasted at least five years and that taught me many things.

I met Sammy for the first time at the end of December 1947: he had come to greet me at LaGuardia Airport in New York, a city buried under snow, where airplanes had been unable either to take off or to land for two days. This was my first visit to the United States; it was to last five months. Of course, Eilenberg was not unknown to me, because since the end of the war I had begun to be interested in algebraic topology. Notably I had studied the article in the 1944 Annals of Mathematics in which Eilenberg set forth his theory of singular homology (one of those theories which immediately takes on a definitive shape). I had, for my part, reflected on the "Kimneth formula", which gives the Betti numbers and the torsion coefficients of the product of two simplicial complexes. In fact, that formula amounts to a calculation of the homology groups of the tensor product of two graded differential groups as a function of the homology groups of each of them. The solution involves not only the tensor product of the homology groups of the factors but also a new functor of these groups, the functor $\text{Tor}$. At the time of my first meeting with Sammy, I was quite happy with telling that to him.

This was the point of departure for our collaboration, by means of postal mail at first. Then Sammy came to spend the year 1950-51 in Paris. He took part in my seminar at the Ecole Normale, devoted that year to cohomology of groups, spectral sequences, and sheaf theory. Sammy gave two lectures on spectral sequences. Armand Borel and Jean-Pierre Serre took an active part in this seminar also.

Independently of the seminar, Sammy and I had work sessions with the aim of writing an article that would develop some of the new ideas born out of the Kimmeth formula. We went from discovery to discovery, Sammy having an extraordinary gift for formulating at each moment the conclusions that would emerge from the discussion. And it was always he who wrote everything up as we went along in precise and concise English. After the notion of satellites of a functor came that of derived functors, with their axiomatic characterization. Gradually the theory included several existing theories (cohomology of groups, cohomology of Lie algebras, in the sense of Chevalley and Eilenberg, cohomology of associative algebras). Then came the concept of hyperhomology.

Of course, this work together took several years. Sammy made several trips to my country houses (in Die and in Dolomieu). Outside of our work hours he participated in our family life.

Sammy knew how to put his friends to work. I think I remember that he persuaded Steenrod to contribute the preface of our book, where the evolution of the ideas is explained perfectly. He arranged also for other colleagues to collaborate in the writing of the chapter devoted to finite groups. Our initial project of a mere article for a journal was transformed; it became a book that we would propose to a publisher and for which it would be necessary to find a title that captured its content. We finally agreed on the term Homological Algebra. The text was given to Princeton University Press in 1953. I do not know why the book appeared only in 1956.

For fifteen years Sammy was also an active member of the Bourbaki group. It was, I think, in 1949 that André Weil, who was living in the United States, made contact with him in order to have him collaborate on a draft for use by Bourbaki, entitled "SEAW Report on Homotopy Groups and Fiber Spaces". It is therefore very natural that Eilenberg was invited to the Congress that Bourbaki held in October 1950. He was immediately appreciated and became a member of the group under the name "Sammy". It is necessary to say that he mastered the French language perfectly, which he had learned when he was living in his native Poland.

The collaboration of Sammy with Bourbaki lasted until 1966. He took part in the summer meetings, which lasted two weeks. He knew admirably how to present his point of view, and he often made us agree to it.

The above gives only a faint idea of Samuel Eilenberg's mathematical activity. The list made in 1974 of his publications comprises, besides 4 books, 111 articles; the first 37 articles are before his emigration from Poland to the United States in...
1939, and almost all are written in French. He was not yet twenty years old when he began to publish. The celebrated articles written with S. Mac Lane extended from 1942 to 1954. The list of his other collaborators is long: N. E. Steenrod, J. A. Zilber, T. Nakayama, T. Ganea, J. C. Moore, G. M. Kelly, to cite only the main ones. Starting in 1966, Sammy became actively interested in the theory of automata, which led him to write a book entitled Automata, Languages, and Machines, published in 1974 by Academic Press.

I have not mentioned a magnificent collection of sculptures in bronze, silver, or stone, patiently collected in India, Pakistan, Indonesia, Cambodia,..., some of which dated to the third century B.C. In 1967 he gave a great part of his collection to the Metropolitan Museum in New York.

In 1982 Eilenberg retired from Columbia University, where he had taught since 1947. In 1986 his mathematical work was recognized by the award of the Wolf Prize in Mathematics, which he shared with Atle Selberg.

The last time I saw Sammy was when the Université de Louvain-la-Neve organized a conference in his honor. Our meeting was not without emotion. He was for me a friend whose kindness, humor, and faithfulness cannot be forgotten.

Saunders Mac Lane

Samuel Eilenberg, who made decisive contributions to topology and other areas of mathematics, died on Friday, January 30, 1998, in New York City. He had been a leading member of the department of mathematics at Columbia University since 1947. His mathematical books, ideas, and papers had a major influence.

Eilenberg was born in Poland in 1913. At the University of Warsaw he was a student of Borsuk in the active school of Polish topology. His thesis, concerned with the topology of the plane, was published in Fundamenta Mathematica in 1936. Its results were well received both in Poland and in the USA. In 1938 he published in the same journal another influential paper on the action of the fundamental group on the higher homotopy groups of a space. Algebra was not foreign to his topology.

Early in 1939 Sammy's father told him, "Sammy, it doesn't look good here in Poland. Get out." He did, arriving in New York on April 23, 1939, and going at once to Princeton. At that university Oswald Veblen and Solomon Lefschetz efficiently welcomed refugee mathematicians and found them suitable positions at American universities. Sammy's work in topology was well known, so a position for him was found at the University of Michigan. There Ray Wilder had an active group of topologists, including Norman Steenrod, then a recent Princeton Ph.D. Sammy immediately fitted in, did collaborative research (for example, with Wilder, O. G. Harrold, and Deane Montgomery). His 1940 paper in the Annals of Mathematics formulated and codified the ideas of the "obstructions" recently introduced by Hassler Whitney. He also argued with Lefschetz. Finding the Lefschetz book (1942) obscure in its treatment of singular homology, he provided an elegant and definitive treatment in the Annals (1944).

Sammy's idea was to dig deep and deeper till he got to the bottom of each issue. This I learned when I lectured at Ann Arbor about group extensions. I had calculated an example of the group of group extensions for an interesting factor group involving a prime number p. When I told Sammy this result, he immediately saw that it answered a question of Steenrod about the regular cycles of the p-adic solenoid (inside a solid torus, wrap another one p times around, and so on, ad infinitum). So Sammy and I stayed up all night to find out the reason for this unexpected appearance of group extensions. We found out more: it rested on a "universal coefficient theorem" which gave cohomology with any coefficient group G in terms of homology and an exact sequence involving Ext, the group of group extensions. Thus Sammy insisted on understanding this unexpected connection between algebra and topology. There was more there: the connection involved mapping topology into algebra, so we were forced to invent functors, natural transformations, and categories to describe this. All told, this led to our fifteen joint papers.

They all involved the maxim: Dig deeper and find out. For example, Hurewicz and Heinz Hopf had observed that the fundamental group of a space had effects on the higher homology and cohomology groups. Sammy, with his knowledge of his singular homology theory, had just the needed tools to understand this, which resulted in our discovery of the cohomology of groups. Sammy saw that this idea went further, so he started Gerhard Hochschild on his study of the cohomology of algebras and then went on to write, with Henri Cartan, that very influential book on homological algebra, which caught the interest of many algebraists and provided the first book presentation of the important French technique of spectral sequences.

Sammy applied his maxim in other connections. With Joe Zilber he developed the category of simplicial sets as a new type of space—using his singular simplices with face and degeneration operations. With Calvin Elgot he wrote about recursion, a topic in logic. By himself he wrote two volumes on Automata, Languages, and Machines. And with
Eldon Dyer he prepared two volumes (not yet published) on *General and Categorical Topology*.

Algebraic topology was decisively influenced by Eilenberg's earlier 1952 work with Norman Steenrod, entitled *Foundations of Algebraic Topology*. At that time there were many different and confusing versions of homology theory, some singular, some cellular. This book used categories to show that they all could be described conceptually as presenting homology functors from the category of pairs of spaces to groups or to rings, satisfying suitable axioms such as "excision". Thanks to Sammy's insight and his enthusiasm, this text drastically changed the teaching of topology.

At Columbia University Sammy took vigorous steps to build up the department. He trained many graduate students. For example, his students and postdocs in category theory included Harry Applegate, Mike Barr, Jonathan Beck, David Buchsbaum, Peter Freyd, Alex Heller, Daniel Kan, Bill Lawvere, Fred Linton, Steve Schanuel, Myles Tierney, and others. He was an inspiring teacher.

Early in 1996 Sammy was felled by a stroke. It became hard for him to talk. In May 1997 I was able to visit him; he was lively and passed on to me a not clearly understood proposal. He was then able to spend some time in his apartment on Riverside Drive. I think his message then to me was the same maxim: Keep on pressing those mathematical ideas.

Next, I comment on Eilenberg's contributions to the sources of homological algebra. The starting idea that homology theory for topological spaces could be used for algebraic objects first arose with the discovery of the cohomology groups of a group. Hurewicz had considered spaces which are aspherical (any image of a higher-dimensional sphere can be deformed into a point) and had shown that the fundamental group \( \pi_1 \) determines the homotopy type of the space—and hence its homology and cohomology groups. Hopf had then found explicit formulas for the homology (Betti) groups of such a space.

Then Eilenberg-Mac Lane exhibited the \( n \)th cohomology group \( H^n(X, A) \) of such a space with coefficients in an abelian group \( A \) as a functor of \( \pi_1 \) and \( A \)—the \( n \)th cohomology \( H^n(\pi_1, A) \) of the group \( \pi_1 \) with coefficients in the \( \pi_1 \)-module \( A \). In particular \( H^1 \) was simply the group of "crossed homomorphisms" \( \phi: \pi_1 \to A \) satisfying

\[
  f(xy) = xf(y) + f(x)
\]

and taken modulo the "principal" such—those \( f \) given as \( f(x) = xa - a \) for some \( a \) in \( A \). The elements of \( H^n(\pi_1, A) \) were functions \( f(x_1, \ldots, x_n) \) of \( n \) elements \( x_i \) satisfying a suitable equation, modulo trivial solutions. In other words, the cohomology of \( \pi_1 \) was given as the cohomology of a certain chain complex, the so-called "bar resolution". In the terminology subsequently refined by Cartan-Eilenberg, \( H^n(\pi_1, -) \) was the \((n - 1)^{st}\) "derived" functor of \( H^1(\pi_1, -) \). In other words, old functors lead to new ones.

Eilenberg very quickly saw that such cohomological methods would apply to any algebraic situation. He explained this in the 1949 paper [2]. In 1948 he wrote with Chevalley a paper on the cohomology theory of Lie algebras, and about the same time he encouraged Gerhard Hochschild, then one of Chevalley's Ph.D. students, to introduce cohomology groups for associative algebras. In each of these cases the cohomology groups in question were the derived functors of naturally occurring Hom functors. Classical questions of algebraic topology also entered by way of the Künneth formulas. These formulas originally were stated to give the Betti numbers and torsion coefficients of a product of two spaces \( X \) and \( Y \). This really involved the tensor product of homology groups, and in the famous Eilenberg-Steenrod book it appears in the following short exact sequence:

\[
  0 \to \sum_{m+n=q} H_m(X) \otimes H_q(Y) \to H_n(X \times Y) \to \sum_{m+n=q-1} \text{Tor}(H_m(X), H_q(Y)) \to 0.
\]

Here "exact" means that at each point the image of the incoming arrow is the kernel of the outgoing arrow. Also, \( \text{Tor}(A, B) \) is a functor of abelian groups, as is \( \otimes \); in fact, \( \text{Tor} \) turns out to be the first derived functor of \( \otimes \)!

Some definitions of these terms do suffice for the topological task in question: elements of finite order in the groups \( A \) and \( B \) give elements in \( \text{Tor} \). I clearly recall an occasion when I tried to explain to Professor Künneth at Erlangen University that this abstract language did indeed produce his original numerical Künneth formulas. As stated, \( \text{Tor} \) is the first derived functor of \( \otimes \); it turns out for modules that there are also higher derived functors \( \text{Tor}_n(A, B) \) for each \( n \). The construction of these higher torsion products and their description by generators and relations were examined by Eilenberg-Mac Lane; these products provided new examples of higher derived functors of modules. For abelian groups \( A \) and \( B \), \( \text{Tor}_n(A, B) = 0 \) when \( n > 1 \).

Now return to the functor \( \text{Ext}(A, B) \), the group of abelian group extensions \( E \) of \( B \) by \( A \), so that
E appears in a short exact sequence of abelian groups:

\[ 0 \rightarrow B \rightarrow E \rightarrow A \rightarrow 0. \]

It turns out that the functor \( \text{Ext}(A, -) \) is the first derived functor of \( \text{Hom}(A, -) \) and thus that there are higher derived functors \( \text{Ext}_n(A, -) \). They vanish for abelian groups \( A \), but not generally for modules. The work of the Japanese mathematician Yoneda showed that an element of \( \text{Ext}_n(A, B) \) could be represented as a long exact sequence of modules (with \( n \) intermediate terms):

\[ 0 \rightarrow B \rightarrow E_1 \rightarrow E_2 \rightarrow \cdots \rightarrow E_n \rightarrow A \rightarrow 0. \]

All these various examples of the construction of new functors as "derived" functors of given ones were at hand for Eilenberg. He saw how they could be used to determine a homological "dimension" for algebraic objects, and he established the connection with the Hilbert notion of a syzygy in a 1956 paper \[3\]. This provided the background for the influential Cartan-Eilenberg book \[1\] on homological algebra. This text emphasized how the derived functors for a module \( M \) could be calculated from any "resolution" of \( M \) by free modules, a long-exact-sequence

\[ 0 \rightarrow M \rightarrow X_0 \rightarrow X_1 \rightarrow M_2 \rightarrow \cdots \]

with all \( X_j \) free. One simply applies the functor to the resolution with the \( M \) term dropped and then takes the homology or cohomology of the resulting complex. This effectively generalized the computation from specific "bar resolutions" used to define the cohomology of a group. The ideas of homological algebra were presented in two pioneering books by Cartan-Eilenberg \[1\] and Mac Lane \[4\]. The Cartan-Eilenberg treatise had a widespread and decisive influence in algebra. This again illustrates the genius of Eilenberg: If essentially the same idea crops up in different places, follow it out and find out where it lives.

**Alex Heller**

When I met Samuel Eilenberg in 1947, he was introduced as Sammy. He was always referred to as Sammy. It would be wrong to speak of him otherwise. I was then a student; I promptly became his student. I would like to record what drew me then to Sammy and continued over the years to do so—namely, what I perceived as his radical insistence on lucidity, order, and understanding as opposed to trophy hunting, and his idea of how that understanding was to be achieved.

Perhaps I should illustrate this by a partial (in both senses) account of his mathematical career. At the end of the 1930s algebraic topology had amassed a stock of problems which its then available tools were unable to attack. Sammy was prominent among a small group of mathematicians—among them, for example, J. H. C. Whitehead, Hassler Whitney, Saunders Mac Lane, and Norman Steenrod—who dedicated themselves to building a more adequate armamentarium. Their success in doing this was attested to by the fact that by the end of the 1960s most of those problems had been solved (inordinately many of them by J. F. Adams).

Sammy’s contributions appeared for the most part in a series of collaborations. With Mac Lane he developed the theory of cohomology of groups, thus providing a proper setting for the remarkable theorem of Hopf on the homology of highly connected spaces. This led them to the study of the Eilenberg-Mac Lane spaces and thus to a deeper understanding of the relations between homotopy and homology. Their most fateful invention perhaps was that of category theory, responding, no doubt, to the exigencies of algebraic topology but destined to radiate across most of mathematics.

In collaboration with Steenrod, Sammy drained the Pontine Marshes of homology theory, turning an ugly morass of variously motivated constructions into a simple and elegant system of axioms applied, for the first time, to functors. This was a radical innovation. Heretofore homology theories had been procedures for computing; henceforth they would be mathematical objects in their own right. What was especially remarkable was that in order to achieve this, Sammy and Steenrod undertook to raise the logical level of the things that might be so regarded.

The algebraic structures of the new algebraic topology were proving themselves useful in other parts of mathematics: in algebra, representation theory, algebraic geometry, and even in number theory. Together with Henri Cartan, Sammy systematized these structures under the rubric of Homological Algebra, once more raising the level of discourse by introducing such notions as derived functors. I am tempted to insert a parenthesis here. This latest innovation brought its authors into conflict with the “establishment” by putting in question the very notion of definition, raising a fundamental question of the relation between category theory and set theory that has yet to be put definitively to rest. Since homological algebra has proved indispensable, the honors lie, I think, with Cartan and Eilenberg. In any case, the field proliferated so rapidly that Grothendieck, only a few years later, was said to have spoken of their book as “le diplococcus,” regarding it apparently as palaeontology.

The roots of homological algebra lay nevertheless in algebraic topology, and Sammy, in collabor-
ortion with John Moore, returned to these. They introduced such novelties as differential graded homological algebra and relative homological algebra to provide homes for the new techniques introduced not only by Sammy and his collaborators but also by a new generation including Serre, Grothendieck, and Adams. Notable among them are the so-called Eilenberg-Moore spectral sequences, which deal with pullbacks of fibrations and with associated fiber bundles.

Unfortunately neither Sammy nor his last collaborator, Eldon Dyer, lived to complete their ultimate project of refounding algebraic topology in the correct—which is to say, homotopical—setting. Perhaps this project was too ambitious. I learned from Eldon how much agony accompanied even such choices as that of the correct definition of a topological space. Some part of their book may yet survive, and others are already continuing their project piecemeal.

As I perceived it, then, Sammy considered that the highest value in mathematics was to be found, not in specious depth nor in the overcoming of overwhelming difficulty, but rather in providing the definitive clarity that would illuminate its underlying order. This was to be accomplished by elucidating the true structure of the objects of mathematics. Let me hasten to say that this was in no sense an ontological quest: the true structure was intrinsic to mathematics and was to be discerned only by doing more mathematics. Sammy had no patience for metaphysical argument. He was not a Platonist; equally, he was not a non-Platonist. It might be more to the point to make a different distinction: Sammy’s mathematical aesthetic was classical rather than romantic.

Category theory was one of Sammy’s principal tools in his search for mathematical reality. Category theory also developed into a mathematical subject with its own honorable history and practitioners, beginning with Mac Lane and including, notably, F. W. Lawvere, Sammy’s most remarkable student, who saw it as a foundation for all of mathematics and justified this intuition with such innovations as categorical semantics and topos theory. Sammy did not, I think, want to be reckoned a member of this school. I believe, in fact, that he would have rejected the idea that mathematics needed a foundation. Category theory was for him only a tool—in fact, a powerful one—for expanding our understanding. It was his willingness to search for this understanding at an ever higher level that really set him apart and that made him, in my estimation, the author of a revolution in mathematics as notable as that initiated by Cantor’s invention of set theory. Like Cantor, Sammy has changed the way we think about mathematics.

Peter Freyd

Thirty years ago I found myself a neighbor of Arthur Upham Pope, the master of ancient Persian art. He had retired in his nineties to an estate in the center of the city of Shiraz in southern Iran, where I lived, briefly, across the street. I found an excuse for what has to be called an audience, and I mentioned that I was a friend of Samuel Eilenberg.

“I don’t know him,” he said. “I know of him, of course. How do you know him?”

“We work in the same area of mathematics.”

“You’re talking about a different Eilenberg. I meant the dealer in Indian art.”

“Actually, it’s the same person. He’s both a mathematician and a collector of Indian art.”

“Don’t be silly, young man. The Eilenberg I mean is not a collector of Indian art, he’s the dealer in Indian art. I know him well. He established the historicity of one of the Persian kings. He certainly is not a mathematician.”

End of audience.

In later years even Arthur Upham Pope would have known. In the art world, Eilenberg became universally known as “Professor”. Indeed, if one walked with him in London or Zürich or even Philadelphia and one heard “Professor!”, it was always Eilenberg who was being hailed, and it was always the art world hailing him.

If you heard “Sammy!” you knew it was a mathematician.

It was complicated, explaining that name. For a person who knew him first through his works, it was hard to conceive of him as “Sammy”. And upon meeting him for the first time, it was even harder: He was in charge of entire fields of mathematics—indeed, he had created a number of them. Whenever he was in a room, he was in charge of the room, and it did not matter whose room it was. Sammy? The name did not fit.

But he had to have a name like Sammy. I said it was hard to explain. Here was one of the most aggressive people one might ever meet. He would challenge almost anything. If a person mentioned something about the weather, he would challenge it: once in California I heard him insist that it was not weather; it was climate. But somehow it was almost always clear: it was all right to challenge him right back. Aggressive and challenging, but not at all pompous. One cannot be pompous with a name like Sammy.

Peter Freyd is a professor of mathematics at the University of Pennsylvania. His e-mail address is pjf@saul.cis.upenn.edu.
Sammy kept his two worlds, mathematics and art, at something of a distance. But both worlds seemed to agree on one thing, the very one that Arthur Upham Pope had insisted upon: Sammy was the dealer.

Without question, Sammy loved playing the role of dealer. In the days when mathematicians were in demand and jobs were easy to come by, Sammy loved to tell about the math market he was going to create. The trade would be in mathematician futures: “This one’s done only two lemmas and one proposition in the last year; the most recent theorem was two years ago; better sell this one at a loss.” With his big cigar (expensive) and his big gold ring (in fact, a valuable Indian artifact), he could enter his dealer mode at a moment’s notice. One always wondered just how many young mathematicians’ careers were in his hands.

But his two worlds, mathematics and art, perceived this role of dealer quite differently. In mathematics we understood that it was a role he loved playing, but that he was only playing. His being a mathematician was what counted, and he would have been the same mathematician whether or not he played the dealer, indeed, whether or not he played — and he did—high-stakes poker. This was not so clear in his other world.

It was usually frustrating trying to explain to others how Sammy was perceived by his fellow mathematicians. Sammy had an unprintable way of saying that mathematics required both intelligence and aggression. But imagine not knowing how his mathematics—when he had finished—would totally belch that aggression. Imagine not knowing how remarkably well-behaved his mathematics always was. Imagine not knowing how his mathematics, when he had finished, always seemed preordained and how it seemed no more aggressive than, say, the sun rising at its appointed sunrise time.

Forty years ago Sammy hoped to turn the study of Indian bronzes into an equally well-behaved subject. He had already acquired a reputation for being the best detector of fakes in the business, and he believed he could axiomatize the process. He even had a provisional list of axioms, and it was truly an elegant list.

A few years later we found ourselves at a small French-style bistro in La Jolla, California. We had been out of touch: there had been an argument about mathematical ethics, but somehow we had resolved it; the dinner was something of a celebration of the resolution. I asked him about his book on bronzes.

“Do the axioms fail?”

“What does that mean?”

“It means that I’ve been taken. I bought a fake.”

He had suspected it only after the work had been in his bedroom for a few weeks. He had the pleasure, at least, of investigating until he found out who the master faker was and tracking him down in his studio, not to berate him, but to congratulate him.

After that, Sammy made a point of not building bridges between his two worlds. I recall just one exception. He moved from a conversation about sculpture to one about mathematics. Sculptors, he said, learn early to create from the inside out: what finally is to be seen on the surface is the result of a lot of work in conceptualizing the interior. But there are others for whom the interior is the result of a lot of work on getting the surface right. “And,” Sammy asked, “isn’t that the case for my mathematics?”

Style is only one part of his mathematics—as, of course, he knew—but there are, indeed, wonderful stories about Sammy, attending only to what seemed the most superficial of stylistic choices, restructuring entire subjects on the spot. Many have witnessed this triumph of style over substance, particularly with students. But the most dramatic example had a stellar cast. D. C. Spencer gave a colloquium at Columbia in the spring of 1962, and Sammy decided it was time to demonstrate his get-rid-of-subscripts rule: “If you define it right, you won’t need a subscript.” Spencer, with the greatest of charm—it was for good reason that he was already affectionately known as “Uncle Don”—followed Sammy’s orders and proceeded to restructure his subject while standing there at the board. One by one, the subscripts disappeared, each disappearance preceded by a Sammy-dictated redefinition. He had virtually no idea of the intended meanings of any of the symbols. He was operating entirely on the surface, looking only at the shape of the syntax.

The process went on for several minutes, until Sammy took on the one proposition on the board.

“So now what does that say?”

“Sammy, I don’t know. You’re the one making all the definitions.”

So Sammy applied his definitions, and one by one the subscripts continued to disappear, until finally the proposition itself disappeared: it became the assertion that a thing was equal—behold—to itself.

“My mother’s father had the town brewery and he had one child, a daughter. He went to the head of the town yeshiva and asked for the best student.” Sammy told me one day. “So my future father became a brewer instead of a rabbi.”

Sammy regarded prewar Poland with some affection. He felt that he had been well nurtured by the Polish community of mathematicians, and he told me of his pleasure on being received by Stefan Banach himself, a process of being welcomed to the holy of holies, the café in which Banach
spent his time during the annual Polish mathematical conferences. By the time Sammy came to the U.S. in his mid-twenties he was a well-known topologist.

When I questioned him on his attitude about pre-war Poland, he answered that one must "watch the derivative": Don't judge just by how good things are, but by how fast they're becoming better.

Sammy's view of Poland since the war was more complicated. It was particularly complicated by what he viewed as its treatment of category theory as a fringe subject.

In the late 1950s Sammy began to concentrate his mathematical activities, both research and teaching, on category theory. He and Mac Lane had invented the subject, but to them it was always an applied subject, not an end in itself. Categories were defined in order to define functors, which in turn were defined in order to define natural transformations, which were defined finally in order to prove theorems that could not be proved before. In this view, category theory belonged in the mainstream of mathematics.

There was another view, the "categories-as-fringe" view. It said that categories were defined in order to state theorems that could not be stated before, that they were not tools but objects of nature worthy of study in their own right. Sammy believed that this counterview was a direct challenge to his role as the chief dealer for category theory. He had watched many of his inventions become standard mathematics—singular homology, obstruction theory, homological algebra—and he had no intention of leaving the future of category theory to others.

Today the language of category theory has permeated a good part of mathematics and is treated with some respect. It was not ever so. There were years before the words "category" and "functor" could be pronounced unapologetically in diverse mathematical company. One of my fondest memories comes from sitting next to Sammy in the early 1960s when Frank Adams gave one of his first lectures on how every functor on finite-dimensional vector spaces gives rise to a natural transformation on the K-functor. Frank used that construction to obtain what are now called the Adams operations, and he used those to count how many independent vector fields there could be on a sphere. It was not until then that it became permissible to say "functor" without a little snort.

In those years, Sammy was a one-man employment agency for a fresh generation of mathematicians who viewed categories not just as a language but as a potentially central mathematical subject. For the next thirty-five years he went to just about every category theory conference, and, much more important, he used his masterly expository skills to convey categorical ideas to other mathematicians. Sammy's efforts succeeded for the language of category theory, and he never abandoned his efforts for the theory itself. He was confident that the categorical view would eventually be the standard mathematical view, with or without his salesmanship. Its inevitability would be based not on Sammy's skills as a dealer but on the theorems whose proofs required category theory. That was obvious to Sammy. He wanted to make it obvious to everyone else.

**Hyman Bass**

Sammy visited the University of Chicago for a topology meeting while he was department chair at Columbia. I was then a graduate student, working with Irving Kaplansky on topics in homological algebra. So I was already familiar with some of Sammy's work when I first met him and we discussed mathematics. Homological algebra was insinuating itself into commutative algebra and algebraic geometry through the pioneering work of Maurice Auslander and David Buchsbaum (Sammy's student) and J.-P. Serre. Kaplansky was introducing many of my cohorts to this work.

When I graduated in 1959, in a now distant time of affluent mathematical opportunity, I contemplated a year at the Institute for Advanced Study. But Sammy, while I accompanied him to an art dealer in downtown Chicago (an errand whose significance I only later appreciated), persuaded me that it would be better first to launch my professional career as a regular faculty member, doing both research and teaching. That might now seem a difficult case to make, but it fit with my own disposition, and, in any case, Sammy had a charismatic charm and warm humor that were hard to resist.

Sammy’s mentoring made me virtually his student. Columbia's was a small and intimate department, with such figures as Harish-Chandra, Serge Lang, Paul Smith, Ellis Kolchin, Dick Kadison, Edgar Lorch, Masatake Kuranishi, Lipman Bers, Joan Birman, and, briefly, Heisuke Hironaka, Steve Smale, Wilfried Schmid, and many others. The department featured some strong personalities, but Sammy, along with Lipman Bers when he arrived somewhat later, set the tone and style of the department. Research in topology, algebraic geometry, complex analysis, number theory, and the then budding category theory were quite active there. Though a faculty member, I functioned much like a student, learning about both mathematics and the intellectual culture of our discipline.

Over the years my appreciation deepened for the way Sammy worked and thought about mathematics. Though quite accomplished at computa-

---

*Hyman Bass is professor of mathematics at Columbia University. His e-mail address is hb@math.columbia.edu.*
tion and geometric reasoning, Sammy was preeminently a formalist. He fit squarely into the tradition of Hilbert, E. Artin, E. Noether, and Bourbaki; he was a champion of the axiomatic unification that so dominated the early postwar mathematics. His philosophy was that the aims of mathematics are to find and articulate with clarity and economy the underlying principles that govern mathematical phenomena. Complexity and opaqueness were, for him, signs of insufficient understanding. He sought not just theorems, but ways to make the truth transparent, natural, inevitable for the “right thinking” person. It was this “right thinking”, not just facts, that Sammy tried to teach and that, in many domains, he succeeded in teaching to a whole generation of mathematicians.

In some ways Sammy seemed to have a sense of the structure of mathematical thinking that almost transcended specific subject matter. I remember the uncanny sensation of this on more than one occasion when sitting next to him in department colloquia. The speaker was exposing a topic with which I knew that Sammy was not particularly familiar. Yet a half to two thirds of the way through the lecture, Sammy would accurately begin to tell me the kinds of things the speaker was going to say next.

Though his mathematical ideas may seem to have a kind of crystalline austerity, Sammy was a warm, robust, and very animated human being. For him mathematics was a social activity, whence his many collaborations. He liked to do mathematics on his feet, often prancing while he explained his thoughts. When something connected, one could read it in his impish smile and the sparkle in his eyes.

He was engaged with the world in many ways, a sophisticated and wise man who took a refined pleasure in life. His was a most satisfying and inspiring influence on my own professional life. After his stroke, it was painful to see Sammy, frail and gaunt and deprived of speech when his still active mind had so much yet to say. Yet he bravely showed the same good humor and dignity that marked his whole life. He leaves us with much to treasure, even while we miss him.

References

---

**Some Ph.D. Students of Samuel Eilenberg**

Kuo-Tsai Chen (1950)
Alex Heller (1950)
David Buchsbaum (1954)
Ramaiyengar Sridharan (1954)
Kalathoor Varadarajan (1954)
F. William Lawvere (1963)
Harry Applegate (1965)
Estelle Goldberg (1965)
Myles Tierney (1965)
George A. Hutchinson (1967)
Jonathan M. Beck (1967)
Stephen C. Johnson (1968)
Albert Feuer (1974)
Chang-San Wu (1974)
Martin Columbic (1975)
Alan Littleford (1979)
Interviewing for a Job in Academia

Thomas Hull, Michael A. Jones, and Diana M. Thomas

All three of us have been on the job market repeatedly over the last few years searching for positions at schools which emphasize teaching. We put extensive time and effort into our job searches, and our preparation led to on-campus interviews and job offers. The experience and insights obtained in our job searches may help other candidates on the market.

In our opinion, the AMS Employment Register is a valuable tool for making contacts that can lead to on-campus interviews. We provide suggestions on how to make the most out of your interviews at the Joint Meetings and at prospective schools. To understand our backgrounds, we begin with a short biographical section that contains details on our job qualifications and requirements.

Biographical Information

THOMAS HULL, Ph.D. (Graph Theory), University of Rhode Island, 1997. When I started graduate school, I heard about the tough academic job market. I was determined to learn as much about the job application process as possible while still in graduate school. I attended many conferences, learned to network, updated my vita regularly, and received plenty of good advice. Preparing for the job market was as much a part of my daily graduate student career as teaching and performing research.

My efforts paid off: I had 14 interviews at the Winter Meetings in 1997 (either through the Employment Register or on the side), went on 5 on-campus interviews, and received 2 job offers. I accepted a tenure-track assistant professorship at Merrimack College. During my first year at Merrimack, I served on a search committee; my duties included interviewing candidates at the Winter Meetings in Baltimore.

MICHAEL A. JONES, Ph.D. (Game Theory), Northwestern University, 1994. Applying for jobs is just like any other activity: practice makes perfect. I have had plenty of practice over the last five years. My first post-Ph.D. position was a three-year position at the U.S. Military Academy at West Point. Although I tested the academic job waters while at West Point, I completed my three-year position and took a one-year visiting position at Loyola University, Chicago. I applied to approximately 80 positions with no restrictions to geographical area. After being on the market four out of the last five years, I was starting to feel pretty confident about the application process, yet my lack of success in previous years had left me nervous about actually receiving an offer. All of the experience finally paid off: I had 17 interviews at the Winter Meetings in Baltimore, went on 4 on-campus interviews, and received 1 job offer. In fall 1998 I began a tenure-track position at Montclair State University of New Jersey.

DIANA M. THOMAS, Ph.D. (Dynamical Systems), Georgia Tech, 1996. My first post-Ph.D. job was a three-year position at the U.S. Military Academy at West Point. When I went on the market again, I restricted my search to the New York City metropolitan area. Since my job search was selective, I
decided to send out only 30 applications tailored to each school. I let prospective schools know that I had colleagues in the area that I collaborated with and that I attended seminars at other local schools. I felt that this showed the schools that I was already very active in this geographical location. I also made an effort to try to meet people from the schools at conferences and seminars. In my opinion, such a detailed and focused approach creates an advantage in a selective job search. My results were 6 interviews at the Winter Meetings, 7 on-campus interviews, and 3 job offers. Four of the schools from the Joint Meetings invited me for an on-campus interview. I accepted a position for a tenure-track assistant professor at New Jersey City University, which I began in fall 1998.

The Employment Register

By now you probably have some preconceived notions about the Employment Register (ER). For those who are unfamiliar with the ER, 15-minute interviews are conducted every 20 minutes in a large room where interviewers from schools sit at numbered tables. Some candidates are disappointed with their interviews and/or with the number of interviews received through the matching program. However, taking the ER seriously helped us make job contacts that led to on-campus interviews and job offers. Here are some pointers on how to make the most out of your ER interviews and other contacts you have with prospective schools at the Joint Math Meetings.

- **Attend the Joint Meetings at least once before you are on the market.**

  **TH:** By attending the Joint Meetings, you can see how the ER and Interview Center work; this should make you more comfortable and confident when you are on the market.

  **DT:** Remember to talk to the graduate students who are ahead of you and participating in the ER; ask them questions about their interview experiences.

- **Contact schools before the meetings.**

  **MJ:** Apply for jobs as early as possible so that employers receive your application materials before the end of the fall semester. Also, you may want to e-mail schools that are going to be at the Meetings (determine this from the ER List of Employers) to let them know that you are interested in meeting with them.

  **TH:** Many schools do interviews outside of the ER. They e-mail their candidates beforehand and schedule interviews on their own. These interviews are usually longer and can be more valuable. Do not worry that these outside interviews may conflict with interviews you might get through the ER, as you will be able to reschedule any conflicts.

- **Sign up for the ER List of Candidates.**

  **MJ:** Even if you are not attending the Meetings, by submitting a shortened vita to the ER List of Candidates, a possible employer may see your information and contact you.

- **Stay at one of the central hotels.**

  **MJ:** In between interviews, I found it helpful to retreat to the serenity of my hotel room to prepare for the next interview. Staying at one of the main hotels means that you do not have to travel as far to get to your room.

- **Take the interview seriously.**

  **MJ:** The interview is an opportunity for you to put a face with your name, to make a good impression, and to demonstrate your ability to communicate.

  **TH:** Having a personality associated with your résumé makes a big difference. Even a 15-minute interview can be enough for a search committee to remember you and make your résumé stand out when they are back home flipping through several hundred applications.

- **Bring copies of your application materials.**

  **MJ:** Even if you have applied to a position previously, offer the interviewers copies of your application materials. Since schools typically have two interviewers, providing an additional copy means that both interviewers can look over your materials.

- **Bring a teaching portfolio.**

  **DT:** If an interviewer was tired or could not think of questions to ask me, I brought out my teaching material. Cranell [2] provides suggestions about what a teaching portfolio could contain.

- **Research the school before the interview. Do not use the interview as a get-to-know the school chat.**

  **MJ:** Although the ER provides college guides, consider bringing your own; these guides provide brief descriptions of the schools and useful data (e.g., SAT scores, class size, library funding, etc.).

  **DT:** I used the computer facilities at the meetings to examine schools’ Web sites. I noted the professors who have research interests that matched mine and kept track of special programs, software usage, etc.

- **Contact schools through the message boards and message boxes.**

  **DT:** I did not get matched to interview with some of the schools in which I was really interested. I left notes in their boxes at the ER. One school was able to squeeze me into their schedule, and our meeting led to an on-campus interview.

  **MJ:** When contacting a school, provide a copy of your vita and give explicit reasons why they
should see you and why you are serious about their position. Interviewers are extremely busy at the meetings; do not waste their time unless you fit their position.

- Give a talk at the meeting.

TH: Send in an abstract for a general 10-minute talk, preferably on your dissertation research. Schools that are interested in you will come to your talk, providing you with another chance to make an impression. Keep the talk clear and fun, especially if you are trying to attract liberal arts schools.

MJ: Let your interviewers know when and where you will be speaking.

- Give your interviewers an opportunity to get to know you better.

DT: I told interviewers about a senior thesis student who was presenting a poster in a student session. The schools had an opportunity to talk firsthand about my in-class performance with one of my students.

MJ: If your letter writers are at the meetings, ask them if you can refer interviewers to them to talk about your background and abilities.

- Dress well.

TH: It is better to err on the side of overdressing. Go with whatever makes you feel comfortable, but look nice. Try to dress professionally.

- Be happy!

TH: The interviewers are tired, perhaps talking with thirty candidates in one day. They have as much desire as you do to make this process easier. Try to put yourself in their shoes. They want to meet someone happy and fun. Take a minute to chat about the talk you just saw. Make them think that talking with you is a pleasure, not a chore, and they will remember you.

- Take notes.

TH: If you are successful, you will be interviewing with many different schools and meeting many different people. Keep a notebook and scribble down impressions after each interview.

MJ: I prepared a standard form which I used for all of my interviews. Before the interview I filled in as much of the form as possible. Filling in the gaps provided me with questions to ask the interviewers. For each school I made a list of items that I wanted to mention.

- Send “thank you” notes after the meeting.

TH: Keep the notes short (e-mail is fine), but let them know that you appreciated their time and you are interested in their position.

**Typical Interview Questions**

You will be asked many questions. Because your time will be limited, you should have answers prepared ahead of time. Practice answering the following questions with your adviser or fellow job seekers.

- **Tell us about your dissertation.**

  Give a 2-3 sentence response understandable by a mathematician in any field. If requested, go into further detail.

- **What kinds of courses do you want to teach?**

  Be specific and honest. Remember, you may end up working there and having to teach the courses you claimed you wanted to teach.

- **How would you approach teaching basic-level math courses?**

  Realize that many math departments service other departments. Teaching lower-level courses well is important for their livelihood. Even if you do not have experience teaching, prepare yourself for these types of questions.

- **What do you think of calculus reform and/or teaching technology (e.g., graphing calculators)?**

  Do not come across as too opinionated. The safe thing to do is say that there are good points to calculus reform, but there are problems too. Stress your experiences with calculus reform and technology usage in the classroom.

- **How would you describe your teaching style?**

  This is a tough question that you need to prepare well. Looking through your student evaluations may help you develop an answer. You could also ask a colleague to sit in on your class and provide you with information on your teaching style.

- **What distinguishes your teaching from that of your peers?**

  Try to come up with something original that will stick in their minds.

- **What type of salary are you looking for?**

  Even though this question may seem unfair, be prepared to deal with it.

- **What are your research plans beyond your dissertation?**

  Be clear on what your research plans are. You are not expected to have a crystal ball and know what you will work on in the future. But interviewers want to be reassured that you have ideas beyond your dissertation that you can work on after you leave graduate school.

- **What do you see yourself doing in the next five years?**
Be honest with these questions. If you have a specific research plan, outline it briefly. If you would rather spend your time focusing on teaching, say so. There are schools out there that are looking for both of these answers, so do not be afraid to be honest and true to yourself.

**On-Campus Interviews**

Most on-campus interviews follow a script that reads something like: fly in, go on a campus tour, meet the faculty and administration, give a talk, and return home. Realize that different schools have different methods of searching for and ranking a candidate. Typically, a search committee decides on which top three or four applicants to interview; they also rank their top candidates before the interview. From personal conversations it seems that the rankings did not change after the interviews were conducted. This may seem surprising at first, but rank is typically determined by substantial criteria like publication record, teaching experience, field of expertise, letters of recommendation, etc. Most likely your publication list or teaching experience will not change drastically from the time you send in your application to the time you interview at the school. Here are some suggestions that may help in the interview process.

- **Know your audience.**

  MJ: Some schools will require a talk at the undergraduate level, while others want a more high-powered talk. Make sure you are informed at what level to pitch the talk.

- **Prepare multiple versions of your talk.**

  DT: Typically, schools will ask you to prepare a talk aimed at an advanced undergraduate mathematics major. Since the job talk is the one time most of the faculty are able to see you in action, you also want to show you do solid and interesting research. It is difficult to determine how to strike a balance. I eventually had three versions of my talk prepared (nontechnical, advanced undergraduate, and technical). Job talks are usually given in the afternoon, so after spending the day with the faculty I got a feel for which version of the talk to present. You could also ask the school in advance if you can give two half-hour talks instead of one hour-long talk. The first talk would be geared toward students, while the second talk would be for faculty.

- **Bring and leave a portfolio with all of your accomplishments.**

  DT: Individual committee members may be looking for specific information. Your portfolio provides information that the faculty want to know and did not have time to ask you during your interview. Make sure it is well organized and tabbed so your interviewers can quickly find relevant information. My portfolio contained: (1) AMS Cover Sheet and vita; (2) classroom exercises, handouts, and projects/samples of student work; (3) completed research papers; (4) papers in progress; (5) grants received; (6) student evaluations. Leave the portfolio behind for faculty who were unable to make your acquaintance.

  MJ: It is also a good idea to keep this portfolio up-to-date for departmental reviews and to help organize your materials for tenure.

- **When teaching a course, do not do anything fancy.**

  DT: I was asked to teach a class for one interview. I had the students break into groups. The students did not have time to warm up to me and did not feel comfortable interacting with me. Teaching a class on an interview is almost like teaching on the first day of class, only with faculty watching. If you are required to do this for your interview, give a well-prepared clear lecture with periodic questions thrown at the class.

- **Be yourself.**

  DT: Do not try to be every member’s ideal candidate. Most faculty have probably looked at many applications and served on search committees for previous job searches. They will know if you are trying too hard to tailor yourself for their position.

  TH: I know of one job seeker who openly told schools that she did not want to do any research after her dissertation. And what do you know? At one of the schools she interviewed with, this was exactly what they wanted to hear. You help everyone, including yourself, by being honest.

- **Ask for feedback.**

  DT: If you do not receive an offer from a school, contact them and ask for feedback on your interview. They may be able to provide insights on the search process and how you came across. You can use the information to determine how to improve your interview better next time.

**Questions to Ask the Search Committee**

While on an interview you will have many opportunities to ask questions. We suggest that you come prepared with a list of questions, because you may forget to ask a particular question if you are nervous or anxious about the interview. Moreover, good questions will help engage faculty members in discussion and reflect well on your personality. Ask questions to help determine if you would be happy and successful at the institution. Below are a few questions to get you started, which we have divided into different categories.

*Life Issues*

- Can you provide specific information about the health insurance and retirement packages?
• Is there affordable housing in the area? Where do the other faculty live?
• What types of childcare facilities are available, and where do faculty send their children to school?
• Would my children be able to attend the college for free or for reduced tuition?

Teaching Environment
• Typically, how many contact hours and separate preparations will I have per term?
• Are there course reductions for junior faculty and for faculty to pursue research?
• What kind of computer facilities are available for the students? How, if ever, is technology used in the classroom? Does this include access to a network with standard mathematical software packages?
• Will I be able to teach a variety of courses ranging in levels?
• Is summer teaching available? expected?
• Is there an undergraduate colloquium series? Is there an undergraduate math club and/or chapter of Pi Mu Epsilon?

Research Environment
• Are there start-up funds available for your research? What computer equipment do individual faculty members receive?
• Are there opportunities for a research-based leave or early sabbatical (before tenure)?
• Does the library have CD-ROM abstracts like Mathematical Reviews, an online subscription to MathSciNet, or subscription to document retrieval services? How is the library at getting interlibrary loan materials? Will I have input in future acquisitions to the collection?
• Is there a department colloquium or seminar series?
• Is there travel money to attend and/or present at conferences?
• Are there funds for undergraduate research?

Service Responsibilities
• Will I be responsible for advising students? And if so, how many students?
• How are the committee assignments made? Will I have an opportunity to serve on campuswide as well as departmental committees?
• Are the service requirements less for junior faculty?

Assessment of Performance
• How is teaching evaluated for tenure and promotion?
• What are the research expectations to receive tenure?
• Is there a yearly review? Is there a three-year review?

• How many people have come up for tenure in the past ten years? How many have received tenure?

Conclusion
Our best advice is to prepare well for your interview. Unfortunately, you will encounter situations that will take you by surprise. Minimize this by talking to young faculty and fellow graduate students about their experiences. Further, consult Web pages, like the Young Mathematicians Network [4] or the AMS Web site [1], to glean tips from the advice of job market veterans.

There is no set formula for a successful job search. There is an infinite number of factors that come into play when a department hires a new faculty member, and many will have nothing to do with you! But the interview is an aspect that you can partially control to prove that you will be a cherished addition to their department. Do not let the things that are in your control work against you. An ounce of preparation is worth a ton of good impressions.

Acknowledgments
The authors would like to thank Neil Calkin and an anonymous referee for their helpful comments and suggestions.

References
Borcherds, Gowers, Kontsevich, and McMullen Receive Fields Medals

On August 18, 1998, four Fields Medals were presented at the Opening Ceremonies of the International Congress of Mathematicians (ICM) in Berlin. The four medalists are: Richard E. Borcherds, William Timothy Gowers, Maxim Kontsevich, and Curtis T. McMullen.

At the 1924 Congress in Toronto a resolution was adopted that at each ICM two gold medals should be awarded to recognize outstanding mathematical achievement. J. D. Fields, a Canadian mathematician who was secretary of the 1924 Congress, later donated funds establishing the medals, which were named in his honor. Consistent with Fields's wish that the awards recognize both existing work and the promise of future achievement, the medals are awarded to young mathematicians, where "young" has traditionally been interpreted to mean no more than forty years of age in the year of the Congress. In 1966 it was agreed that, in light of the great expansion of mathematical research, up to four medals could be awarded at each ICM. Today the Fields Medal is widely recognized as the world's highest honor in mathematics.


The committee choosing the 1998 Fields Medalists consisted of: John Ball (Oxford University), John Coates (Cambridge University), J. J. Duistermaat (University of Utrecht), Michael H. Freedman (Microsoft Research), Jürg Fröhlich (Eidgenössische Technische Hochschule, Zürich), Robert MacPherson (Institute for Advanced Study, Princeton), Yuri Manin (chair, Max-Planck-Institut für Mathematik, Bonn), Kyoji Saito (University of Kyoto), and Stephen Smale (City University of Hong Kong).

Richard Borcherds

Richard Borcherds was born on November 29, 1959, in Cape Town, South Africa. He received his undergraduate and doctoral degrees from the University of Cambridge. He has held various positions at Cambridge and at the University of California, Berkeley. Currently he is on leave from Berkeley and is a Royal Society Research Professor at Cambridge. In 1992 he received a European Mathematical Society Prize at the First European Congress of Mathematicians in Paris. He was an invited speaker at the ICM in Zürich in 1994.

As a student of John H. Conway, Borcherds began his research career in finite group theory. He has distinguished himself not only by utilizing techniques and ideas from outside of finite group theory but also by producing results that have had an impact in other areas. In the classification of fi-
finite simple groups, one of the most mysterious objects found was the monster group. There are various conjectures that attempt to connect the monster to other parts of mathematics. Borcherds invented the notion of a vertex algebra and used it to solve the Conway-Norton conjecture, which concerns the representation theory of the monster group (this theory is sometimes called "monstrous moonshine"). He used these results to generate product formulae for certain modular and automorphic forms. The first such formulae were found in the one-dimensional case by Euler and Jacobi, and the conventional wisdom in algebraic geometry was that such product formulae could not exist in higher dimensions. Borcherds's work is also important in physics, as it lays rigorous groundwork for conformal field theory in two dimensions.

William Timothy Gowers
William Timothy Gowers was born on November 20, 1963, in Marlborough, England. He received his undergraduate and doctoral degrees from the University of Cambridge, where he was a student of Belá Bollobás. Gowers was a Research Fellow at Trinity College, Cambridge, before spending four years at University College, London. He was then appointed as a Lecturer at Cambridge and a Fellow of Trinity College. Currently he holds the Rouse Ball Chair of Mathematics at Cambridge. He was an Invited Speaker at the ICM in Zürich in 1994. In 1996 he received a European Mathematical Society Prize at the Second European Congress of Mathematics in Budapest.

Gowers works in the areas of Banach space theory and combinatorics. His main achievements are his solutions to a number of famous problems first stated in the 1930s by Stefan Banach. Gowers and B. Maurey exhibited in 1991 a Banach space having the property that none of its infinite-dimensional subspaces has an unconditional basis. An unconditional basis provides a useful coordinatization of the space, guaranteeing many "symmetries" (automorphisms).

Gowers also produced an example of a Banach space that is not isomorphic to any of its hyperplanes, thereby solving the famous Banach hyperspace problem. He proved a "dichotomy theorem", which says that every Banach space has either a subspace that has an unconditional basis, and therefore many symmetries, or is such that all of its subspaces have only trivial symmetries. This work solves in the affirmative the homogeneous space problem, one of the central problems in Banach space theory, which asks whether a homogeneous Banach space is a Hilbert space. A hallmark of Gowers's work is the way in which it combines techniques of analysis with combinatorial arguments. His work in combinatorics and combinatorial number theory includes results about Szeméredi's lemma and an improved proof of Szeméredi's theorem on arithmetic progressions.

Maxim Kontsevich
Maxim Kontsevich was born on August 25, 1964, in Moscow. He received his doctoral degree from the University of Bonn, under the direction of Don B. Zagier. After holding a professorship at
the University of California, Berkeley, he moved to his present position as professor at the Institut des Hautes Études Scientifiques in Bûres-sûr-Yvette, France. In 1992 Kontsevich received a European Mathematical Society Prize at the First European Congress of Mathematics in Paris. He was a Plenary Speaker at the ICM in 1994 in Zürich.

Kontsevich first received international attention for his doctoral thesis, in which he proved a conjecture of Edward Witten. This conjecture says that the generating function for intersection numbers on the moduli spaces of algebraic curves satisfies the Korteweg-de Vries equation. Also drawing on ideas of Witten, Kontsevich produced a vast generalization of the Gauss linking number for knots. He then used this generalization and a new notion of "graph cohomology" to generate Vassiliev knot invariants as well as invariants for three-manifolds. Kontsevich produced the first mathematical definition of the "number" of rational curves on Calabi-Yau manifolds, such as three-dimensional quintics, and gave an explicit formula for this number. This work was crucial for later work in the area of mirror symmetry. Most recently Kontsevich has established that any Poisson manifold admits a formal quantization and has provided an explicit formula for the flat case.

Curtis T. McMullen

Curtis T. McMullen was born on May 21, 1958, in Berkeley, California. He received his undergraduate degree in 1980 from Williams College and his doctoral degree in 1985 from Harvard University. His thesis advisor was Dennis Sullivan. McMullen has held positions at the Massachusetts Institute of Technology, the Mathematical Sciences Research Institute, the Institute for Advanced Study, Princeton University, and the University of California, Berkeley. At present he is a professor of mathematics at Harvard. In 1991 he received the Salem Prize.

McMullen has produced important results in several areas of mathematics, including the theory of computation, dynamical systems, and three-manifolds. In his doctoral thesis he used dynamical systems techniques to solve completely the question of whether there exist generally convergent algorithms for finding the zeros of polynomials of degree three or greater. Newton’s method converges for almost all quadratic polynomials and almost all initial points. McMullen exhibited an analogous algorithm for degree three polynomials and proved that no such algorithm exists for degree four and higher. He has also made important strides toward solving one of the central conjectures in one-dimensional dynamics: Are the hyperbolic maps of degree $d$ dense in all maps of degree $d$? McMullen proved that, given $P_c : \mathbb{C} \to \mathbb{C}$, $P_c = z^2 + c$, if $c$ is in a connected component of the Mandelbrot set that intersects the real axis, then $P_c$ is hyperbolic. He also brought new ideas and insights from dynamical systems to the geometrization program for three-manifolds formulated by 1982 Fields Medalist William Thurston. McMullen has also worked with Sullivan on a "dictionary" between the theory of iterations of rational maps of the Riemann sphere and that of Kleinian groups.

—Allyn Jackson

Wiles Receives Special Award

At the ICM Opening Ceremonies, Andrew J. Wiles of Princeton University received a one-time Special Tribute from the International Mathematical Union in recognition of his work that led to the proof of Fermat’s Last Theorem. Because he is over forty years old, Wiles was not considered eligible for a Fields Medal. Instead of a gold medal he received the "IMU Silver Plaque", or, as number theorist Don B. Zagier called it, a "Quantized Fields Medal". Wiles’s award also differed from the Fields Medals in that no lecture was presented about his work. Instead, the next day Wiles himself gave a special lecture entitled "Twenty Years of Number Theory".

In 1993 Wiles announced that he had proved Fermat’s Last Theorem. The ground-breaking research he did in order to produce the proof seemed likely to secure him a Fields Medal at the ICM in Zürich in 1994 until a gap appeared in the proof. The gap was not repaired until after the Zürich Congress. With the proof complete, the general consensus was that Wiles had done work of Fields Medal quality. This view was reinforced by the 3,000 people assembled for the ICM Opening Ceremonies, who gave Wiles a thundering round of applause longer than that given to any of the other awardees.

—A. J.
Peter Shor Receives Nevanlinna Prize


The University of Helsinki granted funds to award the Nevanlinna Prize, which honors the work of a young mathematician (less than forty years of age) in the mathematical aspects of information science. The prize is presented every four years in conjunction with the Congress. Previous recipients of the Nevanlinna Prize are Robert Tarjan (1982), Leslie Valiant (1986), Alexander Razborov (1990), and Avi Widgerson (1994).

The committee choosing the 1998 Nevanlinna Prize recipient consisted of Bjorn Engquist (University of California, Los Angeles), Tom Leighton (Massachusetts Institute of Technology), David Mumford (Brown University, chair), and Alexander Razborov (Steklov Mathematical Institute, Moscow).

Peter Shor was born on August 14, 1959. He received his undergraduate degree from the California Institute of Technology and his doctoral degree from the Massachusetts Institute of Technology. Before going to AT&T in 1986 he held a postdoctoral position at the Mathematical Sciences Research Institute in Berkeley.

All present-day computers are based on the laws of classical physics. In the 1980s Paul Benioff, David Deutsch, and Richard Feynman suggested that one could build a far more powerful computer by exploiting principles of quantum mechanics. In 1994 Shor gave the first example of an explicit algorithm by which a quantum computer could solve efficiently (i.e., in polynomial time) a natural problem that seems hard to solve on a classical computer. He developed a quantum algorithm for factorizing integers; no analogous algorithm is known to exist for traditional computers.

Earlier work on algorithms for solving problems on quantum computers dealt with more contrived problems and did not supply such complete results as did Shor's. His work caused great excitement among scientists and mathematicians and also drew wider attention because many cryptosystems are based on the difficulty of factoring numbers on conventional computers. Shor has also done work on quantum error-correcting codes and fault-tolerant quantum computation that addresses some of the main obstructions to making quantum computers a reality. Before his work in quantum computing he produced a number of important results in graph theory and combinatorics.

—Allyn Jackson
CD-ROMs Available from the AMS

These electronic resources from the AMS offer speedy access to valuable information. The extensive data included on each disk will be at your fingertips, as soon as you need it! Any or all of these CD-ROMs make a welcome and useful addition to current mathematical reference resources.

The Mathematician's CD: A Collection of Resources from the AMS

The Mathematician's CD: A Collection of Resources from the AMS brings together a variety of items that have proven useful to the mathematical community. Educators, researchers, students, and librarians now have immediate access to a compilation of valuable information in a convenient CD-ROM format, compatible with Macintosh®, Windows®, and UNIX®. In addition, The Mathematician's CD provides access to up-to-date information with live links to e-MATH, the AMS Web site, and other Web sites.

Contents:
-ams macro and fonts
- Find author and reviewers
- Searchable reference documents
- 1997 AMS catalog
- AMS journals
- Career services
- Software samples
- About the AMS
  * Macintosh is a registered trademark of Apple Computer, Inc.
  * UNIX is a registered trademark of the American National Standards Institute.
  * Windows is a registered trademark of Microsoft Corporation.

The MathResource™ Interactive Math Dictionary

Created by: Jonathan Borwein, Simon Fraser University, Burnaby, BC, Canada; Carolynn Watters, Acadia University, Wolfville, NS, Canada; and Ephraim Borowski, University of Glasgow, Scotland

Published by MathResources, Inc., Halifax, NS, Canada

I really like the interactive math dictionary! I have let some of my students use it for project work to try and get feedback from them. I have had only positive results. The most common response from the students seems to be "Wow!" I mentioned that this software is available and probably would be a good idea that students entering Science/Math/Engineering at University have access to it.

I will also mention the software at teachers conferences etc... every Mathematics Department should have a copy available for the staff and students. A great reference/investigative tool.

-Paul Holder, Mathematics Department Head, St. John High School, New Brunswick, Canada

Finally, coursework I can order for my students with no learning curve. The MathResource puts significant interactive math at their fingertips in 5 minutes.

-Dr. Charles Edmunds, Mathematics Department, Mount St. Vincent University

This math visualizing program was designed by mathematics teachers for mathematics teachers and their students and covers a comprehensive list of topics—from algebra to optimization theory.

The MathResource Interactive Math Dictionary is an interactive database of mathematical topics that combines the attributes of a dictionary with the functionality of a CD-ROM. This powerful tool can work equally well for classroom display or for studying. Each topic has its own guide for quick and easy access to the database. The 4,500 entries include the mathematical examples that can be explored with sample data or by inputting your own. Computation, plotting, and graphing are powered by the Maple™ computer algebra system (run-time version included on disk). The CD-ROM operates within Windows® 3.1 and Windows® 95.

Distributed worldwide by the American Mathematical Society.

Maple is a registered trademark of Waterloo Maple Inc.

The MathResource is a registered trademark of MathResources Inc.

Windows is a registered trademark of Microsoft Corporation.

1996; List $95; All AMS members $85; Order code MRMDNA

Selections from MSRI's Video Archive, Volume I

Published by MSRI, Berkeley, CA


The CD requires RealVideo Player, which can be downloaded for free from the RealNetworks Internet home page. RealVideo Player is available for Windows®95/Windows NT, Windows® 3.1, Macintosh®/MacOS®/MacOS® 8.6/9.1, Solaris® 2.5 and Linux® 2.0.

Distributed worldwide by the American Mathematical Society.

RealVideo is a registered trademark and RealNetworks is a trademark of RealNetworks, Inc.

1998; CD-ROM; List $15; Order code MSRICD1NA

1997 MathSci Disc for Individuals

Now, you can purchase your own MathSci® Disc—at a very special price—thanks to cooperative efforts between the American Mathematical Society and SilverPlatter® Information. MathSci Disc for Individuals: 1988–1997 is available exclusively to individuals affiliated with an institution that currently subscribes to MathSci Disc or any MathSci product from SilverPlatter.

With this specially priced version available from the AMS you won't have to compete for system time at your subscribing institution.

MathSci Disc for Individuals: 1988–1997 is the same current disc to which your institution now subscribes with complete records for Mathematical Reviews covering the years noted.

With your personal copy of MathSci Disc, you can do research on your time, in your own office or home computer. Everything you need is included with MathSci Disc, including the popular SPIRS search software from SilverPlatter and a quick reference card to get you up and running immediately.

MathSci Disc for Individuals: 1988–1997 is for personal use only and may not be transferred to other persons or institutions. Mid-year updates are not available with this special version, nor can SilverPlatter provide technical support for this particular product.

MathSci is a registered trademark of the American Mathematical Society

SilverPlatter is a registered trademark of SilverPlatter International N.V.

1998; ISBN 0-8218-1049-9; List $150; Individual member $100; Order code CD87/NA

All prices subject to change. Charges for delivery are $3.00 per order. For air or air delivery outside of the continental U.S., please include $5.50 per item. Prepayment required. Order from: American Mathematical Society, P.O. Box 6649, Providence, RI 02940-4049, USA. For credit card orders, call 1-401-455-4046 or call toll free 1-800-321-AMS (4267) in the U.S. and Canada. 1-800-455-4000 worldwide or place your order through the AMS bookstore at www.ams.org/bookstore. Residents of Canada, please include 7% GST.
SIAM Awards Pólya Prize

The George Pólya Prize for 1998 was awarded by the Society for Industrial and Applied Mathematics at its annual meeting in July to Percy Deift of New York University-Courant Institute, Xin Zhou of Duke University, and Peter Sarnak of Princeton University.

The Pólya Prize is awarded every two years for notable contributions in an area of mathematics that was of interest to George Pólya. The prize is awarded alternately for a notable application of combinatorial theory or for a contribution in any of the following areas: approximation theory, complex analysis, number theory, orthogonal polynomials, probability theory, or mathematical discovery and learning. The prize is intended to recognize specific recent work. The prize carries a total cash award of $20,000, which is divided equally among the recipients.

—From a SIAM announcement

MAA Writing Awards Presented

The Mathematical Association of America (MAA) presented several awards for excellence in expository writing at its Summer Mathfest in Toronto in July 1998.

The Carl B. Allendoerfer Awards are given for articles published in Mathematics Magazine; they carry a cash award of $500. The 1998 award went to Dan Kalman of American University, Robert Mena of California State University, Long Beach, and Shahriar Shahriari of Pomona College for their joint article “Variations on an irrational theme—geometry, dynamics, algebra”, Mathematics Magazine, April 1997.

The Trevor Evans Award is given to authors of exceptional articles that are accessible to undergraduates and that were published in Math Horizons. The prize carries a cash award of $250. Two awards were given this year: to Tom M. Apostol of the California Institute of Technology for his article “What is the most surprising result in mathematics? (Part II)”, Math Horizons, February 1997; and to Martin Gardner of Hendersonville, North Carolina, for his article “The square root of two = 1.41421 35623 73095...”, Math Horizons, April 1997.

The George Pólya Award is given for articles published in The College Mathematics Journal and has a cash prize of $500. This year three recipients were chosen. Kevin G. Kirby of Northern Kentucky University was selected for his article “Of memories, neurons, and rank-one corrections”, The College Mathematics Journal, January 1997. Aimee Johnson of Swarthmore College and Kathleen Madden of Drew University were honored for their article "Putting the pieces together: Understanding Robinson's nonperiodic tilings", The College Mathematics Journal, May 1997.

The Chauvenet Prize carries a cash award of $1,000 and is given to a member of the MAA for an outstanding expository article on a mathematical topic. The recipients of the 1998 Chauvenet Prize are Alan Edelman of the Massachusetts Institute of Technology and Eric Kostlan for the article “How many zeros of a random polynomial are real?”, published in the Bulletin of the American Mathematical Society (N.S.) 32 (1995).

"Elaine Kehoe

London Mathematical Society Prizes Awarded

The London Mathematical Society has announced the awarding of several prizes for 1998.

The De Morgan Medal for outstanding contributions to mathematics has been awarded to Robert A. Rankin of Glasgow University, for his major contributions to the theory of numbers and in particular to the theory of modular forms. His achievements include new estimates of the differences between consecutive prime numbers, results on the distribution of zeros of Poincaré series, and work on cusp forms and the number of representations of an integer by the sum of eight or more squares. His work on the theory of the Ramanujan tau function and similar arithmetical functions gave birth to the method now usually known as the Rankin-Selberg method. The immediate application of his method was a nontrivial estimate for the coefficients of modular forms, which was used by Deligne and Serre in their work relating cusp forms to Artin L-functions. The spirit of this method influenced Deligne’s proof of the Weil conjectures.

The Senior Berwick Prize, given for an outstanding piece of mathematical research, was awarded to Brian Davies of King’s College, London, for his survey article “$L^p$ spectral theory of higher order elliptic operators”, published in the Bulletin of the London Mathematical Society. The article is representative of Davies’s contributions to the development of operator theory, his fundamental work on heat semigroups, and his more recent work on higher-order operators.

The Junior Whitehead Prizes are given annually to mathematicians under forty years of age. The 1998 awardees are Jonathan Chapman and Jan Nekovar (Cambridge University), and Igor Rivin (Warwick University). Chapman received the prize for his contributions to the mathematical theory of superconductivity and other areas of applied mathematics. He has developed new methodologies for high-precision asymptotics for differential and difference equations and a construction for isospectral drums with different rectilinear boundaries. Nekovar has used a wide range of tools from modern arithmetic algebraic geometry in his work on a number of important problems. His contributions include an extension of Kolyvagin’s method to higher weight modular forms, a theory of $p$-adic height pairings for very general Galois representations, and an analogue of the Gross-Zagier result. He is currently working on syntomic regulators, a project central to current developments in arithmetic algebraic geometry. Rivin’s award is for his work on hyperbolic geometry. His thesis gave a complete description of the possible dihedral angles of compact convex polyhedra in hyperbolic three-space. Subsequently he developed, with C. Hodgson, further techniques to understand the finite volume case. He has also studied the relation between ideal hyperbolic polyhedra and local Euclidean structures on triangulated surfaces and has solved many important nonlinear problems in hyperbolic geometry by transforming them into tractable linear ones.

“From an LMS announcement

USA Wins Medals at Mathematical Olympiad

A team of six American high school students won six medals at the 39th Annual International Mathematical Olympiad (IMO), held in Taipei, Taiwan, on July 15 and 16, 1998. Competing against teams from 76 countries, the USA finished in third place, behind Iran and Bulgaria. Each team member won either a gold or silver medal.

The winning team members were: Reid Barton (Arlington, Massachusetts, home schooled), gold medalist; Gabriel Carroll (Oakland Technical High School, Oakland, California), gold medalist; Kevin Lacker (Sycamore High School, Cincinnati, Ohio), silver medalist; Alexander Schwartz (Radnor High School, Radnor, Pennsylvania), gold medalist; Paul Valiant (Milton Academy, Milton, Massachusetts), silver medalist; and Melanie Wood (Park Tudor School, Indianapolis, Indiana), silver medalist. The team was chosen on the basis of the youngsters’ performance in the 27th USA Mathematical Olympiad held in May, and team members attended the Mathematical Olympiad Summer Program at the University of Nebraska-Lincoln. They were coached by Titu Andreescu (Illinois Mathematics and Science Academy) and were also accompanied by Elgin Johnston (Iowa State University) and Walter E. Mientka (University of Nebraska-Lincoln). The USA Mathematical Olympiad is a program of the American Mathematics Competitions. Financial and program support is provided by the Army Research Office, the Office of Naval Research, the Microsoft Corporation, Wolfram Research, Inc., the Matilda R. Wilson Fund, and the University of Nebraska-Lincoln.

“From an MAA announcement

Deaths

William A. Blankenship, of Pasadena, MD, died on June 4, 1998. Born on August 18, 1920, he was a member of the Society for 56 years.

Harold L. Dorwart, professor emeritus at Trinity College, Hartford, CT, died on July 28, 1998. Born on August 27, 1902, he was a member of the Society for 70 years.
DICKRAN H. ERKILETIAN, professor emeritus at the University of Missouri-Rolla, died in June 1997. Born on September 22, 1913, he was a member of the Society for 56 years.

SIEGFRIED K. GROSSER, of Vienna University, died in January 1998. Born on November 12, 1931, he was a member of the Society for 34 years.

I. HENSON HARRIS, of Mayfield, KY, died on March 15, 1998. Born on December 12, 1912, he was a member of the Society for 51 years.

ROBERT F. JACKSON, of Toledo, OH, died on July 30, 1997. Born on January 2, 1909, he was a member of the Society for 61 years.

HEWITT KENYON, professor emeritus at George Washington University, died on June 18, 1998. Born on August 31, 1920, he was a member of the Society for 48 years.

THOMAS H. KIRKPATRICK, of Sun City, AZ, died on May 12, 1998. Born on May 3, 1908, he was a member of the Society for 41 years.

HASELL T. LABORDE, of Macon, GA, died on July 16, 1998. Born on December 1, 1921, he was a member of the Society for 47 years.

WILLIAM N. REINHARDT, of the University of Colorado, died on June 22, 1998. Born on May 12, 1939, he was a member of the Society for 33 years.

IRVING SEGAL, of the Massachusetts Institute of Technology, died on August 31, 1998. Born on September 13, 1918, he was a member of the Society for 60 years.

Visiting Mathematicians

(Supplementary List)

Mathematicians visiting other institutions internationally during the 1998–99 academic years were listed in the following 1998 issues of the Notices: June/July, pp. 730-31; August, p. 885; September, p. 994; and October, p. 1177. The following is an update (home country is listed in parentheses).

SHENGWENG WANG (China), Central Michigan University, Operator Theory, 9/98-12/98.

Mathematics Opportunities

American Mathematical Society Centennial Fellowships

Invitation for Applications for Awards for 1999-2000

Deadline: December 1, 1998

The AMS Centennial Research Fellowship Program makes awards annually to outstanding mathematicians to help further their careers in research. Recently the AMS Council approved changes in the rules for the fellowships. From 1984-96, the fellowship program was aimed at midcareer mathematicians. The changes adopted three years ago redirected the fellowship program toward recent Ph.D.s. The eligibility rules are as follows.

Applicants must: (1) be citizens or permanent residents of a country in North America, (2) have held their doctoral degrees for at least two years at the time of the award, (3) not have permanent tenure, and (4) have held less than two years of research support at the time of the award. (Each year of a full-time teaching appointment with teaching load less than four [respectively, five] courses per year on the semester [respectively, quarter] system will count in this respect as one-half year of research support.) Recipients may not hold the Centennial Fellowship concurrently with other research fellowships (e.g., Sloan Foundation Fellowships or National Science Foundation Postdoctoral Fellowships), they may not use the stipend solely to reduce teaching at the home institution, and they are expected to spend some of the fellowship period at another institution that has a stimulating research environment suited to the candidate's research development.

The stipend for fellowships awarded for 1999-2000 is expected to be approximately $37,000, with an additional expense allowance of about $1,500. Acceptance of the fellowship cannot be postponed. Fellowship holders may use their stipend as full support for a year or may combine it with half-time teaching and use it as half support over a two-year period.

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. Because of the generosity of the AMS membership, it has been possible to award two to five fellowships a year for the past ten years. A list of previous fellowship winners can be found at http://www.ams.org/ams/prizes.html.

Applications should include a short research plan describing both an outline of the research to be pursued and a program for using the fellowship, including institutions at which it will be used and reasons for the choices. The selection committee will base its decision on both the research potential of the applicant, based on track record and letters of recommendation, and on the quality and feasibility of the research plan.

The deadline for receipt of applications is December 1, 1998. Awards will be announced in February 1999 or earlier if possible.

For application forms write to the Executive Director, American Mathematical Society, P.O. Box 6248, Providence, RI 02940-6248, or send electronic mail to ams@ams.org, or call 401-455-4103. Application forms are also available via the Internet at http://www.ams.org/employment/.

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

NSF Interdisciplinary Grants in the Mathematical Sciences

The objective of the Interdisciplinary Grants in the Mathematical Sciences (IGMS) is to enable mathematical scientists to undertake research and study in another discipline so as to (1) expand their skills and knowledge in areas other than the mathematical sciences, (2) subsequently apply this knowledge in their research, and (3) enrich the educational experiences and broaden the career options of their students.

Recipients of an IGMS award are expected to spend eleven months full time in a twelve-month period either in a nonmathematical academic science department or in an industrial, commercial, or financial institution. The expected outcome is sufficient familiarity with another discipline so as to open opportunities for effective collaboration by the mathematical scientist with researchers in another discipline.

The deadline for receipt of proposals is November 25, 1998. Further information can be found at http://www.nsf.gov/cgi-bin/getpub?nsf98145/.

—NSF announcement
For Your Information

Andreescu Appointed Director of Mathematics Competitions

Titu Andreescu has been appointed the new director of the American Mathematics Competitions. He will assume the position in January 1999.

Andreescu has served as chair of the USA Mathematical Olympiad Committee, head coach of the International Mathematical Olympiad team, and director of the Mathematical Olympiad Summer Program. He was most recently an instructor of mathematics at the Illinois Mathematics and Science Academy in Aurora, Illinois. From 1981 through 1989 he was Distinguished Professor of Mathematics at Loga Academy in Timisoara, Romania. He received the Distinguished Teacher Award from the Romanian Ministry of Education in 1983 and the Edith May Sliffe Award for Distinguished High School Mathematics Teaching from the Mathematical Association of America in 1994. In his new position he succeeds Walter E. Mientka of the University of Nebraska, who will become the executive director of the International Mathematical Olympiad 2001 U.S.A., Inc.

—From an MAA announcement

Comments Sought on NCTM Draft of Updated Standards

The National Council of Teachers of Mathematics (NCTM) has released a draft version of Principles and Standards for School Mathematics. This document updates the Council's Standards for mathematics education. An electronic version of the document, which features a wider range of examples and elaborations, has been simultaneously released.

Individuals interested in commenting on the draft may do so by forwarding comments directly to NCTM. See NCTM's Web site, http://www.nctm.org/standards2000/, for both the text and the interactive electronic formats of the document as well as instructions for submitting comments. A hard copy of the draft can also be ordered from NCTM by calling 888-220-7952; there is a nominal fee for shipping and handling. The deadline for comments is May 1, 1999.

—NCTM announcement

Listserver on Library Issues

MathLib is a listserv on library issues of interest to mathematicians and math librarians which was organized by the AMS Library Committee.

The list is not moderated, and messages to MathLib are being archived on the Mathematics Archives (http://archives.math.utk.edu/hypermail/mathlib/).

The list is open to subscribers only; to become a subscriber, send a message to majordomo@archives.math.utk.edu with only the words "subscribe mathlib" (without the quotation marks) in the body of the message. A subscription will then be approved by one of the moderators of the list.

No commercial products or services may be advertised on the list, but the list may be used to discuss commercial library materials, resources, and equipment.

—Larry Husch
AMS Library Committee

New Mathematics Classification Scheme

Mathematical Reviews and Zentralblatt für Mathematik have teamed up to produce a revision of the Mathematics Subject Classification (MSC) used by both journals. The current MSC was last revised in 1991, and the new classification is scheduled to appear in the year 2000. The revision process has been under way for two years now, and during this time MR and Zbl have gathered many suggestions...
for changes and improvements. At the International Congress of Mathematicians in Berlin in August of this year, MR and Zbl held a joint session to present the proposed MSC2000.

There were a number of guiding principles in the MSC revision. First, the classification should be kept relatively stable to facilitate searches stretching over long periods of time. Each five-digit code should retain the same meaning in the new classification, so that new topics that are added get new numbers. The level of detail should remain fairly constant across all mathematical areas. Finally, the classification must be adequate to categorize current research as well as emerging new topics.

The classifications take the form nnXmm, where n and m are single digit numbers and X is a letter. The top level of the classification is given by the digits nn and may be found on AMS membership application forms, such as the one that appears in every issue of the Notices. Currently there are 61 top-level categories. The second level of classification, denoted by two digits and a letter, nnX, comprises several hundred categories. There are more than 5,000 categories at the third and finest level of the classification.

In MSC 2000 four new categories are planned at the top level. Dynamical systems and ergodic theory, currently found under subsections 58F and 28D, will appear under a new section, number 37. The reason for the change is that the growth in this area created a need for more subsections than could be handled with the present classification. Mechanics and deformable solids, currently under section 73, will be moved to a new section, number 74, which has been completely rewritten to take into account new topics and more modern views of the subject. Game theory, economics, and social and behavioral sciences now appear under 90A, 90D, and 92G-K. They will be shifted to a new section, number 91, to provide more coherence in the classification of these topics.

These three new categories are based on expansions or reorganizations of existing ones. The fourth new category is entirely new: section 97, for mathematics education. Currently there are no plans for MR or Zbl to start reviewing the literature in mathematics education. Rather, this category was added as a way of recognizing the professional interests of a segment of the mathematics community. The scheme for the section 97 classification is based largely on that used by Zentralblatt für Didaktik der Mathematik.

In addition to the new categories at the top level, there are numerous other changes as well. For example, section 04, set theory, has been subsumed under section 03, mathematical logic and foundations, and section 32, several complex variables and analytic spaces, has been substantially revised. Hundreds of changes have been made at finer levels of the classification; one example is the addition of subsection 68W to cover the topic of algorithms.

MR and Zbl will not make further changes in the top level of the MSC, but do anticipate a few further changes at the finest level. The current plan for MSC2000 can be found on the Web at www.ams.org/mathweb/msc2000/ and www.emis.de/msc2000.html.

—Allyn Jackson
Upcoming Deadlines

December 1, 1998: Deadline for receipt of applications for the AMS Centennial Fellowships. For application forms write to the Executive Director, American Mathematical Society, P.O. Box 6248, Providence, RI 12940-6248, send e-mail to ams@ams.org, or call 401-455-4103. Application forms are also available on the Web at http://www.ams.org/employment/.

December 1, 1998: Deadline for receipt of applications for the Latin American and Caribbean competition for the Guggenheim Memorial Fellowships. Application forms are available from the John Simon Guggenheim Memorial Foundation, 90 Park Avenue, New York, NY 10016; telephone 212-687-4470, fax 212-697-3248, e-mail fellowships@gf.org, or via the Web at http://www.gf.org/.

Where to Find It

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

AMS e-mail addresses
November 1998, p. 1369

AMS Ethical Guidelines
June 1995, p. 694

AMS officers and committee members
October 1998, p. 1209

Board on Mathematical Sciences and Staff
May 1998, p. 632

Bylaws of the American Mathematical Society
November 1997, p. 1339

Classification of degree-granting departments of mathematics
January 1997, p. 48

Mathematical Sciences Education Board and Staff
May 1998, p. 632

Mathematics Research Institutes
National Science Board of NSF
contact information
November 1996, p. 1380

NSF Mathematical and Physical Sciences
Advisory Committee
May 1997, p. 597

Officers of the Society 1997 and 1998 (Council, Executive Committee, Publications Committees, Board of Trustees)
May 1998, p. 625

Program officers for federal funding agencies (DoD, DoE, NSF)
October 1998, pp. 1181–1183
From the AMS

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 should be made through each address. This list is also available on the AMS’s Web site, e-MATH, 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 send correspondence to the AMS Acquisitions Department.

ams@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.

eims-info@ams.org
to request general information about deadlines and rates for Employment Information in the Mathematical Sciences.

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

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

mathdoc@ams.org
for users of Current Mathematical Publications, Mathematical Reviews, and MathSci who wish to order a copy

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

ams-latex@ams.org
to request the \LaTeX\ macro package and documentation. (*see Note)

ams-mem@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.

ams-tex@ams.org
to request the \LaTeX\ macro package and documentation. (*see Note)
Algebra and Algebraic Geometry

Trends in Ring Theory
Vlastimil Dlab, Carleton University, Ottawa, ON, Canada, and László Márki, Hungarian Academy of Sciences, Budapest, Editors

The Ring Theory Conference (University of Miskolc, Hungary) successfully accomplished its two goals: 1) to reflect contemporary trends in the subject area and 2) to offer a meeting place for a large number of Eastern European algebraists and their colleagues from around the world. Particular emphasis was placed on recent developments in the following four areas: representation theory, group algebras, PI algebras, and general ring theory. This book presents 13 of the invited lectures.

Deformations of Galois Representations and Hecke Algebras
J. Tilouine, Université de Paris Nord, Villetaneuse, France

This book presents an expanded version of a course delivered at Hokkaido University (Sapporo, Japan) and at the Mehta Research Institute (Allahabad, India). Its aim is to examine aspects of the relationship connecting the local moduli space of deformations of a mod $p$ “modular” Galois representation to the corresponding local component of a $p$-adic Hecke algebra.

Published by Narosa Publishing House and distributed by the AMS exclusively in North America and Europe and non-exclusively elsewhere.

1996; 108 pages; Softcover; ISBN 81-7319-106-9; List $24; All AMS members $19; Order code DGRNA

Deformations of Galois Representations and Hecke Algebras

- Trends in Ring Theory
- Deformations of Galois Representations and Hecke Algebras

All prices subject to change. Charges for delivery are $3.00 per order. For optional air delivery outside of the continental U.S., please include $6.50 per item. Prepayment required. Order from: American Mathematical Society, P.O. Box 6248, Providence, RI 02940-0001, USA. For credit card orders, fax 1-401-455-4480 or call toll free 1-800-321-4AMS (4267) in the U.S. and Canada, 1-401-455-4000 worldwide. Or place your order through the AMS bookstore at www.ams.org/bookstore. Residents of Canada, please include 7% GST.
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 a TeX version which can be downloaded from the e-math "Employment Information" menu, http://www.ams.org/employment/), 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 Joint Committee on Employment Opportunities has adopted the cover sheet on the facing page as an aid to job applicants and prospective employers. The form is now available on e-math in a TeX format which can be downloaded and edited. The purpose of the cover form is to aid department staff in tracking and responding to each application.

Mathematics Departments in Bachelor’s, Master’s and Doctorate granting institutions have been contacted and are expecting to receive the form from each applicant, along with any other application materials they require. Obviously, not all departments will utilize the cover form information in the same manner. Please direct all general questions and comments about the form to: emp-info@ams.org or call the Professional Programs and Services Department, AMS, at 800-321-4267 extension 4105.

JCEO Recommendations for Professional Standards in Hiring Practices

The JCEO believes that every applicant is entitled to the courtesy of a prompt and accurate response that provides timely information about his/her status. Specifically, the JCEO urges all institutions to do the following after receiving an application:

(1) Acknowledge receipt of the application immediately; and
(2) Provide information as to the current status of the application, as soon as possible.

The JCEO recommends a triage-based response, informing the applicant that he/she
(a) is not being considered further;
(b) is not among the top candidates; or
(c) is a strong match for the position.
**AMS STANDARD COVER SHEET**

<table>
<thead>
<tr>
<th>Last Name</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>First Name</td>
<td></td>
</tr>
<tr>
<td>Middle Names</td>
<td></td>
</tr>
<tr>
<td>Address through June 1999</td>
<td></td>
</tr>
<tr>
<td>Home Phone</td>
<td></td>
</tr>
<tr>
<td>e-mail Address</td>
<td></td>
</tr>
<tr>
<td>Current Institutional Affiliation</td>
<td></td>
</tr>
<tr>
<td>Work Phone</td>
<td></td>
</tr>
</tbody>
</table>

**Highest Degree and Source**

Year of Ph.D. (optional)

Ph.D. Advisor

If the Ph.D. is not presently held, date on which you expect to receive ______

**Indicate the mathematical subject area(s) in which you have done research using, if applicable, the 1991 Mathematics Subject Classification printed on the back of this form. 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.**

[ ]

[ ]

[ ]

[ ]
1991
Mathematics Subject Classification

00 General
01 History and biography
03 Logic and foundations
04 Set theory
05 Combinatorics
06 Order, lattices, ordered algebraic structures
08 General mathematical 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
39 Finite differences 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, optimal control
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
73 Mechanics of 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 Economics, operations research, programming, games
92 Biology and other natural sciences, behavioral sciences
93 Systems theory, control
94 Information and communication, circuits
Volume 4, 1998 (year to date)

M. F. Newman and Michael Vaughan-Lee, Some Lie rings associated with Burnside groups

George Kamberov, Prescribing mean curvature: existence and uniqueness problem

Bruce Geist and Joyce R. McLaughlin, Eigenvalue formulas for the uniform Timoshenko beam: the free-free problem

Navin Keswani, Homotopy invariance of relative eta-invariants and C*-algebra K-theory

Kevin Ford, The distribution of totients

Palle E. T. Jorgensen and Steen Pedersen, Orthogonal harmonic analysis of fractal measures

Pavel Etingof and Alexander Kirillov, Jr., On Cherednik Macdonald-Mehta identities

Takashi Hara and Gordon Slade, The incipient infinite cluster in high-dimensional percolation


ERA-AMS publishes high-quality research announcements of significant advances in all branches of mathematics. Authors may submit manuscripts to any editor. All papers are reviewed, and the entire Editorial Board must approve the acceptance of any paper. Papers are posted as soon as they are accepted and processed by the AMS.

ERA-AMS offers you...
- decreased turn-around time from submission to print
- fast access to your specific area of interest
- up-to-the-minute research information

To obtain submission information and the template, send email to: era-info@ams.org with the word "help" in the subject line.

For more information, contact:
cust-serv@ams.org
1-800-321-4267, 1-401-455-4000,
fax 1-401-455-4046

www.ams.org/era/
Mathematics Calendar

The most comprehensive and up-to-date Mathematics Calendar information is available on e-MATH at http://www.ams.org/mathcal1/.

November 1998

2-4 Randomized and Derandomized Algorithms for Discrete Structures, Institute for Advanced Study, Princeton, New Jersey.
Organizers: N. Alon, noga@math.tau.ac.il; A. Frieze, frieze@random.math.cmu.edu; B. Reed, reed@ecp6.jussieu.fr.
Sponsor: DIMACS Center and the Institute for Advanced Study.

Aim: This workshop is devoted to two techniques which have wide application in theoretical discrete optimization: the semi-random method and Szemeredi's Regularity Lemma. The second of these techniques applies only to large graphs. Most applications of the first are to large structures. The most ambitious goal of the workshop is to foster collaborative research projects which combine the semi-random method and the Regularity Lemma.

Information: Contact B. Reed (Université Pierre et Marie Curie), reed@ecp6.jussieu.fr. WWW information: http://dimacs.rutgers.edu/Workshops/index.html.

6-8 Ahlfors - Bers Colloquium, The University at Stony Brook, Stony Brook, New York.
Aim: This is the second conference in a series of conferences focused on the mathematical developments stemming from the work of Lars V. Ahlfors and Lipman Bers in the broadly defined areas of Riemann surfaces, uniformization and Teichmüller theory. The first conference in this series was the Bers Colloquium, held at C.U.N.Y. Graduate Center, in October, 1995.
Support: The conference is being supported by the N.S.F. There is limited support available, primarily for advanced graduate students and postdocs.
Organizing Committee: W. Abikoff, A. S. Basmajian, C. J. Earle, F. W. Gehring, J. Gilman, L. Keen, L. Kra (chair), A. Marden, and B. Maskit.

11-12 Workshop on Nonlinear Spectral Theory and Eigenvalue Problems for Nonlinear Differential Equations, Certosa di Pontignano, Università di Siena, Siena, Italy.
Aim: This meeting should provide an opportunity for scientific exchange and cooperation between people working in abstract nonlinear spectral theory and others more experienced in boundary and eigenvalue problems for nonlinear differential equations.
Organizers: J. Appell (Wuerzburg), R. Chiappinelli (Siena).
Invited Speakers: J.-P. Gossez (Bruxelles), A. Szulkin (Stockholm), A. Vignoli (Roma), J. R. L. Webb (Glasgow).
Information: Detailed information and scientific programme: see the Web page of the workshop at the site http://www.mat.unisi.it/web/workann1.htm.

January 1999

11-12 Evolution as Computation, Princeton University, Princeton, New Jersey.
Sponsor: DIMACS Center.
Contact: L. Landweber, Princeton Univ., e-mail: lfl@princeton.edu.
Local Arrangements: S. Barb, Princeton Univ., tel: 609-696-1771; e-mail: barbu@cs.princeton.edu.
Program: This DIMACS workshop will draw together computer scientists and molecular evolutionary biologists in a different context to explore the computational power of biological processes over evolutionary time. The solicited topics include biological models of nucleic acid information processing and genome evolution; molecules, 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 mathcal1@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 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 e-MATH on the World Wide Web. To access e-MATH, use the URL: http://e-math.ams.org/ (or http://www.ams.org/). (For those with VT100-type terminals or for those without WWW browsing software, connect to e-MATH via Telnet: e-math.ams.org, login and password e-math) and use the Lynx option from the main menu.)
cells, and metabolic circuits that register logical relationships among proteins; the changing logic of the genetic code; genetic algorithms; genetic programming; machine learning; Kolmogorov complexity, and the evolution of complex adaptive systems. The goal is to combine theory and experiments to construct a quantitative view of the processes that take place in cells and the combinatorial processes that drive evolution at the molecular level. By analogy to computational systems, these processes will provide examples of the "biological software" that with the appropriate vector and interface might ultimately be coaxed to perform computations in vivo. Presented under the auspices of the Special Focus on DNA Computing.

Information: WWW: http://dimacs.rutgers.edu/Workshops/index.html.

* 15–16 Workshop on Algorithm Engineering and Experimentation (ALENE99), Omni Hotel, Baltimore, Maryland.


Organizers: C. C. McGeoch (Amherst College), e-mail: ccm@cs.amherst.edu.

Aim: The aim of ALENE99 is to provide a forum for the presentation of original research in the implementation and experimental evaluation of algorithms and data structures. The scientific program will include invited talks as well as contributed research papers, and will include time for discussion and debate of topics in this rapidly evolving research area. This workshop is colocated with SODA '99 and will be held on the two days preceding that conference.

Sponsors: DIMACS Center and SIAM.

Information: http://dimacs.rutgers.edu/Workshops/index.html.

February 1999

* 12–13 Fifteenth Conference on Applied Mathematics (CAM), University of Central Oklahoma, Edmond, Oklahoma.

Program: An interdisciplinary conference on mathematics with applications, this year's CAM will feature J. Gallian of the Univ. of Minnesota at Duluth, who will speak on "The Mathematics of Identification Numbers." Also featured will be W. Briggs of the Univ. of Colorado, who will speak on "Differential and Difference Equations in Population Genetics." A special program on "Teaching Quantitative Reasoning to Liberal Arts Students" will also be provided by Dr. Briggs, based on ideas he incorporated into his recent textbook.

Call for Papers: Abstracts should be postmarked by December 31, 1998, and mailed to the address below. As in past years, CAM will include a session for graduate and undergraduate student papers on mathematics and its applications and will provide Outstanding Student Presentation Awards for the best papers. Presenters should specify whether their paper is intended for the Session on Computer Science, the Session on Differential Equations, the Session on Applied Mathematics, or the Student Session.

Information: Conference on Applied Mathematics, College of Mathematics and Science, Univ. of Central Oklahoma, 100 N. University, Edmond, OK 73034; tel: 405-974-5381; fax: 405-974-3824; e-mail: cam@aix1.ucok.edu.

March 1999

* 17–19 International Conference on Differential Equations and Nonlinear Mechanics, University of Central Florida, Orlando, Florida.


Objective: Definite plans are made to invite several leading authorities in the world. The talks will focus on the recent developments in the above mentioned fields and their applications. A conference proceedings is also planned. There will be ample opportunity for the participants (local as well as outside) to hold informal discussions, which may lead to collaborative research. Participation is open to scientists/engineers working at the conference level on theoretical or practical aspects of the theme of the conference. Some support may be available for travel and local expenses.

Information: Correspondence and inquiries should be sent to the Conference Director: K. Vajravelu, Department of Mathematics, Univ. of Central Florida, Orlando, FL 32816; tel: 407-823-5089; fax: 407-823-6253; e-mail: vajravelu@ugauss.uccf.edu.

* 25–28 International Conference on Algebra and its Applications, Ohio University, Athens, Ohio.

Topics: Theory of Rings and Modules, Coding Theory, and Applied Linear Algebra.


Keynote Speaker: E. Zelmanov.

Funding: This conference is supported by funding from the National Security Agency and Ohio University.

Information: Those interested please e-mail algbr@bing.math.ohiou.edu and send a hard copy of the abstract (if you wish to contribute) so as to reach us by November 15, 1998. For more updates and additional information, please visit our webpage at http://www.bing.math.ohiou.edu/~algbr.

Additional Information: For accommodations, please call any of the following hotels at their local numbers (not toll-free).

before March 4, 1999, for these highly discounted rates. Refer to ICAA Conference.


May 1999

* 19–22 Fourth International Joint Meeting of the AMS and the Sociedad Matematica Mexicana (SMM), University of North Texas, Denton, Texas.

* 31–June 4 The 19th International Conference on Distributed Computing Systems (ICDCS '99), Austin, Texas.

Topics: The technical areas of the conference include: Cooperative and groupware systems, Specification and verification, Fault-tolerance and security, Distributed algorithms, Distributed software engineering, Distributed database, Distributed operating systems, Communication protocols, Mobile systems, Multimedia systems, Real-time systems, Internet applications, and Distributed Synchronization.

Information: For more information, please contact B. Buckles, Tulane Univ., Dept. of EECS, New Orleans, LA 70118; tel: 504-862-3373; fax: 504-862-3293; WWW: http://www.eecs.tulane.edu/ICDCS/; buckles@eecs.tulane.edu; or see the conference home page, URL: http://www.eecs.tulane.edu/ICDCS/.

June 1999

* 1–4 Day on Diffusion'99, St.Petersburg Branch of Steklov Mathematical Institute, St. Petersburg, Russia.

Organizers: Faculty of Physics, St. Petersburg University; St. Petersburg Branch of Steklov Mathematical Inst.; Euler International Mathematical Inst.

Topics: Asymptotic methods, Mathematical aspects of wave phenomena, Inverse prob-
Mathematics Calendar

August 1999

1-7 EQUADIFF 99, Free University, Berlin, Germany.

Program: EQUADIFF 99 is one of a series of conferences devoted to all mathematical aspects of differential equations.

Local Organization: H.-G. Bothe (Freie Univ., Berlin), R. Loehr, Freie Univ. Berlin, Mathematics Institut, Berlin, Germany: fax: +49-30-838-75 409. E-mail: equadiff@math. fu-berlin. de.

Contact Address: EQUADIFF 99, c/o R. Loehr, Freie Univ. Berlin, Mathematics Institut I, Arnimallee 2-6, D-14195 Berlin, Germany; fax: +49-30-838-75 409.

Minisymposia: There will be 37 minisymposia, each representing the current state of research in different aspects of partial differential equations.

Social Program: Excursions to Potsdam and Brandenburg.

Preregistration: Please send the form on our web site http://www.math.fu-berlin.de/~equadiff/ to preregister and receive the Second Announcement in January 1999. Preregistration forms are also available by sending an e-mail message with empty subject line and body to: e-mail: equadiff@math.fu-berlin.de.

Contact Address: EQUADIFF 99, c/o R. Loehr, Freie Univ. Berlin, Mathematics Institut I, Arnimallee 2-6, D-14195 Berlin, Germany; fax: +49-30-838-75 409.

Contributed Talks: Titles/Abstracts can be submitted as LATEX or PostScript files to equadiff@math.fu-berlin.de. Please indicate in which minisymposium your abstract would fit best, if any. Acceptance and affiliation of talks to minisymposia will be decided on by referees. Deadline for submission of abstracts is April 1, 1999.

Conference Fees: The conference fee will be DM 350, – for regular participants (DM 450, in case of registration after April 1, 1999). Included in registration fee is public transport ticket, welcome reception, program book of abstracts and the conference proceedings.

Important Deadlines: January 1, 1999: second announcement; April 1, 1999: early registration, title and abstract of contributed talks, contributions for proceedings.

October 1999

15-17 AMS Southeastern Section Meeting, University of North Carolina, Charlotte, North Carolina.

Information: Information will appear on the meetings pages of e-MATH.

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

April 2000

1-2 AMS Eastern Section Meeting, University of Massachusetts, Lowell, Massachusetts.

Information: Information will be posted on the meetings pages of e-MATH.

July 2000

17-22 International Congress on Mathematical Physics, Imperial College, London, United Kingdom.

Satellite Meetings: Bristol: FDEs and Schrödinger operators; Cambridge: Statistical mechanics; Edinburgh: Dynamical systems; L•nnon: Noncommutativity, geometry and probability; Kings College, London: Disordered systems, quantum groups and integrable systems; Queen Mary and Westfield College, London: Strings, branes and M-theory; Oxford: The mathematical theory of biological systems; Warwick: Geometry and analysis on path spaces and related fields; Imperial College: Young researchers symposium.

Information: Information will be posted on the meetings pages of e-MATH.

September 2000

22-24 AMS Central Section Meeting, University of Toronto, Toronto, Ontario, Canada.

Information: Information will be posted on the meetings pages of e-MATH.

November 2000

3-5 AMS Northeastern Section Meeting, Columbia University, New York, New York.

Information: Information will be posted on the meetings pages of e-MATH.

April 2001

28-29 AMS Northeastern Section Meeting, Stevens Institute of Technology, Hoboken, New Jersey.

Information: Information will appear on the meetings pages of e-MATH.

January 2002

6-9 Joint Mathematics Meetings, San Diego Convention Center, San Diego, California.

Information: Information will appear on the meetings pages of e-MATH.

July 1999

12-16 First International Joint Meeting of the American Mathematical Society and the Australian Mathematical Society, Melbourne, Australia.

Information: Information will be posted on the Meetings pages of e-MATH.
New Publications Offered by the AMS

Algebra and Algebraic Geometry

Characters of Finite Groups. Part 2
Ya. G. Berkovich, University of Haifa, Israel, and E. M. Zhmud', Kharkov University, Ukraine

This book places character theory and its applications to finite groups within the reach of people with a comparatively modest mathematical background. The work concentrates mostly on applications of character theory to finite groups. The main themes are degrees and kernels of irreducible characters, the class number and the number of nonlinear irreducible characters, values of irreducible characters, characterizations and generalizations of Frobenius groups, and generalizations of monomial groups. The presentation is detailed, and many proofs of known results are new.

Contents: Degrees and kernels of irreducible characters; Involutions; Connectedness and Zassenhaus groups; The Nagao theorem; Linear groups; Permutation characters; Characters of \( SL(2, p^n) \); Zeros of characters; The Schur index; On degrees of irreducible components of induced characters; Groups in which only two nonlinear irreducible characters have equal degrees; Groups with small sums of degrees of some characters; On sums of degrees of irreducible characters; Groups whose nonlinear irreducible characters take three distinct values; Nonsolvable groups with many involutions; On kernels of nonlinear irreducible characters; On monolithic characters; The class number; Problems; Notes on the bibliography; Bibliography; Author index; Subject index; List of corrections to part 1.

Translations of Mathematical Monographs, Volume 181

Hopf Algebras, Polynomial Formal Groups, and Raynaud Orders
Lindsay N. Childs, State University of New York at Albany, Cornelius Greither, Université Laval, Quebec, PQ, Canada, David J. Moss, MapInfo Corporation, Troy, NY, Jim Sauerberg, Saint Mary’s College, Moraga, CA, and Karl Zimmermann, Union College, Schenectady, NY

This book gives two new methods for constructing \( p \)-elementary Hopf algebra orders over the valuation ring \( R \) of a local field \( K \) containing the \( p \)-adic rational numbers. One method constructs Hopf orders using isogenies of commutative degree 2 polynomial formal groups of dimension \( n \), and is built on a systematic study of such formal group laws. The other method uses an exponential generalization of a 1992 construction of Greither. Both constructions yield Raynaud orders as iterated extensions of rank \( p \) Hopf algebras; the exponential method obtains all Raynaud orders whose invariants satisfy a certain \( p \)-adic condition.

Contents: Introduction to polynomial formal groups and Hopf algebras; Dimension one polynomial formal groups; Dimension two polynomial formal groups and Hopf algebras; Degree two formal groups and Hopf algebras; \( p \)-Elementary group schemes—Constructions and Raynaud’s theory.

Memoirs of the American Mathematical Society, Volume 136, Number 651

November 1998
NOTICES OF THE AMS 1379
Rings and Things and a Fine Array of Twentieth Century Associative Algebra  
Carl Faith, Professor Emeritus, Rutgers University, New Brunswick, NJ

This book surveys more than 125 years of aspects of associative algebras, especially ring and module theory. Included are certain categorical properties from theorems of Frobenius and Stickelberger on the primary decomposition of finite Abelian groups, Hilbert's basis theorem and his Nullstellensatz, Maschke's theorem on the representation theory of finite groups over a field, and the fundamental theorems of Wedderburn on the structure of finite-dimensional algebras and finite skew fields. Two of the author's prior works (Algebra: Rings, Modules and Categories, I and II, Springer-Verlag, 1973) are devoted to the development of modern associative algebra and ring and module theory. Those works serve as a foundation for the present survey.

This book is the first to probe so extensively such a wealth of historical development. A special feature is the in-depth study of rings with chain condition on annihilator ideals pioneered by Noether, Artin, Jacobson, and others.

In addition to the mathematical survey, the author gives candid and descriptive impressions of the last half of the twentieth century in "Part II: Snapshots of Some Mathematical Friends and Places". Beginning with his teachers and fellow graduate students at the University of Kentucky and at Purdue, Faith discusses his Fulbright-Nato postdoctoral at Heidelberg and at IAS, his year as a visiting scholar at Berkeley, and the many acquaintances he met there and in subsequent travels in India, Europe, and especially Spain.

Comments on the book:
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

"Part II: Snapshots of Some Mathematical Friends and Places" is wonderful! [It is] a joy to read! Mathematicians of my age and younger will relish reading "Snapshots."

James A. Huckaba, University of Missouri-Columbia

Contents: Part I: An array of 20th century associative algebra: Direct product and sums of rings and modules and the structure of fields; Introduction to ring theory: Schar's lemma and semisimple rings, prime and primitive rings, nil, prime and Jacobson radicals; Direct sum decompositions of projective and injective modules; Direct product decompositions of von Neumann regular rings and self-injective rings; Direct sums of cyclic modules; When injectives are flat: Coherent FP-injective rings; Direct decompositions and dual generalizations of Noetherian rings; Completely decomposable modules and the Krull-Schmidt-Azumaya theorem; Polynomial rings over Vamosian and Kerr rings, valuation rings and Prüfer rings; Isomorphic polynomial rings; Group rings and Maschke's theorem revisited; Maximal quotient rings; Morita duality and dual rings; Krull and global dimensions; Polynomial identities and PI-rings; Unions of primes, prime avoidance, associated prime ideals, ACC on irreducible ideals and annihilator ideals in commutative rings; Dedekind's theorem on the independence of automorphisms revisited; Part II: Snapshots of some mathematical friends and places; Envoi to my century; Bibliography; Register of names; Index of terms and authors of theorems.

Mathematical Surveys and Monographs

Summer School in Group Theory in Banff, 1996  
Olga Kharlampovich, McGill University, Montreal, PQ, Canada, Editor

The third annual CRM Summer School took place in Banff (Alberta, Canada) and was aimed toward advanced students and recent PhDs. This volume presents surveys from the group theory part of the theme year and examines different approaches to the topic: a geometric approach, an approach using methods from logic, and an approach with roots in the Bass-Serre theory of groups acting on trees.

The work offers a concise introduction to current directions of research in combinatorial group theory. Surveys in the text are by leading researchers in the field who are experienced expositors. The text is suitable for use in a graduate course in geometric and combinatorial group theory.

Contents: G. Baumslag, Some open problems; I. M. Chiswell, Length functions and -trees; S. M. Gersten, Introduction to hyperbolic and automatic groups; A. Myasnikov, Description of fully residually free groups and irreducible affine varieties over a free group; Y. Kuz’min, Homological methods in group theory; M. du Sautoy, Pro-p groups; S. M. Vovsi, Identities of representations of finite groups.

CRM Proceedings & Lecture Notes, Volume 17
Invariants under Tori of Rings of Differential Operators and Related Topics

Ian M. Musson, University of Wisconsin, Milwaukee, and
Michel Van den Bergh, Free University of Brussels, Belgium

Contents:
Introduction; Notations and conventions; A certain class of rings; Some constructions; The algebras introduced by torus invariants; Dimension theory for torus invariants; Homological properties of the minimal primitive quotients of D(X)G; The latter are of the form B̂ = D(X)G/⟨g − x(g)⟩ where g = Lie(G), X ∈ g* and g − x(g) is the set of all v − x(v) with v ∈ g. They occur as rings of twisted differential operators on toric varieties. It is also proven that if G is a torus acting rationally on a smooth affine variety, then D(X)/G is a simple ring.

If G is a reductive algebraic group acting rationally on a smooth affine variety X, then it is generally believed that D(X)G has properties very similar to those of enveloping algebras of semisimple Lie algebras. In this book, the authors show that this is indeed the case when G is a torus and X = k* × (k*)n. They give a precise description of the primitive ideals in D(X)G and study in detail the ring theoretical and homological properties of the minimal primitive quotients of D(X)G. The latter are of the form B̂ = D(X)G/⟨g − x(g)⟩ where g = Lie(G), X ∈ g* and g − x(g) is the set of all v − x(v) with v ∈ g. They occur as rings of twisted differential operators on toric varieties. It is also proven that if G is a torus acting rationally on a smooth affine variety, then D(X)/G is a simple ring.

Contents: Introduction; Notations and conventions; A certain class of rings; Some constructions; The algebras introduced by torus invariants; Dimension theory for B̂; Finite global dimension; Finite dimensional representations; An example; References.

Memoirs of the American Mathematical Society, Volume 136, Number 650


Rank 3 Amalgams

Bernd Stellmacher, University of Bielefeld, Germany, and
Franz Georg Timmesfeld, University of Giessen, Germany

Let G be a group, p a fixed prime, I = 1,..., n and let B and P, l ∈ I be a collection of finite subgroups of G. Then G satisfies P, (with respect to p, B and P, l ∈ I) if:

1. G = {P,l | l ∈ I},
2. B is the normalizer of a p−Sylow-subgroup in P,
3. No nontrivial normal subgroup of B is normal in G,
4. O′(P,kO(P)) is a rank 1 Lie-type group in char p (also including solvable cases).

If n = 2, then the structure of P, P; was determined by Delgado and Stellmacher. In this book the authors treat the case n = 3. This has applications for locally finite, chamber transitive Tits-geometries and the classification of quasithin groups.

Contents: Introduction; Weak (B,N,)-pairs of Rank 2; Modules; The Graph G; The structure of L(G) and Z(G); The case b ≥ 2; The case b = 0; The case b = 1 and the proof of Theorems 1 and 4; The proof of Theorems 2 and 3.

Memoirs of the American Mathematical Society, Volume 136, Number 649


Des Catégories Dérivées des Catégories Abéliennes

Jean-Louis Verdier, University of Paris VII, France

A publication of the Société Mathématique de France.

Verdier’s thesis, never published nor circulated until now. The aim of this thesis was to create the appropriate homological framework to state and prove the generalizations of the duality theorems of Grothendieck. This framework is the theory of derived categories, whose foundations are put forth in this text. This notion of triangulated category is introduced for the first time. This notion, inspired by topological and cohomological examples, has proved to be extremely fruitful. The text is written in French.

Titles in this series are 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: Les catégories de complexes des catégories additives; Catégories triangulées; Les catégories dérivées; Index des notations; Index terminologique; Bibliographie; Table des matières.

Asterisque, Number 239

Analysis

Pôles de Diffusion Engendrés par un Coin
Nicolas Burq, Ecole Polytechnique, Palaiseau Cedex, France
A publication of the Société Mathématique de France.

In this volume, the author studies the scattering poles generated by a trapped ray connecting a corner to itself. He gives an asymptotic expansion of (almost) every pole located under a curve \( \text{Im} z < N \log \text{Re} z \) (for any \( N \)). It is shown that these poles are asymptotically on logarithmic curves.

Titles in this series are 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 the American Mathematical Society, P.O. Box 62489, Providence, RI 02940-8489.

Contents: Introduction; Propagation des singularités; La résolvante; Construction des opérateurs; Un problème de Grushin; Demonstration du théorème 1; Annexes.

Astrisque, Number 242

November 1997, 122 pages, 1991 Mathematics Subject Classification: 35P25, 35L05, 35L20, Individual member \$23,
List \$25, Order code AST/242N

Flat Extensions of Positive Moment Matrices: Recursively Generated Relations
Raul E. Curto, University of Iowa, Iowa City, and Lawrence A. Fialkow, State University of New York, New Paltz

In this book, the authors develop new computational tests for existence and uniqueness of representing measures \( \mu \) in the Truncated Complex Moment Problem: \( y_{ij} = \int \frac{x^i y^j}{\mu} \) for \( 0 \leq i + j \leq 2m \).

Conditions for the existence of finitely atomic representing measures are expressed in terms of positivity and extension properties of the moment matrix \( M(n; y) \) associated with \( y = y^2 \): \( y_0, \ldots, y_{2m}, \ldots, y_{2n}, y_0 > 0 \). This study includes new conditions for flat (i.e., rank-preserving) extensions \( M(n + 1) \) of \( M(n) \geq 0 \); each such extension corresponds to a distinct rank \( M(n) \)-atomic representing measure, and each such measure is minimal among representing measures in terms of the cardinality of its support. For a natural class of moment matrices satisfying the tests of recursive generation, recursive consistency, and normal consistency, the existence problem for minimal representing measures is reduced to the solubility of small systems of multivariable algebraic equations. In a variety of applications, including cases of the quartic moment problem \( (n = 2) \), the text includes explicit constructions of minimal representing measures via the theory of flat extensions. Additional computational tests are used to prove non-existence of representing measures or the non-existence of minimal representing measures. These tests are used to illustrate, in very concrete terms, new phenomena, associated with higher-dimensional moment problems that do not appear in the classical one-dimensional moment problem.

Contents: Introduction; Flat extensions for moment matrices; The singular quartic moment problem; The algebraic variety of \( y \); J. E. McCarthy’s phenomenon and the proof of Theorem 1.5; Summary of results; Bibliography; List of symbols.

Memoirs of the American Mathematical Society, Volume 136, Number 648

List \$36, Institutional member \$29, Order code MEMO/136/648N

Operator Algebras and Quantum Field Theory
S. Doplicher, Universita di Roma "La Sapienza", Rome, Italy, and R. Longo,
J. E. Roberts, and L. Zsidó,
Universita di Roma "Tor Vergata", Rome, Italy, Editors

A publication of International Press.

Operator algebras can be seen as a discipline encompassing noncommutative analysis, geometry, and topology. After the work of Haag in the 1950s and of Araki, Haag, and Kastler in the early 1960s, the original link with quantum mechanics has evolved into a much deeper relation with quantum field theory. This relationship has resulted in mutual interaction and motivation between pure mathematics and mathematical physics.

This volume presents the proceedings from a conference on "Operator Algebras and Quantum Field Theory" held at Accademia Nazionale dei Lincei (Rome, Italy). Additional articles have been included to cover topics not represented at the conference.

This text will also be of interest to those working in mathematical physics.

International Press publications are distributed worldwide, except in Japan, by the American Mathematical Society.

Contents: I. \( C^* \)-Algebras and Their Invariants: G. K. Pedersen,
Extensions of \( C^* \)-algebras classification of inductive limits of the Toeplitz algebra tensored with \( \mathcal{K} \); G. A. Elliott,
D. E. Evans, and H. Su,
Classification of inductive limits of the Toeplitz algebras tensored with \( \mathcal{K} \); M. Rordam,
The stable rank of \( C(X)(F_0) \) is one—A survey; K. Thomsen,
On the reduced \( C^* \)-exponential length; N. C. Phillips,
Continuous embedding of the rotation algebras in the Cuntz algebra \( O_2 \); J. Raeburn,
Crossed products of \( C^* \)-algebras by coactions of locally compact groups; D. Pask,
Cuntz-Krieger algebras associated to directed graphs; V. Azrumanian and J. Renault,
Examples of pseudogroups and their \( C^* \)-algebras; J. L. Sauvageot,
Strong Feller noncommutative kernels, strong Feller semigroups and harmonic analysis; T. A. Loring,
Almost multiplicative maps.


Hypergeometric Summation

Wolfram Koepf, Hochschule für Technik Wirtschaft und Kultur, Leipzig, Germany

A publication of the Vieweg Verlag.

In this book, modern algorithmic techniques for summation—most of which have been introduced within the last decade—are developed and carefully implemented via computer algebra system software (which can be downloaded from the Web; URL is given in the text).

The algorithms of Gosper, Zeilberger, and Petkovšek on hypergeometric summation and recurrence equations and their \(q\)-analogues are covered, and similar algorithms on differential equations are considered. An equivalent theory of hyperexponential integration due to Almkvist and Zeilberger completes the volume.

The combination of all results considered gives work with orthogonal polynomials and (hypergeometric type) special functions a solid algorithmic foundation. Hence, many examples from this very active field are given.

The book is designed for use as framework for a seminar on the topic, but is also suitable for use in an advanced lecture course.

This text will also be of interest to those working in discrete mathematics and combinatorics.

The AMS is exclusive distributor in North America, and non-exclusive distributor worldwide except in Germany, Switzerland, Austria, and Japan.

Contents: Introduction; The gamma function; Hypergeometric identities; Hypergeometric database; Holonomic recurrence equations; Gosper’s algorithm; The Wilf-Zeilberger method; Zeilberger’s algorithm; Extensions of the algorithms; Petkovšek’s algorithm; Differential equations for sums; Hyperexponential antiderivatives; Holonomic equations for integrals; Rodrigues formulas and generating functions; Appendix: Installation and software; Bibliography; List of symbols; Index.

Vieweg Advanced Lectures in Mathematics, Volume 5


Applications

DNA Based Computers II

Laura Landweber, Princeton University, NJ, and Eric Baum, NEC Research Institute, Princeton, NJ, Editors

The fledgling field of DNA computers began in 1994 when Leonard Adleman surprised the scientific community by using DNA molecules, proteins, enzymes, and chemicals to solve an instance of a hard computational problem. This volume presents results from the second annual meeting on DNA computers held at Princeton only one and one-half years after Adleman’s discovery. By drawing on the analogy between DNA computing and cutting-edge fields of biology (such as directed evolution), this volume highlights some of the exciting progress in the field and builds a strong foundation for the theory of molecular computation.

DNA computing is a radically different approach to computing that brings together computer science and molecular biology in a way that is wholly distinct from other disciplines. This book outlines important advances in the field and offers comprehensive discussion on potential pitfalls and the general practicality of building DNA based computers.

Differential Equations

Differential Equations and Applications

P. W. Bates, Brigham Young University, Provo, UT,
S-N. Chow, Georgia Institute of Technology, Atlanta, K. Lu,
Brigham Young University, Provo, UT, and X. Pan,
Zhejiang University,

Hangzhou, People's Republic of China, Editors

A publication of International Press.

This book presents the proceedings of the U.S.-Chinese conference held in Hangzhou, PRC. The conference featured approximately one hundred specialists from the U.S., China, Japan, Korea, Taiwan, and Hong Kong. This was an exceptional opportunity for these scientists to review the state of the art in differential equations as practiced in these Pacific Rim countries. A list of the speakers and the titles of their talks are included.

Contents:

numerical method for a time-dependent singularly perturbed system with turning points; Y. Q. Shen, Computation of a Hopf bifurcation point via one singular value decomposition nearby; P. E. Souganidis, Recent developments in the theory of interface dynamics; F. Talamucci, A mathematical model of phase change in fine porous media; G. Wayne, Invariant manifolds and the asymptotics of parabolic equations in cylindrical domains; J. C. Wei, On the effect of domain geometry and boundary geometry in some singular perturbation problem; J. Zhan, Harmonic map and Ginzburg-Landau type system; S. Zheng, Global existence and asymptotic behavior of weak solutions to nonlinear thermoviscoelastic systems; T. Ouyang and J. Shi, Exact multiplicity of solutions and global bifurcation of $\Delta u + f(u) = 0$.

International Press

Nonlocal Bifurcations
Yu. Ilyashenko, Moscow State University, Russia, and Weigu Li, Beijing University, People's Republic of China

This book studies nonlocal bifurcations that occur on the boundary of the domain of Morse-Smale systems in the space of all dynamical systems. These bifurcations provide a series of fascinating new scenarios for the transition from simple dynamical systems to complicated ones. The main effects are the generation of hyperbolic periodic orbits, nontrivial hyperbolic invariant sets and the elements of hyperbolic theory. All results are rigorously proved and exposed in a uniform way. The foundations of normal forms and hyperbolic theories are presented from the very first stages. The proofs are preceded by heuristic descriptions of the ideas. The book contains new results, and many results have not previously appeared in monograph form.

Contents: Introduction; Preliminaries; Bifurcations in the plane; Homoclinic orbits of nonhyperbolic singular points; Homoclinic tori and Klein bottles of nonhyperbolic periodic orbits; Noncritical case; Homoclinic torus of a nonhyperbolic periodic orbit; Semicritical case; Bifurcations of homoclinic trajectories of hyperbolic saddles; Elements of hyperbolic theory; Normal forms for local families; Hyperbolic case; Normal forms for unfoldings of saddlenodes; Bibliography.

Mathematical Surveys and Monographs

Controllability, Stabilization, and the Regulator Problem for Random Differential Systems
Russell Johnson, University of Florence, Italy, and Mahesh Nerurkar, Rutgers University, Camden, NJ

This volume develops a systematic study of time-dependent control processes. The basic problem of null controllability of linear systems is first considered. Using methods of ergodic theory and topological dynamics, general local null controllability criteria are given. Then the subtle question of global null controllability is studied. Next, the random linear feedback and stabilization problem is posed and solved. Using concepts of exponential dichotomy and rotation number for linear Hamiltonian systems, a solution of the Riccati equation is obtained which has extremely good robustness properties and which also preserves all the smoothness and recurrence properties of the coefficients. Finally, a general version of the local nonlinear feedback stabilization problem is solved.

Contents: Introduction; Basic dynamical notions; Random linear control processes; Some facts about random linear systems; Sufficiency conditions for uniform controllability; Dependence of controllability on the dynamics of the flow; Global null controllability; The feedback stabilization problem for random linear systems; The rotation number; The solution of the linear regulator and the stabilization problem; Linearization of the regulator and the stabilization problem; Linearization of the Riccati equation.

Memoirs of the American Mathematical Society, Volume 136, Number 646

Almost Automorphic and Almost Periodic Dynamics in Skew-Product Semiflows
Wenxian Shen, Auburn University, AL, and Yingfei Yi, Georgia Institute of Technology, Atlanta

This volume is devoted to the study of almost automorphic dynamics in differential equations. By making use of techniques from abstract topological dynamics, it is shown that almost automorphy, a notion which was introduced by S. Bochner in 1953, is essential and fundamental in the qualitative study of almost periodic differential equations. Fundamental notions from topological dynamics are introduced in the first part of the book. Harmonic properties of almost automorphic functions such as Fourier series and frequency module are studied. A module containment result is provided.
In the second part, lifting dynamics of \( \omega \)-limit sets and minimal sets of a skew-product semiflow from an almost periodic minimal base flow are studied. Skew-product semiflows with (strongly) order preserving or monotone natures on fibers are given particular attention. It is proved that a linearly stable minimal set must be almost automorphic and become almost periodic if it is also uniformly stable. Other issues such as flow extensions and the existence of almost periodic global attractors, etc., are also studied.

The third part of the book deals with dynamics of almost periodic differential equations. In this part, the general theory developed in the previous two parts is applied to study almost automorphic and almost periodic dynamics which are lifted from certain coefficient structures (e.g., almost automorphic or almost periodic) of differential equations. It is shown that (harmonic or subharmonic) almost automorphic solutions exist for a large class of almost periodic ordinary, parabolic and delay differential equations.

Contents: Acknowledgment; Abstract; Almost automorphy and almost periodicity; Skew-product semiflows; Applications to differential equations.

Memoirs of the American Mathematical Society, Volume 136, Number 647


**General and Interdisciplinary**

**The Man Who Loved Only Numbers**

**The Story of Paul Erdős and the Search for Mathematical Truth**

Paul Hoffman

*Published by Hyperion Press.*

Paul Hoffman, publisher for the *Encyclopedia Britannica,* first met Erdős in 1986 and later endeavored to follow the ultimate peripatetic mathematician on his journeys. Hoffman’s book is the first full-length biography of Erdős. It offers an intimate look at his lifelong prodigy and his enormous circle of mathematical friends.

Readers learn many interesting facts about Erdős and his colleagues. Hoffman discusses Ron Graham’s journey from acrobat and juggler to leading mathematician at AT&T Bell Labs. Included is information about Graham’s role as “point of contact” for Erdős. Also revealed are interesting bits of Erdős trivia. For example, how did Hank Aaron come to have an Erdős number of one?

Through years of interviews with Erdős caretakers and devoted collaborators, the story emerges about the man and his magnificent obsession: the pursuit of mathematical truth. Against the backdrop of Fascism and the Cold War, the spirituality and universal beauty of numbers unfolds. The book captures the poetry of mathematics and shows what mathematics is for Erdős and his colleagues: pure order and beauty that transcends the physical world.

Distributed worldwide by the American Mathematical Society.

Contents: The two-and-a-half-billion-year-old man; Straight from the book; Epszi’s enigma; Problems with Sam and Joe; Einstein vs. Dostoyevsky; Dr. worst case; Marginal revenge; “God made the integers”; Getting the goat; Survivors’ party; “We mathematicians are all a little bit crazy”; Acknowledgments and source notes; Bibliography; Index.


**A Gentle Introduction to Game Theory**

Saul Stahl, *University of Kansas, Lawrence*

The mathematical theory of games was first developed as a model for situations of conflict, whether actual or recreational. It gained widespread recognition when it was applied to the theoretical study of economics by von Neumann and Morgenstern in *Theory of Games and Economic Behavior* in the 1940s. The later bestowal in 1994 of the Nobel Prize in economics on Nash underscores the important role this theory has played in the intellectual life of the twentieth century.

This volume is based on courses given by the author at the University of Kansas. The exposition is "gentle" because it requires only some knowledge of coordinate geometry; linear programming is not used. It is "mathematical" because it is more concerned with the mathematical solution of games than with their applications.

Existing textbooks on the topic tend to focus either on the applications or on the mathematics at a level that makes the works inaccessible to most non-mathematicians. This book nicely fits in between these two alternatives. It discusses examples and completely solves them with tools that require no more than high school algebra.

In this text, proofs are provided for both von Neumann's Minimax Theorem and the existence of the Nash Equilibrium in the \( 2 \times 2 \) case. Readers will gain both a sense of the range of applications and a better understanding of the theoretical framework of these two deep mathematical concepts.

Contents: Introduction; The formal definitions; Optimal responses to specific strategies; The minimax strategy; The minimax strategy; Solutions of zero-sum games; \( 2 \times n \) and \( m \times 2 \) games; Dominance; Symmetric games; Poker-like games; Pure maximin and minimax strategies; Pure nonzero-sum games; Mixed strategies for nonzero-sum games; Finding mixed Nash equilibria for \( 2 \times 2 \) nonzero-sum games; Bibliography; Solutions to selected exercises; Index.

Mathematical World, Volume 13

M-Theory
Edward Witten, Institute for Advanced Study, Princeton, NJ

The problem of unifying quantum mechanics and gravity in a single coherent theory represents an enormous obstacle to full understanding of the forces of nature. The mysterious M-theory has emerged as a likely candidate for such a unifying theory. Whether the "M" stands for marvel or matrix, magic or membrane, it is clear that this area of research is among the most exciting and most profound in all of science today. Edward Witten, one of the world's boldest innovators in this field, provides insights into these extraordinary developments in a completely expository presentation. Students and researchers specializing in mathematics and physics will find this lecture especially appealing. However, because it is completely non-technical, large parts of it can easily be appreciated by viewers with little or no scientific or mathematical training.

This video will also be of interest to those working in mathematical physics.

August 1998, NTSC format on one-half inch VHS videotape, approximately 60 minutes, ISBN 0-8218-1350-1, 1991
Mathematics Subject Classification: 81, 83, Individual member $34.95, List $54.95, Institutional member $44.95, Order code VIDEO/1011

Geometry and Topology

Higher Homotopy Structures in Topology and Mathematical Physics
John McCleary, Vassar College, Poughkeepsie, NY, Editor

Since the work of Stasheff and Sugawara in the 1960s on recognition of loop space structures on H-spaces, the notion of higher homotopies has grown to be a fundamental organizing principle in homotopy theory, differential graded homological algebra and even mathematical physics. This book presents the proceedings from a conference held on the occasion of Stasheff's 60th birthday at Vassar in June 1996. It offers a collection of very high quality papers and includes some fundamental essays on topics that open new areas.

Features:
- Accessible to a broad audience interested in mathematics and physics.
- Offers a comprehensive overview of Stasheff's work.

Contents:
- Contains papers on very current research topics, including operads, combinatorial polyhedra, and moduli spaces.

Contemporary Mathematics

Topics in Symplectic 4-Manifolds
Ronald J. Stern, University of California, Irvine, Editor

A publication of International Press.
The National Science Foundation, International Press, and the University of California at Irvine sponsored the first annual IP Lecture Series—conceived by Peter Li and S.T. Yau, organized by Richard Wentworth and Ronald J. Stern and assisted by Julie Crosby. Over 200 research mathematicians attended the conference and made it an important success.
The lecture series included three one-hour lectures on "Seiberg-Witten and Gromov Invariants" delivered by Clifford Taubes. In addition, ten one-hour invited lectures were delivered by prominent researchers in 4-dimensional smooth and symplectic topology. The lectures by M. Atiyah, R. Gompf, G. Tian, D. McDuff, Y. Ruan, and Z. Szabó were written up for this volume.

International Press publications are distributed worldwide, except in Japan, by the American Mathematical Society.

Contents:
- M. Atiyah, Duality and quantum field theory; R. E. Gompf, Kirby calculus for Stein surfaces; J. Li and G. Tian, Virtual moduli cycles and Gromov-Witten invariants of general symplectic manifolds; D. McDuff, From symplectic...
Mathematical Physics

Quantum Classical Correspondence
D. H. Feng, Drexel University, Philadelphia, PA, and B. L. Hu, University of Maryland, College Park, Editors

A publication of International Press.

A serendipitous development of theoretical physics in the past decade was the apparent confluence of some major issues in several areas of physics: quantum measurement, quantum cosmology and semiclassical gravity, quantum chaos and mesoscopic physics. Although these areas address vastly different aspects of physics, covering atomic, molecular and quantum optics, condensed matter, nuclear physics, particle physics and general relativity, they all share the common concern of how the many quantum and classical features of matter and spacetime and their dynamics are related to each other. This fundamental issue—which lies at the base of all aspects of physics—was the theme of this conference, The Fourth Drexel Symposium on Quantum Nonintegrability.

The series of three conferences held at Drexel University (Philadelphia, PA) was designed to be a forum on quantum chaos and related topics. This book offers a broad perspective on the topic by encompassing the above-mentioned areas into one unifying conference theme: quantum-classical correspondence. The articles included in this volume help to bring into focus the basic issues these areas share.

Contents:

International Press

Mathematical Physics

New Publications Offered by the AMS

NOTICES OF THE AMS

NOVEMBER 1998

1389
Number Theory

Olga Taussky-Todd: In Memoriam
Michael Aschbacher, California Institute of Technology, Pasadena, Don Blasius, University of California, Los Angeles, and Dinakar Ramakrishnan, California Institute of Technology, Pasadena, Editors

A publication of International Press.

This volume presents the refereed proceedings from a one-day conference held in memory of Olga Taussky-Todd. The event was sponsored by the Pacific Journal of Mathematics and by Caltech, where the conference was held. Featured speakers have contributed their talks. Additional contributors were added for this special issue.

This text will also be of interest to those working in algebra and algebraic geometry.

International Press publications are distributed worldwide, except in Japan, by the American Mathematical Society.

Contents: M. Aschbacher, Finite groups acting on homology manifolds; A. M. Aubert, Some properties of character sheaves; D. Blasius, Period relations and critical values of $L$-functions; E. C. Dade, Blocks of fully graded rings; G. Denham and P. Hanlon, On the Smith normal form of the Varchenko bilinear form of a hyperplane arrangement; N. Elkies and B. H. Gross, Embeddings into the integral octonions; A. Freedman, R. N. Gupta, and R. M. Guralnick, Shirshov's presentations of Abelian algebraic groups; W. Luo and D. Ramakrishnan, Determination of modular elliptic curves by Heegner points; I. I. Piatetski-Shapiro, $L$-functions for $GSp_4$; K. A. Ribet, Images of semistable Galois representations; D. E. Rohrlich and J. B. Tunnell, An elementary case of Serre's conjecture; F. Shahidi, On non-vanishing of twisted symmetric and exterior square $L$-functions for $GL(n)$; H. Shahidi, Commutators which commute with one factor; R. Taylor, Icosahedral Galois representations; M. F. Vignéras, Extensions between irreducible representations of a $p$-adic $GL(n)$.

International Press


Finite Fields: Theory, Applications, and Algorithms

Ronald C. Mullin, University of Waterloo, ON, Canada, and Gary L. Mullen, Pennsylvania State University, University Park, Editors

The Fourth International Conference on "Finite Fields: Theory, Applications, and Algorithms" was held at the University of Waterloo in August 1997. This volume presents the refereed proceedings. Because of its applications in so many diverse areas, finite fields continue to grow in importance in modern mathematics. Finite fields now play particularly important roles in number theory, algebra, and algebraic geometry. They also play a crucial role in computer science, statistics, and engineering. Areas of application include but are not limited to algebraic coding theory, cryptography, and combinatorial design theory. Computational and algorithmic aspects of finite field problems are also growing in significance.

The conference drew workers in theoretical, applied, and algorithmic finite field theory. All papers were refereed. They are loosely classified as theoretical and applied and are listed under these general headings. The work contains up-to-date results from leading experts in the field.

Contents: J. V. Brawley, S. Gao, and D. Mills, Computing composed products of polynomials; S. D. Cohen and D. Hachenberger, Actions of linearized polynomials on the algebraic closure of a finite field; P. Fleischmann and W. Lempken, On degree bounds for invariant rings of finite groups over finite fields; S. Gao, J. Howell, and D. Panario, Irreducible polynomials of given forms; Y. Hellegouarch, An application of Galois calculus to $F_q[t]$; M. Henderson and R. Matthews, Composition behavior of sub-linearised polynomials over a finite field; P. Langevin and P. Solé, Kernels and defaults; H. Niederreiter and C. Xing, Global function fields with many rational places and their applications; G. Stein, Traces of roots of unity over prime fields; H. Stichtenoth, The Fermat curve in characteristic $p$; D. Wan, Computing zeta functions over finite fields; T. P. Berger, Cyclic alternate codes induced by an automorphism of a GRS code; C. Carlet, On Kerdock codes; J. Cusanelli, and J. Delpeyroux, Permutation group of the $q$-ary image of some $q^m$-ary cyclic codes; O. Keren and S. Kutsy, The number of solutions to a system of equations and spectra of codes; W. More, The 1D probable prime test; S. M. S. Müller, Carnihek numbers and Lucas tests; T. Blackmore and G. Norton, On the state complexity of some long codes; H. Sakazaki, E. Okamoto, and M. Hambo, ID-based key distribution system over an elliptic curve; R. Fuji-Hara and S. Shinohara, Symmetric sets of curves and combinatorial arrays; J. A. Wood, Weight functions and the extension theorem for linear codes over finite rings.

Contemporary Mathematics, Volume 225

Stochastic Partial Differential Equations: Six Perspectives
René A. Carmona, Princeton University, NJ, and Boris Rozovskii, University of Southern California, Los Angeles, Editors

The field of Stochastic Partial Differential Equations (SPDEs) is one of the most dynamically developing areas of mathematics. It lies at the cross section of probability, partial differential equations, population biology, and mathematical physics. The field is especially attractive because of its interdisciplinary nature and the enormous richness of current and potential future applications.

This volume is a collection of six important topics in SPDEs presented from the viewpoint of distinguished scientists working in the field and related areas. Emphasized are the genesis and applications of SPDEs as well as mathematical theory and numerical methods.


Mathematical Surveys and Monographs


Hodge Theory in the Sobolev Topology for the de Rham Complex
Luigi Fontana, Universitá di Milano, Italy, Steven G. Krantz, Washington University, St. Louis, MO, and Marco M. Peloso, Politecnico di Torino, Italy

In this book, the authors treat the full Hodge theory for the de Rham complex when calculated in the Sobolev topology rather than in the $L^2$ topology. The use of the Sobolev topology strikingly alters the problem from the classical setup and gives rise to a new class of elliptic boundary value problems. The study takes place on both the upper half space and on a smoothly bounded domain.

Features:
- A good introduction to elliptic theory, pseudodifferential operators, and boundary value problems
- Theorems completely explained and proved
- New geometric tools for differential analysis on domains and manifolds

Memoirs of the American Mathematical Society, Volume 131, Number 622; 1998; 100 pages; Softcover; ISBN 0-8218-0830-3; List $39; Individual member $23; Order code MEMO/131/622NA

An Introduction to Measure and Integration
Inder K. Rana, Indian Institute of Technology, Patna

This volume presents a motivated introduction to a subject that goes under various headings such as real analysis, Lebesgue measure and integration, measure theory, modern analysis, advanced analysis, etc.

Prerequisite for the text is a first course in mathematical analysis. The text can be used for a one-year course in the topic as indicated by the title. Due to the lecture-notes style of the text, it would also be appropriate to use for individual self-study. Included is a chart depicting the logical interdependence of the chapters.

1997; 380 pages; Hardcover; ISBN 81-7319-120-4; List $49; All AMS members $39; Order code IMINA

All prices subject to change. Charges for delivery are $3.00 per order. For optional air delivery outside of the continental U.S., please include $5.50 per item. Payment required. Order from: American Mathematical Society, P. O. Box 622, Providence, RI 02956-0666, USA. For credit card orders, fax 1-401-455-4124 or call toll free 1-800-321-4AMS (4267) in the U.S. and Canada, 1-401-455-4000 worldwide. Or place your order through the AMS bookstore at www.ams.org/bookstore. Residents of Canada, please include 7% GST.
Recently Reviewed AMS Publications

An Introduction to Infinite Ergodic Theory
Jon Aaronson, Tel Aviv University, Israel
Accessible to readers with a firm background in measure-theoretic probability... carefully organized and well written... invaluable both as an introduction and as a reference work on its subject, and this definitely is not just because it is the only one at the moment.
—Zentralblatt für Mathematik

Stochastic Analysis
Michael C. Cranston, University of Rochester, NY, and Mark A. Pinsky, Northwestern University, Evanston, IL, Editors
This very rich volume... is an extremely valuable contribution to the literature on the interplay between stochastics and analysis. The editors have done a marvellous job in collecting a number of papers on subjects which in their entirety constitute the current activities in the field... This volume has a particularly high standard and appears to be of special significance to current research activity in the ever-increasing field of stochastics and analysis.

Some Points of Analysis and Their History
Lars Garding, Lund University, Sweden
This lively book is a guided tour through some of the highlights of twentieth-century analysis... can be recommended... to a graduate student seminar... one can pick up a number of the gems of analysis without having to mine whole seams.
—Bulletin of the American Mathematical Society

Knots, Links, Braids and 3-Manifolds: An Introduction to the New Invariants in Low-Dimensional Topology
V. V. Prasolov, Moscow, Russia, and A. B. Sossinsky, Institute of Electronics and Mathematics, Moscow, Russia
Provides an excellent introduction both to classical material and recent developments in 3-dimensional topology and knot theory. The presentation is elementary and extremely clear... should not be missing on the bookshelf of any working and/or teaching low dimensional topologist.

Riemannian Geometry
Takashi Sakai, Okayama University, Japan
This book on differential geometry packs into about 350 pages a great variety of topics—from the basics to spectral geometry and the topology of Riemannian manifolds... A good text for a graduate course in which students are well-prepared and motivated... should also be a very good reference for a practicing mathematician interested in Riemannian geometry... touches on a great many subjects in addition to those it covers in detail.

The Ergodic Theory of Discrete Sample Paths
Paul C. Shields, University of Toledo, OH
A very original book on a topic of current interest written by an experienced author.

All prices subject to change. Charges for delivery are $3.00 per order. For optional air delivery outside of the continental U.S., please include $6.50 per item. Prepayment required. Order from: American Mathematical Society, P.O. Box 6248, Providence, RI 02906-0001, USA. For credit card orders, call 1-401-455-4046 or call toll free 1-800-321-4AMS (4267) in the U.S. and Canada, 1-401-455-4000 worldwide. Or place your order through the AMS bookstore at www.ams.org/bookstore. Residents of Canada, please include 7% GST.
Classified Advertisements

Positions available, items for sale, services available, and more

ALABAMA
THE UNIVERSITY OF ALABAMA AT BIRMINGHAM

Applications are invited for two tenure-track positions to begin September 1, 1999. One position is at the level of associate professor and one position is at the level of assistant professor. Applicants should have demonstrated strong potential in research commensurate with the level of the position and a commitment to excellent teaching. Postdoc experience is desirable for candidates applying for the position of assistant professor. All qualified candidates are encouraged to apply. We are especially interested in candidates whose research is compatible with the department's current research expertise in computational aspects of these research areas. Our home page can be found at http://www.math.uab.edu/.

In order to apply, please send a completed AMS standard cover sheet (available from the AMS - http://www.ams.org/employment/coversheet-info.html) and a curriculum vita. Review of applications will begin November 15, 1998, and will continue until the positions are filled. Please arrange for at least three letters of reference to be sent. Applications and letters of reference should be sent to the following address: Search Committee, Department of Mathematics, UAB, Birmingham, AL 35294-1170. UAB is an AA/EO Employeer.

CALIFORNIA
UNIVERSITY OF CALIFORNIA AT BERKELEY
Tenured or Tenure-track Position
Department of Mathematics
Berkeley, CA 94720

Pending budget approval, we invite applications for one or more positions effective July 1, 1999, at either the tenure-track (assistant professor) or tenured (associate or full professor) level, in the general areas of pure or applied mathematics.

Tenure-track applicants are expected to have demonstrated outstanding research potential, normally including major contributions beyond the doctoral dissertation. Such applicants should send a resume, and reprint or preprints, and/or dissertation abstract, and ask three people to send letters of evaluation to the Vice Chair of Faculty Affairs at the above address. It is the responsibility of the tenure-track applicants to make sure that letters of evaluation are sent. All letters of evaluation are subject to Berkeley campus policies on confidentiality of letters of evaluation, a summary of which can be found on our home page (http://math.berkeley.edu) by clicking on People, then Faculty Positions at Berkeley.

Tenure applicants are expected to demonstrate leadership in research and should send a curriculum vitae, list of publications, a few selected reprints or preprints, and the names and addresses of three references to the Vice Chair of Faculty Affairs at the above address. The applicant should indicate whether they are applying for an associate professor or full professor position. The department will assume responsibility to solicit letters of evaluation and will provide evaluators with a copy of the summary of policies on confidentiality of letters of evaluation.

All applicants are requested to use the AMS standardized application form and to indicate their subject area using the AMS subject classification numbers. The form is the Academic Employment in Mathematics, Application Cover Sheet. It is available at the AMS home page (http://www.ams.org/) and in the printed Notices. All applicants are requested to use the AMS standardized application form and to indicate their subject area using the AMS subject classification numbers. The form is the Academic Employment in Mathematics, Application Cover Sheet. It is available through the AMS at the following address: AMS, P.O. Box 6248, Providence, RI 02940. (321-4267) in the U.S. and Canada, or 401-455-4084 worldwide, for further information.

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 1998 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 fractional text. Headlines, 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 issue-September 18, 1998; January issue-October 26, 1998; February issue-November 12, 1998; March issue-December 21, 1998; April issue-January 16, 1999; May issue-February 23, 1999.

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-AMS (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, via fax, 401-331-3842, or send e-mail to classifieds@ams.org. AMS location for express delivery packages is 201 Charles Street, Providence, Rhode Island 02904. Advertisers will be billed upon publication.
courtesy of the American Mathematical Society.

We should receive material for both tenure-track and tenure applications no later than November 15, 1998. Applications postmarked after the deadline will not be considered. The University of California is an Equal Opportunity, Affirmative Action Employer.

UNIVERSITY OF CALIFORNIA AT BERKELEY
Temporary Postdoctoral Positions
Department of Mathematics
Berkeley, CA 94720

Several temporary positions beginning in fall 1999 are anticipated for new and recent Ph.D.s of any age, in any area of pure or applied mathematics. The terms of these appointments may range from one to three years. Applicants for NSF or other postdoctoral fellowships are encouraged to apply for these positions. Mathematicians whose research interests are close to those of regular department members will be given some preference. Applicants should send a resume and reprints, preprints, and/or dissertation abstract, and ask three people to send letters of evaluation to the Vice Chair for Faculty Affairs at the above address. All letters of evaluation are subject to confidentiality of letters of evaluation, a summary of which can be found on our home page (http://math.berkeley.edu/ by clicking on People, and then Faculty Positions at Berkeley). We request that applicants use the AMS standardized application form and indicate their subject area using the AMS subject classification numbers. The form is the Academic Employment in Mathematics, Application Cover Sheet. It is available courtesy of the American Mathematical Society.

We should receive this material no later than December 1, 1998. Applications postmarked after the deadline will not be considered. The University of California is an Equal Opportunity, Affirmative Action Employer.

UNIVERSITY OF CALIFORNIA, DAVIS
Visiting Research Assistant Professorships in Mathematics

Applications are invited for anticipated Visiting Research Assistant Professorship (VRAP) positions in the Department of Mathematics at the University of California, Davis, effective July 1, 1999. These positions are contingent upon budgetary and administrative approval.

Duties include mathematical research, undergraduate, and graduate teaching. The teaching load is four-quarter courses per year. Minimal qualifications include a Ph.D. degree in mathematical sciences and great promise in research and teaching. Applicants for these positions are required to have completed their Ph.D. no earlier than 1995. Visiting positions are renewable for a total of three years contingent upon satisfactory performance in research and teaching. Salaries for 1999 will be $38,500.

The Department of Mathematics is interested in applicants in the following areas for the VRAP positions: (1) Analysis/PDEs, (2) Applied Mathematics, (3) Geometry/Topology/Discrete Mathematics, (4) Mathematical Physics/Representation Theory, (5) Numerical Analysis/Scientific Computation.

The application deadline is December 15, 1998, or until positions are filled. To initiate the application process, request an application package by writing an e-mail message to: vraps@math.ucdavis.edu. Those who do not have access to e-mail can obtain a package by writing to: Chair of VRAP Search Committee, Department of Mathematics, University of California, Davis, California 95616-8633

The University of California, Davis, is an Affirmative Action/Equal Opportunity Employer with a strong institutional commitment to the achievement of diversity among its faculty and staff.

UNIVERSITY OF CALIFORNIA, RIVERSIDE
Department of Mathematics
Assistant Professor Position in Analysis

Applications and nominations are invited for an entry level, assistant professor position in analysis beginning July 1, 1999. A doctorate in mathematics is required as is demonstrated excellence or strong promise in research and teaching. Responsibilities include teaching undergraduate and graduate level courses and seminars, conducting scholarly research, and participating in service activities. Established criteria of the University of California determine salary and level of appointment. To assure full consideration, applicants should send their curriculum vitae, including a list of publications, and have at least three letters of recommendation sent to:
Analysis Search Committee, Department of Mathematics, University of California, Riverside, CA 92521-0135
by Tuesday, December 1, 1998. UCR is an Affirmative Action/Equal Opportunity Employer.

UNIVERSITY OF CALIFORNIA, SANTA CRUZ
Department of Mathematics

The Mathematics Department at the University of California, Santa Cruz, is recruiting for a tenure-track assistant professor position in analysis beginning July 1, 1999. A doctorate in mathematics is required as is demonstrated excellence or strong promise in research and teaching. Responsibilities include teaching undergraduate and graduate level courses and seminars, conducting scholarly research, and participating in service activities. Established criteria of the University of California determine salary and level of appointment. To assure full consideration, applicants should send their curriculum vitae, including a list of publications, and have at least three letters of recommendation sent to:
Analysis Search Committee, Department of Mathematics, University of California, Santa Cruz, CA 95064.

The application deadline is December 15, 1998, or until positions are filled. The University of California, Santa Cruz, is an Affirmative Action/Equal Opportunity Employer.

UNIVERSITY OF CALIFORNIA, SANTA CRUZ
Department of Mathematics

Applications and nominations are invited for an entry level, assistant professor position in analysis beginning July 1, 1999. A doctorate in mathematics is required as is demonstrated excellence or strong promise in research and teaching. Responsibilities include teaching undergraduate and graduate level courses and seminars, conducting scholarly research, and participating in service activities. Established criteria of the University of California determine salary and level of appointment. To assure full consideration, applicants should send their curriculum vitae, including a list of publications, and have at least three letters of recommendation sent to:
Analysis Search Committee, Department of Mathematics, University of California, Santa Cruz, CA 95064.

The application deadline is December 15, 1998, or until positions are filled. The University of California, Santa Cruz, is an Affirmative Action/Equal Opportunity Employer.

UNIVERSITY OF CALIFORNIA, SANTA CRUZ
Department of Mathematics

The Department of Mathematics at the University of California, Santa Cruz, is recruiting for a tenure-track assistant professor position in analysis beginning July 1, 1999. A doctorate in mathematics is required as is demonstrated excellence or strong promise in research and teaching. Responsibilities include teaching undergraduate and graduate level courses and seminars, conducting scholarly research, and participating in service activities. Established criteria of the University of California determine salary and level of appointment. To assure full consideration, applicants should send their curriculum vitae, including a list of publications, and have at least three letters of recommendation sent to:
Analysis Search Committee, Department of Mathematics, University of California, Santa Cruz, CA 95064.

The application deadline is December 15, 1998, or until positions are filled. The University of California, Santa Cruz, is an Affirmative Action/Equal Opportunity Employer.

UNIVERSITY OF CALIFORNIA, SANTA CRUZ
Department of Mathematics

The Mathematics Department at the University of California, Santa Cruz, is recruiting for a tenure-track assistant professor position in analysis beginning July 1, 1999. A doctorate in mathematics is required as is demonstrated excellence or strong promise in research and teaching. Responsibilities include teaching undergraduate and graduate level courses and seminars, conducting scholarly research, and participating in service activities. Established criteria of the University of California determine salary and level of appointment. To assure full consideration, applicants should send their curriculum vitae, including a list of publications, and have at least three letters of recommendation sent to:
Analysis Search Committee, Department of Mathematics, University of California, Santa Cruz, CA 95064.

The application deadline is December 15, 1998, or until positions are filled. The University of California, Santa Cruz, is an Affirmative Action/Equal Opportunity Employer.
COLORADO

UNIVERSITY OF COLORADO AT BOULDER
Department of Mathematics

Applications are invited for a tenure-track faculty position at the assistant professor level beginning in the fall of 1989 in algebraic geometry. Candidates should have earned a Ph.D. in mathematics by August 1999, have demonstrated interest and ability in teaching, and have experience in and commitment to mathematical research.

This position requires teaching at various levels, mathematical research, and service. The ideal candidate will have a strong research emphasis in algebraic geometry. Applications, including a resume and four letters of reference, should be sent to: Search Committee, Department of Mathematics, Campus Box 395, University of Colorado, Boulder, CO 80309-0395. Reviewing of applications will begin December 15, 1998, and continue until the position is filled.

The University of Colorado is committed to diversity and equality in education and employment.

CONNECTICUT

CONNECTICUT COLLEGE

Connecticut College invites applications for a tenure-track assistant professor position in the Mathematics Department starting August, 1999. Requirements include a Ph.D. in mathematics, teaching experience, and a strong commitment to quality teaching and research.

We are seeking an individual whose area of specialization will strengthen our course offerings in one or more of the following areas: analysis, complex analysis, topology, and/or geometry. Responsibilities include contributing to the research environment in the department, and helping to foster a stimulating atmosphere for both undergraduate mathematics majors and other students who take mathematics courses at the College. The ability to participate in collaborative research with undergraduates is highly desirable.

Connecticut College is an small, private, highly selective college with a strong commitment to the liberal arts tradition. Interdisciplinary teaching and research are encouraged. The teaching load is five courses per year. More information about this position and the College may be obtained at our Web page http://www.conn. edu/cacadd/Mth/jeb.htm.

Applications should be sent to a letter of application, curriculum vitae, statements on teaching and research, and three to five letters of reference to:

Professor Kathleen A. McKeon
Connecticut College Box 5561
New London, CT 06320
(860) 439-2012
(860) 439-2700 (fax)
e-mail: math-dept@conn collaps.edu

Review of applications will begin November 30, 1998, and continue until the position is filled.

Connecticut College is an Affirmative Action/Equal Opportunity Employer and is actively seeking to further diversify its faculty and staff.

FLORIDA

UNIVERSITY OF CENTRAL FLORIDA
Department of Mathematics
Orlando, FL 32816-1364

Applications are invited for at least one tenure-track position starting August 1999 at the rank of assistant professor. Candidates must have a Ph.D. in mathematics at the time of application and a history of good teaching, strong research, and grant funding (or a high potential for funding). Fields of interest include: graph theory, combinatorics, mathematical optimization with additional expertise in algebra or combinatorics, mathematical optimization with additional expertise in operations research, and applied areas of mathematics related to differential equations and approximation. The department offers a BS, MS, and Ph.D. in mathematics. Please arrange for vita, transcripts, and at least three letters of reference to be sent to Chair of Search Committee, Department of Mathematics, University of Central Florida, Orlando, FL 32816-1364. In order to receive full consideration, applications should be postmarked by December 15, 1998.

The University is an Equal Opportunity Affirmative Action Employer.

GEORGIA

GEORGIA INSTITUTE OF TECHNOLOGY

The School of Mathematics expects to have visiting and tenure-track positions at various levels in pure and applied mathematics and statistics, beginning in fall 1999. The School intends to expand its areas of expertise and foresees the potential for 10-15 new appointments in the next 5 years. Candidates with strong research and teaching records or potential should be sent to: Chair of Search Committee, School of Mathematics, Georgia Institute of Technology, Atlanta, GA 30332-0160 USA. Georgia Tech, an institution of the University System of Georgia, is an Equal Opportunity/Affirmative Action Employer.

ILLINOIS

NORTHERN ILLINOIS UNIVERSITY

Anticipated assistant professorship with a specialization in arithmetic algebraic geometry. Ph.D. or equivalent and strong potential in research and teaching required. Application (vita), transcripts, three letters of reference, and a description of research program and teaching experience should be sent to: arithmetic algebraic geometry position, c/o Professor William D. Blair, Department of Mathematical Sciences, Northern Illinois University, DeKalb, IL 60115, by December 31, 1998. AA/EEO.
tions at the assistant professor level available beginning August 16, 1999. Applicants must have an active research program involving differential equations which is interdisciplinary in nature. Preference will be given to applicants doing research in differential equations and mathematical biology. Ph.D. in mathematics required at time of appointment. Candidates must show evidence of, or strong potential for, excellence in both research and teaching. Postdoctoral experience preferred. Send letter of application, CV, and three letters of recommendation to: Differential Equations Position, Department of Mathematics, Southern Illinois University, Carbondale, IL 62901-4408. Closing date is December 1, 1998, or until position is filled. SIUC is an Equal Opportunity/Affirmative Action Employer. Women and minorities are particularly encouraged to apply.

ELMHURST COLLEGE
Mathematics Department

Tenure-track position beginning fall 1999 (pending approval of the Board of Trustees). Qualifications desired: Ph.D. in mathematics at time of hire, interest in continued undergraduate teaching in a liberal arts college. Teaching load: six courses per year. Elmhurst College is a four-year private institution located in the western suburbs of Chicago. Applications should include a curriculum vitae and three letters of reference. Please send to Prof. L. Johnson, Dept. of Mathematics, Elmhurst College, 190 Prospect Ave., Elmhurst, IL 60126, by January 1, 1999. Minority and women candidates are strongly urged to apply. EOE.

UNIVERSITY OF ILLINOIS AT CHICAGO
Dept. of Mathematics, Statistics, and Computer Science

The department has active research programs in all areas of pure mathematics, computational and applied mathematics, combinatorics and computer science, statistics, and mathematics education. See http://www.math.uic.edu for more information. Applications are invited for the following positions, effective August 21, 1999. First, a tenure-track or tenured position. Candidates must have a Ph.D. or equivalent degree in mathematics, computer science, or related field, an outstanding research record, and evidence of strong teaching ability. Salary negotiable. Second, a research assistant professorship. This is a non-tenure track position normally renewable annually to a maximum of three years. The position carries a teaching load of one course per semester, with the requirement that the incumbent play a significant role in the research life of the department. The salary for FY 1999 is $40,000. Applicants must have a Ph.D. or equivalent degree in mathematics, computer science, or related field, and evidence of outstanding research potential. We encourage applicants to submit an electronic cover letter. The electronic cover letters may be sent to the email address at http://www.math.uic.edu or may be obtained by sending an e-mail to the address phds@math.uic.edu. However, for this search we still require that an original paper application must also be submitted. Send vita and direct three letters of recommendation, indicating the position being applied for, to: Henri Gillet, Head, Dept. of Mathematics, Statistics, and Computer Science, University of Chicago, 5760 S. Morgan (M/C 249), Chicago, IL 60607. To be considered, materials must be received by September 15, 1999. Minorities, persons with disabilities, and women are particularly encouraged to apply. UIC is an AA/EOE employer.

ILLINOIS WESLEYAN UNIVERSITY

The Department of Mathematics and Computer Science at Illinois Wesleyan University invites applications for a full-time, tenure-track position jointly in both mathematics and computer science to begin August 1999. Candidates must have a Ph.D. in computer science or mathematics and possess considerable expertise in both areas. The position is open to all areas of specialization in mathematics and CS.

Illinois Wesleyan is a highly selective undergraduate liberal arts university of 1,900 students located in Bloomington, Illinois, a community of about 100,000. The Department of Mathematics and Computer Science is located in the new Center for Natural Science Learning and Research. This $25 million facility is equipped with over thirty Sun SPARC stations for student and faculty use. For additional information on the computer science curriculum and facilities see http://www.cs.wesleyan.edu. Send letter of application, AMS cover sheet, and resume, and three letters of reference under separate cover, to: Dr. Mervyn Jeter, Chair, Department of Mathematics and Computer Science, Illinois Wesleyan University, P.O. Box 2900, Bloomington, IL 61702-2900.

Illinois Wesleyan University is an Equal Opportunity Employer. Applications will be reviewed beginning January 31, 1999. Preference may be given to candidates who complete by this date. Preliminary interviews for this position will be held at the Joint Mathematics Meetings in San Antonio, Texas (January 1999). Review of applications will continue until the position is filled.

NORTHEASTERN UNIVERSITY
Department of Mathematics
2033 Sheridan Road
Evanston, Illinois 60208-2730
Boas Assistant Professor

Applications are solicited from people whose research is related to probability for two Ralph Boas assistant professorships of three years each starting in September 1999. These positions are part of the Emphasis Year in Probability which the department will be sponsoring in 1999-2000.

Applications should be sent to the Emphasis Year Committee at the department address and include: (1) the American Mathematical Society's Application 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.

Classified Advertisements

Interviews for this position may be held at the Joint AMS-MAA Mathematics Meetings in San Antonio, Texas (January 1999).

I. WESLEYAN UNIVERSITY

The Department of Mathematics and Computer Science at Illinois Wesleyan University invites applications for a full-time, tenure-track position jointly in both mathematics and computer science to begin August 1999. Candidates must have a Ph.D. in computer science or mathematics and possess considerable expertise in both areas. The position is open to all areas of specialization in mathematics and CS.

Illinois Wesleyan is a highly selective undergraduate liberal arts university of 1,900 students located in Bloomington, Illinois, a community of about 100,000. The Department of Mathematics and Computer Science is located in the new Center for Natural Science Learning and Research. This $25 million facility is equipped with over thirty Sun SPARC stations for student and faculty use. For additional information on the computer science curriculum and facilities see http://www.cs.wesleyan.edu. Send letter of application, AMS cover sheet, and resume, and three letters of reference under separate cover, to: Dr. Mervyn Jeter, Chair, Department of Mathematics and Computer Science, Illinois Wesleyan University, P.O. Box 2900, Bloomington, IL 61702-2900.

Illinois Wesleyan University is an Equal Opportunity Employer. Applications will be reviewed beginning January 31, 1999. Preference may be given to candidates who complete by this date. Preliminary interviews for this position will be held at the Joint Mathematics Meetings in San Antonio, Texas (January 1999). Review of applications will continue until the position is filled.

NORTHEASTERN UNIVERSITY
Department of Mathematics
2033 Sheridan Road
Evanston, Illinois 60208-2730
Boas Assistant Professor

Applications are solicited from people whose research is related to probability for two Ralph Boas assistant professorships of three years each starting in September 1999. These positions are part of the Emphasis Year in Probability which the department will be sponsoring in 1999-2000.

Applications should be sent to the Emphasis Year Committee at the department address and include: (1) the American Mathematical Society's Application 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.

November 1998 Notices of the AMS 1397
In order to ensure full consideration, applications should be received by December 1, 1998. 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, Illinois 60208-2730

Applications are invited for anticipated tenure-track or tenured positions starting September 1999. Priority will be given to exceptionally promising research mathematicians. Fields of interest within the department include algebra, algebraic geometry, analysis, dynamical systems, probability, partial differential equations, and topology.

Application material should be sent to Personnel Committee, at the department address and include: (1) the American Mathematical Society's Application Cover Sheet for Academic Employment, (2) 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 November 1998. Northwestern University is an Affirmative Action/Equal Opportunity Employer committed to fostering a diverse faculty; women and minority candidates are especially encouraged to apply.

INDIANA

UNIVERSITY OF NOTRE DAME
Department of Mathematics
Notre Dame, IN 46556

Regular Positions in Pure Mathematics

The Department of Mathematics of the University of Notre Dame invites applications for two positions starting August 24, 1999. The fields of interest are algebraic geometry, differential geometry, and Lie representation theory, but outstanding candidates in all fields are encouraged to apply. The positions are at the tenure-track level, though a tenured appointment may be possible for an exceptional candidate. The teaching load is one course per semester. Salaries are competitive. Applications, including a curriculum vitae, a letter of application, and a completed AMS Standard Cover Sheet, should be sent to: Alexander J. Hahn, Chair, at the above address. Applications 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 teach articulately and 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 1999; 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 7, 1998, but applications for positions will be reviewed until February 1, 1999, or until positions are closed. AA/EOE

MARYLAND

UNIVERSITY OF MARYLAND
AT COLLEGE PARK
Department of Mathematics

Applications are invited for tenure and tenure-track positions in the Department of Mathematics. Strong preference will be given to applicants whose primary interest is in one of the following categories: (1) algebra, number theory, and algebraic geometry; (2) applied and computational harmonic analysis; (3) probability and statistics, with an emphasis on applications, including applications to financial mathematics.

Candidates at all levels will be considered. Priority will be given to applications received by November 1, 1998. Applications will commence in fall 1999.

The University of Maryland is an Equal Opportunity and 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, Maryland 20742

UNIVERSITY OF MARYLAND
Nonlinear Dynamics and Chaos
Experimental and Mathematical/Computational Faculty

The University of Maryland is seeking two senior and two junior faculty members to join an interdisciplinary research group in nonlinear dynamics and chaos. Two experimental physicists are sought for tenured or tenure-track appointments in the Department of Physics, possibly joint with the Institute for Physical Science and Technology. Two theoretical nonlinear dynamists with a strong interest in computation are sought for tenured or tenure-track positions in the Department of Mathematics, possibly joint with Physics or with the Institute for Physical Science and Technology. An outstanding record or research accomplishments and a proven ability to attract research support are important for the senior positions. Applicants for the experimental positions should reply to: Experimental Nonlinear Dynamics Search, Department of Physics, University of Maryland, College Park, MD 20742-4111. Applicants for the mathematical/computational
positions should reply to: Theoretical Nonlinear Dynamics Search, Department of Mathematics, University of Maryland, College Park, MD 20742-4111. Good teaching is a priority of the university. Priority will be given to applications received by December 1, 1998. The University of Maryland is an Equal Opportunity/Affirmative Action Employer.

MASSACHUSETTS

WILLIAMS COLLEGE
Department of Mathematics
Williamstown, Massachusetts 01267

Anticipated tenure-eligible position in statistics, beginning fall 1999, probably at the rank of assistant professor. In exceptional cases, however, more advanced appointments may be considered. Excellence in teaching and statistics, including scholarship and consulting, and Ph.D. required. Applicants with emphasis in operations research will also be considered.

Please have a vita and three letters of recommendation on teaching and research sent to Hiring Committee. Evaluation of applications will begin November 15 and continue until the position is filled. As an EEO/AA employer, Williams especially welcomes applications from women and minority candidates.

MICHIGAN

CENTRAL MICHIGAN UNIVERSITY
Department of Mathematics

The Department of Mathematics invites applications for a tenure-track position in statistics at the assistant professor level or higher. Candidates should have a Ph.D. in statistics or mathematics, show evidence of having conducted research in statistics, and have effective communication skills. The successful candidate will be expected to: teach graduate and undergraduate statistics and mathematics courses, conduct research in statistics and apply for external funding. Of special interest are individuals with expertise in actuarial science, and with research interests that overlap existing research of the faculty. The usual teaching load is nine semester hours. Salary is competitive and benefits include university-paid retirement, medical, dental, disability, and group life insurance. Pending administrative approval, a second tenure-track position in statistics may also be available.

Central Michigan University has an enrollment of 16,600, of which 2,000 are graduate students, and offers Bachelor’s, Master’s, and Ph.D. degrees. The Department of Mathematics, which includes pure and applied mathematics, statistics, and mathematics education, has thirty-one tenure-track faculty.

Please send a letter of application, résumé, transcript, and names of three references to: Professor Sidney Graham, Chair, Department of Mathematics, Central Michigan, Mt. Pleasant, MI 48859. Phone: 517-774-3596, fax: 517-774-2414, e-mail: math@cmich.edu. Web site: http://www.cmich.edu/units/mth/. Consideration of applications will begin on December 1, 1998, but applications will be accepted until the position is filled.

CMU, an AA/EO institution, is strongly committed to increasing diversity within its community (see http://www.cmich.edu/aaeo.html).

MISSOURI

UNIVERSITY OF MISSOURI-KANSAS CITY
Department of Mathematics and Statistics
Assistant Professorship in Statistics

The Department of Mathematics and Statistics invites applications for a tenure-track position of assistant professor of statistics, beginning in Fall 1999. The applicant should have a Ph.D. in statistics, or a Ph.D. in mathematics with a specialization in statistics. Duties include teaching courses in probability and statistics at both the undergraduate and graduate levels, and research of a quality sufficient to enable the successful candidate to participate in the department’s doctoral and masters programs. The salary is competitive.

Please apply to: Search Committee, Department of Mathematics and Statistics, 206 Haag Hall, University of Missouri-Kansas City, Kansas City, MO 64110-2499.

Applications should include a vita and three letters of recommendation sent to the above address. Prior experience is not necessary, but the application materials should demonstrate strong potential for successful research and effective teaching. Women and minorities are especially encouraged to apply. The University of Missouri-Kansas City is an Affirmative Action/Equal Opportunity Employer.

NEW HAMPSHIRE

DARTMOUTH COLLEGE
John Wesley Young Research Instructornship in Mathematics

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, combinatorics, differential geometry, logic and set theory, number theory, probability and topology. Teaching duties of four ten-week courses spread over two or three quarters typically include at least one course in the instructor’s specialty and include elementary, advanced and (instructor’s option) graduate courses. Nine-month salary of $40,000 supplemented by summer research stipend of $8,889 for instructors in residence for two months in summer. Send letter of application, résumé, graduate transcript, thesis abstract, description of other research activities and interests if appropriate, and three or preferably four 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 15 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.

DARTMOUTH COLLEGE

The Department of Mathematics anticipates a tenure-track opening for an assistant professor of mathematics in the field of combinatorics, with initial appointment in the 1999-2000 academic year. In exceptional cases, an appointment at a higher level is possible. A candidate for the 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 responsibilities in mathematics are 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 recommendation 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 15 will receive first consideration. Dartmouth is committed to Affirmative Action Equal Opportunity Employer.
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.

NEW JERSEY
MONTCLAIR STATE UNIVERSITY
Department of Mathematical Sciences

Applications are invited for a tenure-track position in pure and applied mathematics at the level of assistant professor. Starting date is September 1, 1999. The department is particularly interested in candidates with research interests that include applied mathematics especially in the areas of financial modeling or actuarial science. Candidates are required to have a Ph.D. in mathematics or applied mathematics.

Candidates are expected to be active scholars and to participate in professional and grant activities. Applicants must have a strong commitment to quality teaching in a broad range of courses at the undergraduate level and to a more specialized set of graduate courses.

The Department of Mathematical Sciences at Montclair State University includes undergraduate programs in mathematics, mathematics education, and physics; Master's programs in mathematics, mathematics education, and statistics. Currently, there are thirty full-time faculty in the department.

Applicants should send a vita, a statement of professional goals, research interests and teaching philosophy, and three letters of recommendation to: Department of Mathematical Sciences, Montclair State University, Upper Montclair, NJ 07043. Screening begins immediately and continues until the position is filled.

Montclair State University is an Equal Opportunity/Affirmative Action Employer. Women and minorities are encouraged to apply. Subject to available funding.

RUTGERS UNIVERSITY
Mathematics

The Rutgers University Mathematics Department invites applications for the following positions which may be open beginning September, 1999.

1) Tenure-track and tenure positions. The department anticipates a few openings, mainly tenure-track assistant professorships. Current priority areas include analysis and geometry. However, strong candidates in all fields are encouraged to apply and will be given careful consideration. Candidates must have Ph.D., outstanding research ability in pure or applied mathematics, and concern for teaching. Semester course load now averages six hours.

2) Hill Assistant Professorship (non-tenure track). The Hill Assistant Professorships are five-year renewable positions. Candidates should have received the Ph.D. show outstanding promise of research ability in pure or applied mathematics, and have concern for teaching. Semester course load is approximately six to seven hours.

Applicants should send resume, with the AMS Application Cover Sheet attached, and have at least three letters of recommendation sent to: Search Committee, Department of Mathematics-Hill Center, Rutgers University, 110 Frelinghuysen Road, Piscataway, NJ 08854-8019. No electronic applications will be accepted. Applications should be received by January 5, 1999. Please indicate position(s) desired and give the AMS Subject Classification number of your area(s) of specialization.

Applicants who applied in 1997-98 may, if you wish, request to have your previous application reactivated and submit only such new materials as you choose. Rutgers is an Affirmative Action/Equal Opportunity Employer and encourages applications from women and minority-group members.

NORTH CAROLINA
UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL
Department Of Mathematics

We invite applications for a three-year, nonrenewable research assistant professorship effective fall 1999. Applicants must have a recent Ph.D. in an area of pure mathematics which is currently represented in the department. A strong research potential and a commitment to teaching is required. The teaching load is three courses per year.

Send a curriculum vitae, abstract of current research, statement of teaching goals and four letters of recommendation to: Search Committee, Department of Mathematics, CB #3250 Phillips Hall, UNC-Chapel Hill, Chapel Hill, NC 27599-3250. A copy of this ad may be found on our Website at http://www.math.unc.edu/ under "General Job Announcements." Further information about the Mathematics Dept. may be found at our website http://www.math.unc.edu. EO/AA Employer. Women and minorities are encouraged to apply and to identify themselves voluntarily. Applications received by January 15 are assured of full consideration.

UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL
Tenure-Track Position in Mathematics

Applications are invited for one tenure-track assistant or associate professor position in applied mathematics, with employment to begin fall 1999. Preference will be given to an exceptional candidate in applied scientific computation. A strong research record and doctorate in mathematics, applied mathematics, or a closely related field are required. Preference is given to candidates with a commitment to interdisciplinary university research, collaborations with industry or government, and teaching including development of applied math curricula at undergraduate and graduate levels. This position contributes toward an aggressive plan to build a strong applied and computational mathematics group interacting with existing strengths at UNC in mathematics.

The Ohio State University at Lima, located in northwest Ohio, is one of four regional campuses of The Ohio State University. Full- and part-time faculty in all departments number about 100; we have a current enrollment of approximately 1,500 students. There are eight full-time faculty in the Mathematics Department, and the Department supports a Program Coordinator responsible for the Math Learning Center. Ohio State Lima offers the first two years of the Ohio State General Education Curriculum, three years of course work in many departments, and full programs leading to Bachelor's degrees in psychology, elementary education, and English, and to Master's degrees in education and social work.

Please send letter of application, curriculum vitae, and three letters of reference to Phillip A. Heath, Associate Dean, Mathematics Department Search Committee, 4240 Campus Drive, Lima, OH 45804. For consideration in the first round of screening, applications must be postmarked by December 18, 1998. The Ohio State University is an Equal Opportunity, Affirmative Action Employer. Women, minorities, Vietnam-era veterans, disabled veterans, and individuals with disabilities are encouraged to apply.

Ohio State University

University of Dayton is an Equal Opportunity and Affirmative Action Employer.

Ohio State University at Lima

Applications are invited for two tenure-track positions at the assistant professor level starting in August 1999, one in analysis or applied mathematics, and one in set-theoretic topology or graph theory. Candidates must have a Ph.D. degree in the appropriate area, and preference will be given to those whose research interests are compatible with those of current faculty. For both positions, applicants must have a strong commitment to research and the potential to become an effective teacher.

Responsibilities for the analysis or applied mathematics position include developing and maintaining a research agenda, teaching applied mathematics courses at the graduate level, and advising students and curriculum development in the Master's level program in mathematics. Responsibilities also include teaching a broad range of mathematics courses at the undergraduate level.

Responsibilities for the set-theoretic topology or graph theory position include developing and maintaining a research agenda, teaching a broad range of courses, advising, and curriculum development in the undergraduate program. The applicant will also be expected to work with undergraduate students outside of the traditional classroom setting.

The selection process will begin on December 7, 1998. To receive full consideration, all materials must be received by January 16, 1999. The application package should consist of a current curriculum vitae, abstract of current research, and at least three letters of recommendation. All materials must be sent to: Dr. Ralph Steinlage, Chair of the Topology/Graph Theory Search Committee, Department of Mathematics, University of Dayton, Dayton, OH 45469-2316. Further information can be obtained at http://www.udayton.edu/mathdept/.

The University of Dayton is a private comprehensive Catholic university founded by the Society of Mary in 1850. It has more than 6000 undergraduates and 3000 graduate students. The Department of Mathematics offers B.A. and B.S. degrees in mathematics and the M.S. degree in applied mathematics; our graduate courses also serve the students in the Ph.D. programs in the School of Engineering. The
231 W. 18th Avenue, Columbus, Ohio 43210.

The Ohio State University is an Equal Opportunity/Affirmative Action Employer. Women and minority candidates are encouraged to apply.

WRIGHT STATE UNIVERSITY
Department Chair
Mathematics & Statistics Dept. with thirty-three Ph.D. faculty in metro Dayton area; see http://www.math.wright.edu. Extensive BS programs plus MS in pure or applied math and in applied statistics. Faculty research is emphasized.

Candidates must qualify for appointment as full professor with earned Ph.D. in mathematics or statistics and an excellent record in research and teaching, with leadership experience in program development and administration. Qualities preferred include the ability to provide leadership in a cooperative, supportive collegial environment, experience with both graduate and undergraduate programs, sensitivity to students, and effective interpersonal and communication skills.

Review begins 21 Dec. 98, continuing until position filled. Send vita; brief leadership philosophy statement; names, addresses, phone numbers of five references to: M&S Chair Search Committee, College of Science & Mathematics, 134 Oelman Hall, Wright State University, Dayton, OH 45435.


OKLAHOMA
SAXON PUBLISHERS, INC.
Secondary Mathematics
Assistant Editor
One year assignment (with possible opportunity of renewal in one year increments), Saxon Publishers, Inc., a K-12 textbook publisher, is seeking an assistant secondary math editor to assist a senior editor in revising a 2nd year algebra text. Candidate must be willing to relocate and work onsite. Qualifications: excellent writing and editing skills, solid mathematics background as evidenced by graduate studies and advanced degree. Preferred: familiarity with the Saxon pedagogy, classroom experience with secondary students teaching high school level math, editing experience in the publishing industry. Salary commensurate with experience. Please send résumé, transcript and salary requirements to Saxon Publishers, Inc., Attn: Human Resources, 1320 W. Lindsey, Norman, OK 73069.

OREGON
UNIVERSITY OF OREGON
Applications are being accepted for a two-year postdoctoral position in mathe-

ics or mathematical statistics beginning September, 1999. This is a research position with a reduced teaching load. Qualifications are a Ph.D. in mathematics or mathematical statistics, research accomplishment, and evidence of teaching ability. Preference will be given to candidates with research interests that complement those currently represented. Competitive salary and excellent fringe benefits. Send complete résumé and three letters of recommendation to: Hiring Committee, Mathematics Department, 1222 University of Oregon, Eugene, OR 97403-1222. Closing date is Jun. 15, 1999. Women and minorities are encouraged to apply. An EO/AA/ADA Institution committed to cultural diversity.

PENNSYLVANIA
CARNEGIE MELLON UNIVERSITY
Department of Mathematical Sciences
Lecturer Track Positions
The Department of Mathematical Sciences at Carnegie Mellon University expects to make several lecturer track appointments for 1999-00. These are three-year appointments, with possible renewal, but are not eligible for indefinite tenure. Qualifications: doctorate, established success in education, familiarity with computer use in mathematics education. One of these positions will, in having to have responsibility for undergraduate teaching, be to support the CMAP Program at Carnegie Mellon. Detailed descriptions of all of these positions may be found on our Website: http://www.math.cmu.edu/. The deadline for applications is February 1, 1999. To apply send a letter of application and vita to: Lecturer Track Appointment Committee, Department of Mathematical Sciences, Carnegie Mellon University, Pittsburgh, PA 15213. Letters of reference may be requested. Carnegie Mellon University is an Affirmative Action/Equal Opportunity Employer.

RHODE ISLAND
BROWN UNIVERSITY
J. D. Tamarkin Assistant Professorship
One or more three-year nontenured non-renewable appointments, beginning July 1, 1999. Teaching load: two courses per semester (6 hours per week). Candidates are required to have received a Ph.D. degree by the start of this appointment, and they may have up to two years of academic and/or postdoctoral research experience by then. 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 vita, a completed application form, and three letters of recommendation must be received by December 1, 1998. Requests for application forms and all other inquiries should be addressed to: Assistant Professorship Committee, Department of Mathematics, Brown University, Providence, RI 02912. Application forms are also available from our Website: http://www.math.brown.edu/tamarkin.shtml, and standard AMS application forms are accepted. E-mail inquiries can be addressed to: tamsrch@math.brown.edu. Please do not request application forms by e-mail. Brown University is an Equal Opportunity/Affirmative
Applications are invited for a tenure-track position at the assistant professor level, starting in August 1999. Excellence in teaching and research/scholarship is essential.

A current curriculum vitae, three recent letters of reference, copies of all official transcripts, and a professional statement must be included in an application. Applications will be reviewed beginning November 1, 1998, and will be accepted until the position is filled. To ensure full consideration, an application should be received by January 4, 1999.

Baylor is a Baptist university affiliated with the Baptist General Convention of Texas. As an Affirmative Action/Equal Employment Employer, Baylor encourages minorities, women, veterans, and persons with disabilities to apply. The University offers generous benefits including tuition remission for qualified family members. Send all materials to Mathematics Search Committee, P. O. Box 97328, Waco, TX 76798-7328, e-mail address: Ed_Dzfo rd@baylor.edu.

SOUTHERN METHODIST UNIVERSITY
Department of Mathematics

Applications are invited for two tenure-track assistant professor positions to begin in the fall semester of 1999. Applicants must provide evidence of outstanding potential for research in applied mathematics and a strong commitment to teaching at all levels. The Department of Mathematics has an active doctoral program in applied mathematics, specializing in physical applied mathematics, numerical mathematics and scientific computation. Research interests include fluid mechanics, nonlinear dynamics and the computational aspects of ordinary and partial differential equations. For one position, preference will be given to candidates whose research has an applied component related to industrial applications and/or to other sciences or engineering. The second position is open to any applied mathematician whose research is closely related to the current interests of the department.

To apply, send a letter of application with a curriculum vita, a list of publications, a research statement and a teaching statement to: The Faculty Search Committee, Department of Mathematics, Southern Methodist University, P. O. Box 750150, Dallas, Texas 75275-0150. Applicants must also arrange for three letters of recommendation to be forwarded to the Faculty Search Committee.

The committee will begin its review of the applications on or about January 5, 1999. To ensure full consideration for the position, the application must be postmarked on or before January 5, 1999.

SMU is an Equal Opportunity/Affirmative Action/Title IX Employer.

TEXAS A&M UNIVERSITY
Department of Mathematics

Applications are invited for tenured and tenure-track positions beginning fall 1999. Highest priority will be given to candidates in statistics/bio-statistics. Subject to availability of resources, consideration will also be given to candidates in numerical analysis or bio-mathematics. Applicants must possess a Ph.D. Strong promise in research and teaching is required. Please send a resume and three letters of recommendation to: Alex Wang, Hiring Chair, Department of Mathematics and Statistics, Texas A&M University, Lubbock, TX 79499-1042. Review of applications will begin on December 15, 1998, and will continue until the positions are filled. Additional information is available at http://www.math.ttu.edu/employ.html. Texas A&M is an AA/EEO employer.
Classified Advertisements

send the completed form, a vita, and arrange to have letters of recommendation sent to:
Faculty Hiring
Department of Mathematics
Texas A&M University
College Station, Texas 77843-3368
For full consideration, the complete dossier should be received by January 15, 1999. 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.

TRINITY UNIVERSITY
The Department of Mathematics invites applications for two tenure-track positions at the assistant professor level starting in August 1999. Excellence in teaching is essential, and strong potential in research is expected. Exceptional candidates in any area of mathematics will be considered. However, the department is particularly interested in filling one position in analysis and one in discrete mathematics. Applicants should provide a curriculum vitae, three letters of reference, transcripts, and a professional statement describing their philosophy about both teaching and research. Applications received by December 4, 1998, will be given full consideration. Send all materials to: Chair of the Search Committee, Department of Mathematics, Trinity University, San Antonio, Texas 78212; Phone: 210-736-8205, e-mail: math@trinity.edu.

UTAH

UTAH STATE UNIVERSITY
Head
Department of Mathematics and Statistics
Applications are invited for the position of Head of the Department of Mathematics and Statistics at Utah State University. Applicants should have a doctorate in mathematics or statistics, should qualify for a full professorship at USU, and should enjoy an outstanding and current record of research, excellent teaching credentials at the undergraduate and graduate levels, and an established record of university and professional service. Applicants must possess demonstrated administrative skills and leadership abilities necessary to promote the development of a growing department with diverse research, teaching, and service responsibilities and goals. A strong commitment to support scholarly activity in pure and applied mathematics, statistics, and mathematics education, and to undergraduate and graduate education is required.

Utah State University is a Carnegie 1, Land-Grant institution with an enrollment of 16,000 undergraduate and 4,000 graduate students. The Department of Mathematics and Statistics offers the Ph.D. degree in mathematical sciences and various degree programs at the masters and bachelor levels. The department has approximately thirty-five faculty members with research interests in pure mathematics, applied mathematics, mathematical physics, computational mathematics, mathematics education, and statistics.

Utah State University is located in Cache Valley, just north of the Wasatch Range of the Rocky Mountains. More information about the university and department can be found at http://www.usu.edu/.
The committee will begin screening applications on December 15, 1998, and continue until the position is filled. Send a letter of application, vita, telephone number and e-mail address, and a list of names, mailing addresses, and e-mail addresses of five references to:
Chairman, Screening Committee
Mathematics and Statistics Department
Utah State University
Logan, Utah 84322-3000
Two references should be able to evaluate administrative and leadership skills and one reference should address teaching credentials. For further information, please direct inquiries to deansrch@math.usu.edu.
Utah State University is an Equal Opportunity/Affirmative Action Employer.

UNIVERSITY OF UTAH
The Department of Mathematics at the University of Utah invites applications for the following positions. Availability of positions is contingent upon funding. The hiring committee will select candidates based on their teaching experience and research record.
1. At least one full-time tenure-track appointment in the assistant or associate professorial levels. The department is primarily interested in applicants who work in the research areas represented in the department and who received their Ph.D. degrees prior to 1998.
2. One or more visiting faculty positions of one year or less in any of the professorial ranks, depending upon availability.

To apply for any of these positions, you are strongly encouraged to fill out an application at http://www.math.utah.edu/jobs/ or send the AMS cover sheet. To complete your application, send a curriculum vitae, bibliography, and three letters of recommendation. Visiting professor applicants should indicate the part of the year they wish to visit. Incomplete files will not be considered.

Please send this information to Committee on Staffing, Department of Mathematics, University of Utah, 135 S. 1400 E. JW Marriott 233, Salt Lake City, UT 84112.
The University of Utah is an Equal Opportunity, Affirmative Action Employer and encourages applications from women and minorities, and provides reasonable accommodation to the known disabilities of applicants and employees.

CANADA

UNIVERSITY OF ALBERTA
Department of Mathematical Sciences
The Department of Mathematical Sciences at the University of Alberta invites applications for two tenure-track positions starting July 1, 1999. The positions require a Ph.D. and will be initially considered at the assistant professor level with the salary range $40,638-$57,510.

Functional Analysis (FA-99): A position is available for an outstanding candidate in functional analysis. We are particularly interested in a mathematician working in operator spaces, with an emphasis on Banach space and C* algebra aspects of the theory. Functional analysts in areas such as abstract harmonic analysis, geometric functional analysis, probabilistic methods in Banach spaces and in harmonic analysis, will also be considered.

Postdoctoral Positions: One to three postdoctoral positions may be available within the areas of stochastic processes, scientific computation, partial differential equations, mathematical modeling, and inference. One or more postdoctoral positions may be available in statistics, generalized linear models, survival analysis, missing data analysis and random effects models. These positions will be for one to two years, commencing any time between September 1998 and April 1999, with a competitive compensation package and a travel budget.

Applicants for all positions are expected to possess a strong research record, outstanding promise for future research, excellent communication skills and leadership potential. The successful candidate for tenure-track positions must have a commitment to graduate and undergraduate education in mathematical sciences. The Department of Mathematical Sciences has sixty-four faculty specializing in algebra, fluid dynamics, mathematical statistics, analysis, differential equations, stochastic processes, geometry, numerical analysis, and optimal statistical designs. (For further information, please see http://www.math.ualberta.ca/)

In accordance with Canadian Immigration requirements, priority will be given to Canadian citizens and permanent residents of Canada. If suitable Canadian citizens and permanent residents cannot be found, other individuals will be considered.

Applications should include a curriculum vitae, research plan, and a teaching profile outlining experience and/or interests. Candidates should arrange for at
The closing date for the tenure-track position is Friday, January 8, 1999. Postdoctoral applications will be considered on an ongoing basis. Early applications are encouraged.

The University of Alberta is committed to the principle of equity in employment. As an employer we welcome diversity in the workplace and encourage applications from all qualified men and women, including aboriginal peoples, persons with disabilities, and members of visible minorities.

**University of Alberta**

**Mathematical Finance Position (MF-99)**

Department of Mathematical Sciences

The Department of Mathematical Sciences, University of Alberta, invites applications for a tenure-track assistant professorship in mathematical finance with some expertise in actuarial science starting January 1, 1999. The position requires a Ph.D. and will be initially considered at the assistant professor level with the salary range $40,638–$57,510.

The successful candidate must be able to teach graduate courses on the modelling of the term structure of interest rates and on the mathematics of derivative securities. Moreover, the successful candidate must be willing to teach undergraduate courses in actuarial mathematics. Expertise in the areas of probability theory, stochastic analysis, stochastic differential equations, point processes, or stochastic control is highly desirable.

Applicants are expected to possess a strong research record, outstanding promise for future research, excellent communication skills and leadership potential. The successful candidate must have a commitment to graduate and undergraduate education in mathematics and statistics. The Department of Mathematical Sciences has sixty-four faculty specializing in algebra, fluid dynamics, mathematical statistics, analysis, differential equations, stochastic processes, geometry, numerical analysis, and optimal statistical designs. (For further information, please see [http://www.math.ualberta.ca/](http://www.math.ualberta.ca/).)

Applications should include a curriculum vitae, research plan, and a teaching profile outlining experience and/or interests. Candidates should arrange for at least three confidential letters of reference to be sent to:

S.D. Riemenschneider, Chair  
Department of Mathematical Sciences  
University of Alberta  
Edmonton, Alberta T6G 2G1  
Canada

Closing date for applications is Friday, January 8, 1999, or until a suitable candidate is found. Early applications are encouraged.

Postdoctoral Positions: One to three postdoctoral positions may be available within the areas of stochastic processes, scientific computation, partial differential equation, mathematical modeling, and inference. One or more postdoctoral positions may be available in statistics, generalized linear models, survival analysis, missing data analysis and random effects models. These positions will be for one to two years, commencing any time between September 1998 and April 1999, with a competitive compensation package and a travel budget. Applications will be considered on an ongoing basis.

The University of Alberta is committed to the principle of equity in employment. As an employer we welcome diversity in the workplace and encourage applications from all qualified women and men, including aboriginal peoples, persons with disabilities, and members of visible minorities.

**MEMORIAL UNIVERSITY OF NEWFOUNDLAND**

**St. John's, Newfoundland, Canada**  
A1C 5S7

**Department of Mathematics and Statistics**

Applications are invited for a tenure-track position in ALGEBRA at the level of assistant professor, effective September 1999, subject to availability of funds.

Demonstrated superior capability as a teacher is a requirement for this position. In addition, the successful candidate should have an outstanding research record and will be expected to enhance the current active algebra program in the department. Rank and salary depend upon qualifications and are subject to negotiation.

Applications, marked REF: MS/ALG/99, with complete curriculum vitae, a statement of present research and teaching interests, and the names and mailing/e-mail addresses of at least three referees should be sent to:

MS/ALG/99  
Department of Mathematics and Statistics  
Memorial University of Newfoundland  
St. John's, Newfoundland, Canada A1C 5S7

The closing date for receipt of applications is November 30, 1998, or until the position is filled.

Memorial University is committed to the principle of equity in employment. In accordance with Canadian Immigration requirements, priority will be given to Canadian citizens and permanent residents of Canada.

Memorial University is part of a vibrant, local scientific and engineering community which maintains an inventory of available positions for qualified partners. Partners of candidates for these positions are invited to include their résumé for possible matching with other job opportunities.

**UNIVERSITY OF TORONTO**

**Tenure-Stream Appointment in Algorithmic Mathematics and Theoretical Computer Science**

The University of Toronto solicits applications for a tenure-stream appointment in the field of algorithmic mathematics and theoretical computer science, including complexity and effective methods in scientific computation. The position is subject to budgetary approval.

The appointment is at the downtown (St. George) campus at the level of assistant professor, to begin July 1, 1999. This will be a joint appointment between the Department of Mathematics (75%) and the Department of Computer Science (25%). 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.

Salary commensurate with experience.

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, 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 World Wide Web Employment Opportunities page: [http://www.math.toronto.edu/jobs/](http://www.math.toronto.edu/jobs/). To insure full consideration, this information should be received by December 1, 1998.

In accordance with its Employment Equity Policy, the University of Toronto encourages applications from qualified women or men, members of visible minorities, aboriginal peoples, and persons with disabilities.

**UNIVERSITY OF TORONTO**

**Tenure-Stream Appointment in Algebra and Number Theory**

The University of Toronto solicits applications for a tenure-stream appointment in the fields of algebra and number theory.

The appointment is at the downtown (St. George) campus at the level of assistant professor, to begin July 1, 1999. 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. Salary commensurate with experience.

Applicants should send their complete C.V. 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, 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 World Wide Web Employment Opportunities page: http://www.math.toronto.edu/jobs/. To insure full consideration, this information should be received by December 1, 1998.

In accordance with its Employment Equity Policy, the University of Toronto encourages applications from qualified women and men, members of visible minorities, aboriginal peoples, and persons with disabilities.

UNIVERSITY OF TORONTO
Tenure-Stream Appointment in Algebra, Number Theory and Geometry

The University of Toronto solicits applications for a tenure-stream appointment in the fields of algebra, number theory and geometry. Preference will be given to researchers in arithmetic geometry.

The appointment is at the downtown (St. George) campus at the level of assistant professor, to begin July 1, 1999. Candidates are expected to have demonstrated excellence in both teaching and research. In particular, a candidate’s research record should show clearly the ability to make significant original and independent contributions to mathematics. Salary commensurate with experience.

Applicants should send their complete C.V. 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, 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 World Wide Web Employment Opportunities page: http://www.math.toronto.edu/jobs/. To insure full consideration, this information should be received by December 1, 1998.

In accordance with Canadian immigration requirements this advertisement is directed to Canadian citizens and to permanent residents of Canada. In accordance with its Employment Equity Policy, the University of Toronto encourages applications from qualified women and men, members of visible minorities, aboriginal peoples, and persons with disabilities.

UNIVERSITY OF TORONTO
Tenure-Stream Appointment in Applied Mathematics - Computational Science

The Department of Mathematics, University of Toronto solicits applications for a tenure-stream appointment for a mathematician working in the area of applied mathematics (computational science).

The appointment is at the downtown (St. George) campus at the level of assistant professor, to begin July 1, 1999. 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. Salary commensurate with experience.

Applicants should send their complete C.V. 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, 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 World Wide Web Employment Opportunities page: http://www.math.toronto.edu/jobs/. To insure full consideration, this information should be received by December 1, 1998.

In accordance with Canadian immigration requirements this advertisement is directed to Canadian citizens and to permanent residents of Canada. In accordance with its Employment Equity Policy, the University of Toronto encourages applications from qualified women and men, members of visible minorities, aboriginal peoples, and persons with disabilities.

UNIVERSITY OF TORONTO
Limited Term Assistant Professorships

The Department invites application for one or more limited term assistant professorships which may, subject to budgetary approval, become available at the St. George (downtown), Scarborough, or Mississauga campus, for a period of one to three years, beginning July 1, 1999. Duties consist of teaching and research, and candidates must demonstrate clear strength in both. Preference will be given to candidates with recent doctoral degrees. Salary commensurate with qualifications.

Applicants should send their complete C.V. 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, 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 World Wide Web Employment Opportunities page: http://www.math.toronto.edu/jobs/. To insure full consideration, this information should be received by December 1, 1998.

Further information about academic positions in the Department of Mathematics is available on the World Wide Web by accessing the above URL.

In accordance with Canadian immigration requirements this advertisement is directed to Canadian citizens and to permanent residents of Canada. In accordance with its Employment Equity Policy, the University of Toronto encourages applications from qualified women and men, members of visible minorities, aboriginal peoples, and persons with disabilities.
MEHTA RESEARCH INSTITUTE
India

Mehta Research Institute is a newly established research institute devoted to research in pure mathematics and theoretical physics. Located on the bank of the River Ganges and overlooking the famous site of the confluence of the rivers Ganges and Yamuna, the Mehta Research Institute has a beautiful campus of its own at a distance of about 15 km from the city of Allahabad in North India. The faculty in mathematics has interests in several areas of pure mathematics including algebraic geometry, automorphic forms, complex analysis and number theory. The Institute seeks applications for both postdoctoral and more permanent positions.

The postdoctoral fellowship is presently Rs. 8,000 per month plus free accommodation, liberal leave rules and travel support for attending conferences.

If interested, please write with details to:

The Director
Mehta Research Institute
Chhatnag Road, Jhusi
Allahabad - 211 019
India
e-mail: mail@ari.ernest.in

THE SWISS FEDERAL INSTITUTE
OF TECHNOLOGY ZURICH (ETHZ)

The Swiss Federal Institute of Technology Zurich (ETHZ) invites applications for a professorship in mathematics with specialization in mathematical modelling, numerical analysis, computational sciences.

We are seeking candidates with internationally recognized scientific accomplishments and the ability to lead a research group and to direct high-quality research projects. The candidate should also have interest in and the ability to carry out interdisciplinary collaboration.

The duties of this position include, in addition to participating in service teaching, sharing in the responsibility for instruction in applied and numerical mathematics and simulation of large systems in mathematics, engineering, and natural sciences. Active participation in the interdisciplinary degree program in computational sciences is also expected.

Applications with curriculum vitae and a list of publications should be submitted, to the President of ETH Zurich, Prof. Dr. O. Kuebler, ETH Zentrum, CH-8092 Zurich, no later than December 15, 1998. The ETHZ specifically encourages female candidates to apply with a view towards increasing the proportion of female professors.

Classified Advertisements

INDIA

MEHTA RESEARCH INSTITUTE
India

SWITZERLAND

THE SWISS FEDERAL INSTITUTE
OF TECHNOLOGY ZURICH (ETHZ)

The Swiss Federal Institute of Technology Zurich (ETHZ) invites applications for a professorship in mathematics with specialization in mathematical modelling, numerical analysis, computational sciences.

We are seeking candidates with internationally recognized scientific accomplishments and the ability to lead a research group and to direct high-quality research projects. The candidate should also have interest in and the ability to carry out interdisciplinary collaboration.

The duties of this position include, in addition to participating in service teaching, sharing in the responsibility for instruction in applied and numerical mathematics and simulation of large systems in mathematics, engineering, and natural sciences. Active participation in the interdisciplinary degree program in computational sciences is also expected.

Applications with curriculum vitae and a list of publications should be submitted, to the President of ETH Zurich, Prof. Dr. O. Kuebler, ETH Zentrum, CH-8092 Zurich, no later than December 15, 1998. The ETHZ specifically encourages female candidates to apply with a view towards increasing the proportion of female professors.

Classified Advertisements

INDIA

MEHTA RESEARCH INSTITUTE
India

MEHTA RESEARCH INSTITUTE
India

SWITZERLAND

THE SWISS FEDERAL INSTITUTE
OF TECHNOLOGY ZURICH (ETHZ)

The Swiss Federal Institute of Technology Zurich (ETHZ) invites applications for a professorship in mathematics with specialization in mathematical modelling, numerical analysis, computational sciences.

We are seeking candidates with internationally recognized scientific accomplishments and the ability to lead a research group and to direct high-quality research projects. The candidate should also have interest in and the ability to carry out interdisciplinary collaboration.

The duties of this position include, in addition to participating in service teaching, sharing in the responsibility for instruction in applied and numerical mathematics and simulation of large systems in mathematics, engineering, and natural sciences. Active participation in the interdisciplinary degree program in computational sciences is also expected.

Applications with curriculum vitae and a list of publications should be submitted, to the President of ETH Zurich, Prof. Dr. O. Kuebler, ETH Zentrum, CH-8092 Zurich, no later than December 15, 1998. The ETHZ specifically encourages female candidates to apply with a view towards increasing the proportion of female professors.

Classified Advertisements

INDIA

MEHTA RESEARCH INSTITUTE
India

MEHTA RESEARCH INSTITUTE
India

SWITZERLAND

THE SWISS FEDERAL INSTITUTE
OF TECHNOLOGY ZURICH (ETHZ)

The Swiss Federal Institute of Technology Zurich (ETHZ) invites applications for a professorship in mathematics with specialization in mathematical modelling, numerical analysis, computational sciences.

We are seeking candidates with internationally recognized scientific accomplishments and the ability to lead a research group and to direct high-quality research projects. The candidate should also have interest in and the ability to carry out interdisciplinary collaboration.

The duties of this position include, in addition to participating in service teaching, sharing in the responsibility for instruction in applied and numerical mathematics and simulation of large systems in mathematics, engineering, and natural sciences. Active participation in the interdisciplinary degree program in computational sciences is also expected.

Applications with curriculum vitae and a list of publications should be submitted, to the President of ETH Zurich, Prof. Dr. O. Kuebler, ETH Zentrum, CH-8092 Zurich, no later than December 15, 1998. The ETHZ specifically encourages female candidates to apply with a view towards increasing the proportion of female professors.

Classified Advertisements

INDIA

MEHTA RESEARCH INSTITUTE
India

MEHTA RESEARCH INSTITUTE
India

SWITZERLAND

THE SWISS FEDERAL INSTITUTE
OF TECHNOLOGY ZURICH (ETHZ)

The Swiss Federal Institute of Technology Zurich (ETHZ) invites applications for a professorship in mathematics with specialization in mathematical modelling, numerical analysis, computational sciences.

We are seeking candidates with internationally recognized scientific accomplishments and the ability to lead a research group and to direct high-quality research projects. The candidate should also have interest in and the ability to carry out interdisciplinary collaboration.

The duties of this position include, in addition to participating in service teaching, sharing in the responsibility for instruction in applied and numerical mathematics and simulation of large systems in mathematics, engineering, and natural sciences. Active participation in the interdisciplinary degree program in computational sciences is also expected.

Applications with curriculum vitae and a list of publications should be submitted, to the President of ETH Zurich, Prof. Dr. O. Kuebler, ETH Zentrum, CH-8092 Zurich, no later than December 15, 1998. The ETHZ specifically encourages female candidates to apply with a view towards increasing the proportion of female professors.

Classified Advertisements

INDIA

MEHTA RESEARCH INSTITUTE
India

MEHTA RESEARCH INSTITUTE
India

SWITZERLAND

THE SWISS FEDERAL INSTITUTE
OF TECHNOLOGY ZURICH (ETHZ)

The Swiss Federal Institute of Technology Zurich (ETHZ) invites applications for a professorship in mathematics with specialization in mathematical modelling, numerical analysis, computational sciences.

We are seeking candidates with internationally recognized scientific accomplishments and the ability to lead a research group and to direct high-quality research projects. The candidate should also have interest in and the ability to carry out interdisciplinary collaboration.

The duties of this position include, in addition to participating in service teaching, sharing in the responsibility for instruction in applied and numerical mathematics and simulation of large systems in mathematics, engineering, and natural sciences. Active participation in the interdisciplinary degree program in computational sciences is also expected.

Applications with curriculum vitae and a list of publications should be submitted, to the President of ETH Zurich, Prof. Dr. O. Kuebler, ETH Zentrum, CH-8092 Zurich, no later than December 15, 1998. The ETHZ specifically encourages female candidates to apply with a view towards increasing the proportion of female professors.
Gaussian Measures
Vladimir I. Bogachev, Moscow State University, Russia

This book gives a systematic exposition of the modern theory of Gaussian measures. It presents complete and detailed proofs of fundamental facts about finite and infinite dimensional Gaussian distributions. Covered topics include linear properties, convexity, linear and nonlinear transformations, and applications to Gaussian and diffusions processes. Suitable for use as a graduate text and/or a reference work, this volume contains many examples, exercises, and an extensive bibliography. It brings together many results that have not appeared previously in book form.

Mathematical Surveys and Monographs, Volume 82, 1998; 433 pages; Hardcover; ISBN 0-8218-1054-5; List $95; Individual member $57; Order code SURV/82RT811

New Directions in Dirichlet Forms
Jürgen Jost, Max Planck Institute for Mathematics, Leipzig, Germany; Wilfrid Kendall, University of Warwick, Coventry, England; Umberto Mosco, University of Rome "La Sapienza", Italy; Michael Röckner, University of Bielefeld, Germany; and Karl-Theodor Sturm, University of Bonn, Germany

This book features contributions by leading experts and provides up-to-date, authoritative accounts on exciting developments in the field and on new research perspectives. Topics covered include the following: stochastic analysis on configuration spaces, specifically a mathematically rigorous approach to the stochastic dynamics of Gibbs measures and infinite interacting particle systems; subelliptic PDE, homogenization, and fractals; geometric aspects of Dirichlet forms on metric spaces and function theory on such spaces; generalized harmonic maps as nonlinear analogues of Dirichlet forms, with an emphasis on non-locally compact situations; and a stochastic approach based on Brownian motion to harmonic maps and their regularity.

Titles in this series are co-published with International Press, Cambridge, MA.

AMS/IP Studies in Advanced Mathematics, Volume 6, 1998; 277 pages; Hardcover; ISBN 0-8218-1061-8; List $49; All AMS members $39; Order code AMSSIP/6RT811

Geometry of Differential Equations
A. Khovanski, Russian Academy of Sciences, Moscow, Russia; A. Varchenko, University of North Carolina, Chapel Hill, and V. Vassiliev, Moscow, Russia, Editors

This volume contains articles written by V.I. Arnold's colleagues on the occasion of his 60th birthday. The articles are mostly devoted to various aspects of geometry of differential equations and relations to global analysis and Hamiltonian mechanics.


Homotopy Theory via Algebraic Geometry and Group Representations
Mark Mahowald and Stewart Priddy, Northwestern University, Evanston, IL, Editors

The academic year 1996–97 was designated as a special year in Algebraic Topology at Northwestern University (Evanston, IL). In addition to guest lecturers and special courses, an international conference was held entitled "Current trends in algebraic topology with applications to algebraic geometry and physics". The series of plenary lectures included in this volume indicate the great breadth of the conference and the lively interaction that took place among various areas of mathematics.

Contemporary Mathematics, Volume 220; 1998; 379 pages; Softcover; ISBN 0-8218-6655-2; List $74; Individual member $44; Order code CONM/220RT811

Morita Equivalence and Continuous-Trace $C^*$-Algebras
Iain Raeburn, University of Newcastle, NSW, Australia, and Dana P. Williams, Dartmouth College, Hanover, NH

In this text, the authors give a modern treatment of the classification of continuous-trace $C^*$-algebras up to Morita equivalence. This includes a detailed discussion of Morita equivalence of $C^*$-algebras, a review of the necessary sheaf cohomology, and an introduction to recent developments in the area.

The book is accessible to students who are beginning research in operator algebras after a standard one-term course in $C^*$-algebras. The authors have included introductions to necessary but nonstandard background. The text is self-contained and would be suitable for an advanced graduate or an independent study course.

Mathematical Surveys and Monographs, Volume 60; 1998; 327 pages; Hardcover; ISBN 0-8218-0860-5; List $65; Individual member $39; Order code SURV/60RT811

Selections from MSRI's Video Archive, Volume 1
Published by MSRI

This CD-ROM features video selections from lectures, seminars, and workshops held at the Mathematical Sciences Research Institute (MSRI) in Berkeley, CA from fall 1996 through winter 1998. It represents the inaugural volume in a planned series of CDs to be called "Selections from MSRI's Video Archive". The CD requires RealVideo® Player, which is available for Windows, Macintosh, and IRIX platforms and can be downloaded for free from the RealNetworks™ Internet home page http://www.real.com/. Distributed worldwide by the American Mathematical Society.

*RealVideo is a registered trademark and RealNetworks is a trademark of RealNetworks, Inc.

1998; CD-ROM, List $15; Order code MSRICD/1RT811

All prices subject to change. Charges for delivery are $3.00 per order. For optional air delivery outside of the continental U.S., please include $6.50 per item. Prepayment required.

Order from: American Mathematical Society, P.O. Box 5904, Boston, MA 02102-5904, USA. For credit card orders, fax 1-401-455-4046 or call toll free 1-800-321-4AMS (4267) in the U.S. and Canada, 1-401-455-4000 worldwide. Or place your order through the AMS bookstore at www.ams.org/bookstore. Residents of Canada, please include 7% GST.
THE Ramanujan Journal
An International Journal Devoted to the Areas of Mathematics Influenced by Ramanujan

Editor-in-Chief: Krishnaswami Alladi, University of Florida
Coordinating Editor:
Bruce Berndt, University of Illinois and Frank Garvan, University of Florida

The Ramanujan Journal publishes original papers of the highest quality in all areas of mathematics influenced by Srinivasa Ramanujan. His remarkable discoveries have made a great impact on several branches of mathematics, revealing deep and fundamental connections.

The Ramanujan Journal is indexed/abstracted in Science Citation Index;
Social Sciences Citation Index; Current Contents; Mathematical Reviews;
Zentralblatt für Mathematik/Mathematics Abstracts; MATH; CompactMATH

Cubic Identities of Theta Functions, Seung Hwan Son
On the Evaluation of the Integral,
L.J. Zucker, G.S. Joyce and R.T. Delves
A Higher Level Bailey Lemma: Proof and Application,
Anne Schilling and S. Ole Warnaar
Multi-parameter Ramanujan-type Q-beta Integrals,
S.K. Suslov
On the Curve \( X(q) \), Yaacov Kopeliovich and Jack R. Quine
A 1-psi-1 Summation Theorem for Macdonald Polynomials,
Jyoichi Kaneko.
Polynomes d’Euler et Fraction Continues de
Stieltjes-Rogers, Dominique Dumont et Jiang Zeng

Positivity
An International Journal devoted to the Theory and Applications of Positivity in Analysis

Editor: A.W. Wickstead, Queen’s University of Belfast

Two-Step Fifth-Order Methods for Evolutionary Problems with Positive Operators, Andrei I. Tolstykh
On Non-Negative Measurable Solutions of a Difference Functional Equation, Martin Grine
Some Results on Stability of Retarded Functional Differential Equations Using Dichotomic Map Techniques,
Maria Aparecida Benã, José Geraldo dos Reis
Conservativeness and Extensions of Feller Semigroups,
René L. Schilling
On the Modulus of C.J. Read’s Operator, V.G. Troitsky
RUC-Bases in Orlicz and Lorentz Operator Spaces, F.A. Sukochev
Hermitian and Positive Integrated C-cosine Functions on Banach Spaces, Yuan-Chuan Li, Sen-Yen Shaw

A FREE on-line sample copy is available for review
http://www.wkap.nl/sampletoc.htm?1385-1292+1+1+1997

1999, Volume 3 (4 issues), ISSN 1382-4090
Subscription rate: $262.50
Individuals may subscribe at the reduced rate of: $95.00

Please remember the library! They need your suggestions to serve your needs.
National Mathematical Reviews Subscription Program

The Opportunity

The AMS is sponsoring a program that will offer mathematical communities in many developing countries the opportunity to have access to Mathematical Reviews at affordable prices. Participating countries in this new program will be offered the MR Data Access Fee (MR DAF) at a substantially reduced price. This program will make it possible for individual mathematicians with an interest in a particular mathematical community to contribute directly to that community.

The Program

- Under this new program, once the reduced MR DAF is paid, all institutions within that country will then be able to purchase MR in the format of their choice: print at normal list price and electronic formats at substantially reduced rates. The Program will greatly benefit those universities and institutions which have active research mathematicians but limited economic resources.
- The National Subscription price will be based on a country’s Gross Domestic Product (GDP) and mathematical activity. The subscription price will vary from country to country. The Program will offer substantial discounts on MR subscriptions as compared to institutions subscribing individually.
- The Program is limited, at this time, to countries with a GDP per capita of less than $3,000 and a GDP lower than $50 billion.

How you can help

The AMS is eager to make this Program work and looks forward to widespread participation. The Society is seeking contacts in the following countries to help coordinate and administer the Program. If you know of an appropriate organization or individual in one of these countries that we might contact, please send us the information. Once the Program is established, there will be an opportunity for individual mathematicians to contribute to the National MR Subscription price on behalf of a specific country.

The AMS Contact

Lori Sprague: las@ams.org; 1-800-321-4267; internationally 1-401-455-4064; or by fax 1-401-331-3842.

Eligible countries:

- Algeria
- Armenia
- Azerbaijan
- Bangladesh
- Belarus
- Benin
- Bosnia
- Bulgaria
- Burkina Faso
- Burundi
- Central African Republic
- Congo
- Costa Rica
- Cuba
- Dominican Republic
- Egypt, Arab Republic
- Estonia
- Ethiopia
- Fiji Islands
- Gambia
- Georgia
- Ghana
- Guinea
- Iraq
- Jamaica
- Jordan
- Kazakhstan
- Kenya
- Korea, Democratic Republic
- Kyrgyz Republic
- Latvia
- Lebanon
- Lesotho
- Lithuania
- Macedonia
- Madagascar
- Malawi
- Mauritania
- Moldova
- Mongolia
- Morocco
- Mozambique
- Myanmar
- Nepal
- Niger
- Nigeria
- Papua New Guinea
- Romania
- Rwanda
- Senegal
- Sri Lanka
- Swaziland
- Sudan
- Syrian Arab Republic
- Tajikistan
- Tanzania
- Tunisia
- Turkmenistan
- Uzbekistan
- Vietnam
- Zimbabwe
Gauge Theory and the Topology of Four-Manifolds

Robert Friedman and John W. Morgan, Columbia University, New York, NY, Editors

The lectures in this volume provide a perspective on how 4-manifold theory was studied before the discovery of modern-day Seiberg-Witten theory. One reason the progress using the Seiberg-Witten invariants was so spectacular was that those studying SU(2)-gauge theory had more than ten years' experience with the subject. The tools had been honed, the correct questions formulated, and the basic strategies well understood. The knowledge immediately bore fruit in the technically simpler environment of the Seiberg-Witten theory.

Gauge theory long predates Donaldson's applications of the subject to 4-manifold topology. where the central concern was the geometry of the moduli space. One reason for the interest in this study is the connection between the gauge theory moduli spaces of a Kähler manifold and the algebroid-moduli space of stable holomorphic bundles over the manifold. The extra geometric richness of the SU(2)-moduli spaces may one day be important for purposes beyond the algebraic invariants that have been studied to date. It is for this reason that the results presented in this volume will be essential.

Members of the Mathematical Association of America (MAA) and the National Council of Teachers of Mathematics (NCTM) receive a 20% discount from list price.

IAS/Park City Mathematics Series, Volume 4, 1996; 221 pages; Hardcover; ISBN 0-8218-0694-6, List $59; All AMS members 43%, Order code PCMS/4NA

INSTITUTE FOR MATHEMATICS AND ITS APPLICATIONS ANNOUNCES A PROGRAM ON Reactive Flow and Transport Phenomena 1999-2000

ORGANIZING COMMITTEE: John Chadam, Ash Kapila (Chair), David Levermore, Christian Ringhofer

A one-year program with three parts:
Fall: September - December 1999, COMBUSTION
Winter: January - March 2000, NATURAL RESOURCES AND ENVIRONMENT
Spring: April - June 2000, MULTISCALE AND TRANSITION REGIMES

TWO-YEAR POSTDOCTORAL MEMBERSHIPS

The second year of the appointment will provide a variety of options to enhance career development, including participation in the ANNUAL PROGRAM: 2000-2001 Mathematics in Multi-Media.

All requirements for a doctorate should be completed by September 1, 1999. Applicants must show evidence of mathematical excellence, but they do not need to be specialists in the field. The following materials must be submitted (all materials should arrive by January 15, 1999):

1. Personal statement of scientific interests, research plans, and reasons for wishing to participate in the REACTIVE FLOW AND TRANSPORT PHENOMENA PROGRAM.
2. Curriculum vitae and a list of publications.
3. Three letters of recommendation to be sent directly to the IMA.

SENIOR MEMBERSHIPS

Preference will be given to supplementary support for persons with sabbatical leaves, fellowships, or other stipends.

*********************************

POSTDOCTORATES IN INDUSTRIAL MATHEMATICS

IMA announces two-year positions in Industrial Mathematics, effective September 1, 1999. These appointments are in addition to the regular program and are funded jointly by the NSF and participating industries. They are designed to prepare mathematicians for research careers involving industrial interaction. Applicants should have fulfilled all requirements for a Ph.D. in Mathematics, Applied Mathematics or Statistics by September 1, 1999. Postdoctorates will spend 50% effort working with industrial scientists and 50% effort in the regular IMA program. Requirements and application procedures are the same as for the postdoctoral memberships listed above.

The University of Minnesota is an equal opportunity educator and employer.

The application forms are available via staff@ima.umn.edu, gopher.ima.edu, http://www.ima.umn.edu or call (612) 624-6066.

All correspondence should be sent to either POSTDOC/VISITING MEMBERSHIP COMMITTEE or INDUSTRIAL MATHEMATICS POSTDOCTORATE MEMBERSHIP COMMITTEE Institute for Mathematics and its Applications University of Minnesota 514 Vincent Hall 206 Church St. S.E. Minneapolis, MN 55455-0436
AMERICAN MATHEMATICAL SOCIETY

Please read the "Membership Categories" section of this form to determine the membership category for which you are eligible. Then fill out this application and return it as soon as possible.

Place of Birth

City State Country

Date of Birth

Day Month Year

If formerly a member of AMS, please indicate dates

Check here if you are now a member of either MAA or SIAM

Degrees, with institutions and dates

Present position

Firm or institution

City State Zip/Country

Primary Fields of Interest (choose five from the list at right)

Secondary Fields of Interest (choose from the list at right)

Address for all mail

Telephone number(s)

Electronic address

Signature

Prepayment Methods and Mailing Addresses

All prices quoted in U.S. dollars.

Send checks, money orders, UNESCO coupons to American Mathematical Society, P.O. Box 5904, Boston, MA 02205-5904

To use credit cards, fill in information requested and mail to American Mathematical Society, P.O. Box 6248, Providence, RI 02940-6248 or call (401) 455-4000 or 1-800-321-4AMS.

For Foreign Bank Transfers: American Mathematical Society, State Street Bank and Trust Company, 225 Franklin St., ABA #011000028, Account #0128-262-3, Boston, MA 02110.

American Express □ Discover □ VISA □ MasterCard □

Account number

Expiration date

Application for Membership 1999

(January–December)

Date ........................................ 19

Fields of Interest

If you wish to be on the mailing lists to receive information about publications in fields of mathematics in which you have an interest, please consult the list of major headings below. These categories will be added to your computer record so that you will be informed of new publications or special sales in the fields you have indicated.

EME Education/Mathematics Education
00 General
01 History and biography
03 Mathematical logic and foundations
04 Set theory
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
39 Finite differences 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
68 Numerical analysis
65 Computer science
70 Mechanics of particles and systems
73 Mechanics of 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 Economics, operations research, programming, games
92 Biology and other natural sciences, behavioral sciences
93 Systems theory; control
94 Information and communication, circuits

M9NO
**Membership Categories**

Please read the following to determine what membership category you are eligible for, and then indicate below the category for which you are applying.

**Introductory ordinary member rate** applies to the first five consecutive years of ordinary membership. Eligibility begins with the first year of membership in any category other than student and nominee. Dues are $50.

For **ordinary members** whose annual professional income is below $55,000, the dues are $99; for those whose annual professional income is $55,000 or more, the dues are $132.

The **CMS cooperative rate** applies to ordinary members of the AMS who are also members of the Canadian Mathematical Society and reside outside of the U.S. For members whose annual professional income is $55,000 or less, the dues are $64; for those whose annual professional income is above $55,000, the dues are $112.

For a **Joint family membership**, one member pays ordinary dues, based on his or her income; the other pays ordinary dues based on his or her income, less $20. (Only the member paying full dues will receive the Notices and the Bulletin as a privilege of membership, but both members will be accorded all other privileges of membership.)

Minimum dues for **contributing members** are $198. The amount paid which exceeds the higher ordinary dues level is purely voluntary may be treated as a charitable contribution.

For **students or unemployed individuals**, dues are $33, and annual verification is required.

The annual dues for **reciprocity members** who reside outside the U.S. and Canada are $66. To be eligible for this classification, members must belong to one of those foreign societies with which the AMS has established a reciprocity agreement, and annual verification is required. Reciprocity members who reside in the U.S. or Canada must pay ordinary dues ($99 or $132).

The annual dues for **category-S members**, those who reside in developing countries, are $16. Members can choose only one privilege journal. Please indicate your choice below.

Members can purchase a **multi-year membership** by prepaying their current dues rate for either two, three, four or five years. This option is not available to category-S, unemployed, or student members.

**1999 Dues Schedule (January through December)**

<table>
<thead>
<tr>
<th>Category</th>
<th>Regular Rate</th>
<th>Cooperative Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introductory ordinary member</td>
<td>$50</td>
<td>$25</td>
</tr>
<tr>
<td>Ordinary member</td>
<td>$99</td>
<td>$132</td>
</tr>
<tr>
<td>CMS cooperative rate</td>
<td>$94</td>
<td>$112</td>
</tr>
<tr>
<td>Joint family member (full rate)</td>
<td>$99</td>
<td>$112</td>
</tr>
<tr>
<td>Joint family member (reduced rate)</td>
<td>$79</td>
<td>$99</td>
</tr>
<tr>
<td>Contributing member (minimum $192)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student member (please verify)</td>
<td>$33</td>
<td></td>
</tr>
<tr>
<td>Unemployed member (please verify)</td>
<td>$33</td>
<td></td>
</tr>
<tr>
<td>Reciprocity member (please verify)</td>
<td>$66</td>
<td>$99</td>
</tr>
<tr>
<td>Category-S member</td>
<td>$16</td>
<td></td>
</tr>
</tbody>
</table>

**Multi-year membership**

<table>
<thead>
<tr>
<th>Years</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>$16</td>
</tr>
<tr>
<td>3</td>
<td>$25</td>
</tr>
<tr>
<td>4</td>
<td>$33</td>
</tr>
<tr>
<td>5</td>
<td>$49</td>
</tr>
</tbody>
</table>

1 **Student Verification** (sign below)

I am a full-time student at ________________________________

__________________________ currently working toward a degree.

2 **Unemployed Verification** (sign below) I am currently unemployed and actively seeking employment.

3 **Reciprocity Membership Verification** (sign below) I am currently a member of the society indicated on the right and am therefore eligible for reciprocity membership.

__________________________

Signature

4 □ send NOTICES □ send BULLETIN

**Reciprocating Societies**

- Allahabad Mathematical Society
- Australian Mathematical Society
- Azerbaijan Mathematical Society
- Balkan Society of Geometers
- Berliner Mathematische Gesellschaft e.V.
- Calcuta Mathematical Society
- Croatian Mathematical Society
- Cyprus Mathematical Society
- Danek Matematisk Forerning
- Deutsche Mathematiker-Vereinigung e.V.
- Edinburgh Mathematical Society
- Egyptian Mathematical Society
- Gesellschaft für Angewandte Mathematik und Mechanik
- Glasgow Mathematical Association
- Hellenic Mathematical Society
- Icelandic Mathematical Society
- Indian Mathematical Society
- Iranian Mathematical Society
- Irish Mathematical Society
- Israel Mathematical Union
- János Bolyai Mathematical Society
- The Korean Mathematical Society
- London Mathematical Society
- Malaysian Mathematical Society
- Mathematical Society of Japan
- Mathematical Society of Serbia
- Mathematical Society of the Philippines
- Mathematical Society of the Republic of China
- Mongolian Mathematical Society
- Nepal Mathematical Society
- New Zealand Mathematical Society
- Nigerian Mathematical Society
- Norsk Matematikforbund
- Österreichische Mathematische Gesellschaft
- Palestine Society for Mathematical Sciences
- Polskie Towarzystwo Matematyczne
- Punjab Mathematical Society
- Ramanujan Mathematical Society
- Real Sociedad Matemática Española
- Saudi Association for Mathematical Sciences
- Sociedad Colombiana de Matemáticas
- Sociedad Española de Matemática Aplicada
- Sociedad de Matemática de Chile
- Sociedad Matemática de la República Dominicana
- Sociedad Matemática Mexicana
- Sociedad Uruguaya de Matemática y Estadística
- Sociedade Brasileira de Matemática
- Sociedade Brasileira de Matemática Aplicada e Computacional
- Sociedade Paranaense de Matemática
- Sociedade Portuguesa de Matemática
- Societat Catalana de Matemàtiques
- Societatea Matematicienilor din România
- Société de Mathématiques Appliquées et Industrielles
- Société Mathématique de Belgique
- Société Mathématique de France
- Société Mathématique du Luxembourg
- Société Mathématique Suisse
- Society of Associates of Mathematicians & Computer Science of Macedonia
- Society of Mathematically, Physicists, and Astronomers of Slovenia
- South African Mathematical Society
- Southeast Asian Mathematical Society
- Suomen Matemaatikkojen Liitto
- Svenska Matematikersamfundet
- Ukrainian Mathematical Society
- Union Matematica Argentina
- Union of Bulgarian Mathematicians
- Union of Czech Mathematicians and Physicists
- Union of Slovak Mathematicians and Physicists
- Unione Matematica Italiana
- Vijnana Parishad of India
- Wiskundig Genootschap
Meetings & Conferences of the AMS

PROGRAM ALERT: In order that AMS meeting programs include the most timely information for each speaker, abstract deadlines have been moved to dates much closer to the meeting. What this means is that most meeting programs will appear in the Notices "after" the meeting takes place. However, complete meeting programs will be available on e-MATH about two to three weeks after the abstract deadline. "Remember", e-MATH is your most comprehensive source for up-to-date meeting information. See http://www.ams.org/meetings/.

Chicago, Illinois
DePaul University, Chicago
September 12–13, 1998
Meeting #935
Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of Notices: June 1998
Program issue of Notices: November 1998
Issue of Abstracts: Volume 19, Issue 3

Winston-Salem, North Carolina
Wake Forest University
October 9–10, 1998
Meeting #936
Southeastern Section
Associate secretary: Robert J. Daverman
Announcement issue of Notices: August 1998
Program issue of Notices: December 1998
Issue of Abstracts: Volume 19, Issue 3

State College, Pennsylvania
Pennsylvania State University
October 24–25, 1998
Meeting #937
Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of Notices: August 1998
Program issue of Notices: January 1999
Issue of Abstracts: Volume 19, Issue 4

Program
The complete program for this meeting is available at http://www.ams.org/meetings/. Follow the links to Sectional Meetings to get the most up-to-date information on all of the speakers and the titles of the talks. A new feature allows you to view all of the electronically submitted abstracts on line, too! The December issue of the Notices will carry the full program for this meeting.

Registration and Meeting Information
Registration will take place in the lobby of Schwab Auditorium from 7:30 a.m. to 4:00 p.m. on Saturday and 7:30 a.m. to noon on Sunday. Sessions will take place in Schwab Auditorium and the Willard Building next door.
Registration fees: (payable on-site only) $30/AMS members; $45 nonmembers; $10 emeritus members, students, or unemployed mathematicians. Fees are payable by cash, check, VISA, MasterCard, Discover, or American Express.

Tucson, Arizona
University of Arizona, Tucson
November 14–15, 1998
Meeting #938
Western Section
Associate secretary: Robert M. Fossum
Announcement issue of Notices: September 1998
Program issue of Notices: January 1999
Issue of Abstracts: Volume 19, Issue 4

Deadlines
For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired
New Invited Address
Craig A. Tracy, University of California, Davis, Universality of the distribution functions of random matrix theory.

Program
The complete program for this meeting is available at http://www.ams.org/meetings/. Follow the links to Sectional Meetings to get the most up-to-date information on all of the speakers and the titles of the talks. A new feature allows you to view all of the electronically submitted abstracts online, too! The December issue of the Notices will carry the full program for this meeting.

Registration and Meeting Information
The registration desk will be located in the lobby of the Mathematics Building, and will be open 8:00 a.m. to 5:00 p.m. on Saturday, and 8:00 a.m. to noon on Sunday. Talks will take place in the following buildings: Bio Sciences West, Physics & Atmospheric Sciences (PAS), Shantz, and Mathematics.

Registration fees: (payable on site only) $30/AMS members; $45/nonmembers; $10/emeritus members, students, or unemployed mathematicians. Fees are payable by cash, check, VISA, MasterCard, Discover, or American Express.

San Antonio, Texas
Henry B. Gonzales Convention Center
January 13-16, 1999

Meeting #939
Joint Mathematics Meetings, including the 105th Annual Meeting of the AMS, 82nd 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: October 1998
Program issue of Notices: January 1999
Issue of Abstracts: Volume 20, 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 Invited Addresses
Additions to those announced in the October issue:
Johan de Jong, Princeton University, Title to be announced, Thursday, 2:15 p.m.
Cumrun Vafa, Harvard University (Department of Physics), Title to be announced, Friday, 10:05 a.m.

Gainesville, Florida
University of Florida
March 12-13, 1999

Meeting #940
Southeastern Section
Associate secretary: Robert J. Daverman
Announcement issue of Notices: January 1999
Program issue of Notices: To be announced
Issue of Abstracts: Volume 20, Issue 2

Deadlines
For organizers: Expired
For consideration of contributed papers in Special Sessions: November 25, 1998
For abstracts: January 20, 1999

Invited Addresses
Alexander N. Dranishnikov, University of Florida, Title to be announced.
Gregory F. Lawler, Duke University, Title to be announced.
Michael P. Loss, Georgia Institute of Technology, Title to be announced.
John G. Thompson, University of Florida, Title to be announced.

Special Sessions
Algebraic and Geometric Combinatorics (Code: AMS SS P1),
Andrew J. Vince and Neil L. White, University of Florida.
Analytical Problems in Mathematical Physics (Code: AMS SS M1), Eric A. Carlen, Georgia Institute of Technology, and Laszlo Erdos, Courant Institute, NYU.
Meetings & Conferences


**Finite Groups and Their Representations (Code: AMS SS D1), Alexandre Turull**, University of Florida.


**Groups and Geometries (Code: AMS SS F1), Chat Ho** and **Peter Sin**, University of Florida.

**Linear Operator Theory (Code: AMS SS J1), Leiba Rodman**, College of William & Mary, and **Scott A. McCullough**, University of Florida.


**Probability on Algebraic Structures (Code: AMS SS Q1), Gregory M. Budzban** and **Philip Feinsilver**, Southern Illinois University, Carbondale, and **Arunava Mukherjea**, University of South Florida.

**Structure and Representation Theory of Lattice-Ordered Groups and f-Rings (Code: AMS SS L1), Jorge Martinez**, University of Florida.


**Urbana, Illinois**

University of Illinois, Urbana-Champaign

March 18–21, 1999

**Meeting #941**

Central Section

Associate secretary: Susan J. Friedlander

Announcement issue of Notices: January 1999

Program issue of Notices: To be announced

Issue of Abstracts: Volume 20, Issue 2

**Deadlines**

For organizers: Expired

For consideration of contributed papers in Special Sessions: December 2, 1998

For abstracts: January 27, 1999

**Invited Addresses**

Alexander Beilinson, MIT, Title to be announced.

Alexandra Bellow, Northwestern University, Title to be announced.

Igor Krichever, Columbia University, Title to be announced.

Steven Rallis, Ohio State University, Title to be announced.

Trevor Wooley, University of Michigan, Title to be announced.

**Special Sessions**


Combinatorial Designs (Code: AMS SS M1), Ilene H. Morgan, University of Missouri, Rolla, and **Walter D. Wallis**, Southern Illinois University, Carbondale.

Commutative Algebra (Code: AMS SS P1), Joseph Brennan, North Dakota State University, and Sankar Dutta, Robert Fossum, and **Phillip Griffith**, University of Illinois, Urbana.

Diophantine Equations, Inequalities and Related Arithmetic Problems (Code: AMS SS F1), Michael Bennett, University of Illinois, Urbana, and **Trevor Wooley**, University of Michigan.

Elementary and Analytic Number Theory (Code: AMS SS E1), **Harold G. Diamond** and A. J. Hildebrand, University of Illinois, Urbana.

Galois Representations (Code: AMS SS C1), Nigel Boston, University of Illinois, Urbana, and **Michael Larsen**, University of Missouri.

Graph Theory (Code: AMS SS G1), **Douglas B. West**, University of Illinois, Urbana.

Holomorphic Vector Bundles and Complex Geometry (Code: AMS SS L1), Maarten Bergvelt, Steven Bradlow, and John P. D’Angelo, University of Illinois, Urbana, and **Lawrence Ein**, University of Illinois, Chicago.

Integrable Equations (Code: AMS SS I1), **Igor Krichever**, Columbia University, and **Kirill Vaninsky**, Kansas State University.

Low-Dimensional Topology (Code: AMS SS O1), Mark Brittenham, University of North Texas, Charles Delman, Eastern Illinois University, and **Rachel Roberts**, Washington University.

Martingales and Analysis (Code: AMS SS D1), Joseph Max Rosenblatt, Renming Song, and Richard B. Sowers, University of Illinois, Urbana.

Nonstandard Analysis (Code: AMS SS B1), C. Ward Henson and **Peter Loeb**, University of Illinois, Urbana.


Optimization Problems in Geometry (Code: AMS SS N1), Robert Kusner, University of Massachusetts, Amherst, and **John M. Sullivan**, University of Illinois, Urbana.
Recent Progress in Elementary Geometry (Code: AMS SS A1), John E. Wetzel, University of Illinois, Urbana, and Clark Kimberling, University of Evansville.

Symplectic Geometry and Topology (Code: AMS SS K1), Eugene M. Lerman and Susan Tolman, University of Illinois, Urbana.

Wavelet Analysis and Multiresolution Methods (Code: AMS SS Q1), Tian-Xiao He, Illinois Wesleyan University.

Las Vegas, Nevada
University of Nevada, Las Vegas
April 10-11, 1999

Meeting #942
Western Section
Associate secretary: Bernard Russo
Announcement issue of Notices: February 1999
Program issue of Notices: To be announced
Issue of Abstracts: Volume 20, Issue 3

Deadlines
For organizers: Expired
For consideration of contributed papers in Special Sessions: December 23, 1998
For abstracts: February 17, 1999

Special Sessions
Analysis and Geometry (Code: AMS SS I1), Peter Li and Song-Ying Li, University of California, Irvine.

Combinatorial Theory (Code: AMS SS G1), Kequan Ding, University of Illinois, Urbana, Peter Shiu, University of Las Vegas, Nevada, and Yeong-Nan Yeh, Academia Sinica.

Control and Dynamics of Partial Differential Equations (Code: AMS SS A1), Zhonghai Ding, University of Nevada, Las Vegas.

Diophantine Problems (Code: AMS SS J1), Arthur Baragar, University of Nevada, Las Vegas, and Michael Bennett, University of Illinois.

Geometric Group Theory (Code: AMS SS H1), Eric M. Frieden, Southern Utah University, and Eric Lewis Swenson, Brigham Young University.

Graph Theory (Code: AMS SS B1), Hung-Lin Fu, University of National Chiao-Tung University, Taiwan, Chris A. Rodger, Auburn University, and Michelle Schultz, University of Nevada, Las Vegas.

Invariants, Distributions, Differential Operators and Harmonic Analysis (Code: AMS SS K1), Ronald L. Lipsman, University of Maryland, College Park.

Nonlinear PDEs—Methods and Applications (Code: AMS SS C1), David Costa, University of Nevada, Las Vegas.

Number Theory (Code: AMS SS F1), Gennady Bachman, University of Nevada, Las Vegas, Richard A. Mollin, University of Calgary, and Peter J. Shiue, University of Nevada, Las Vegas.

Numerical Analysis and Computational Mathematics (Code: AMS SS E1), Jun Zhang, University of Minnesota and University of Kentucky, and Jennifer Zhao, University of Michigan, Dearborn.

Set Theory (Code: AMS SS D1), Douglas Burke and Derrick BuBose, University of Nevada, Las Vegas.

Symmetries of Knots and Three-Manifolds (Code: AMS SS M1), Swatee Naik, University of Nevada, Reno, and Jozef H. Przytycki, George Washington University.

Wavelets and Approximation Theory (Code: AMS SS L1), Don Hong, East Tennessee State University, and Xin Li, University of Nevada, Las Vegas.

Buffalo, New York
State University of New York, Buffalo
April 24-25, 1999

Meeting #943
Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of Notices: February 1999
Program issue of Notices: To be announced
Issue of Abstracts: Volume 20, Issue 3

Deadlines
For organizers: Expired
For consideration of contributed papers in Special Sessions: January 6, 1999
For abstracts: March 3, 1999

Invited Addresses
Michèle M. Audin, Université Louis Pasteur, Title to be announced.
Russel Caflisch, University of California, Los Angeles, Title to be announced.
Jeff Smith, Purdue University, Title to be announced.
Alexander Voronov, MIT, Title to be announced.
Gregg J. Zuckerman, Yale University, Title to be announced.

Special Sessions
Combinatorics and Graph Theory (Code: AMS SS C1), Harris Kwong, SUNY College, Fredonia.

Complex Geometry (Code: AMS SS G1), Terrence Napier, Lehigh University, and Mohan Ramachandran, SUNY, Buffalo.

Integrable Systems (Code: AMS SS J1), Michèle Audin, Université Louis Pasteur et NCRS, and Lisa Claire Jeffrey, McGill University.

Knots and 3-Manifolds (Code: AMS SS E1), Thang T.Q. Le, SUNY, Buffalo, William W. Menasco, SUNY, Buffalo, and Morwen B. Thistlethwaite, University of Tennessee.

Mathematical Physics (Code: AMS SS D1), Jonathan Dimock, SUNY, Buffalo.
Meetings & Conferences

Operads, Algebras, and Their Applications (Code: AMS SS H1), Alexander A. Voronov, MIT.
Representations of Lie Algebras (Code: AMS SS F1), Duncan J. Melville, Saint Lawrence University.
Thin Films: Solid and Liquid (Code: AMS SS B1), E. Bruce Pitman and Brian Spencer, SUNY, Buffalo.

Denton, Texas
University of North Texas
May 19-22, 1999

Meeting #944
Fourth International Joint Meeting of the AMS and the Sociedad Matematica Mexicana (SMM).
Associate secretary: Lesley M. Sibner
Announcement issue of Notices: January 1999
Program issue of Notices: To be announced
Issue of Abstracts: Volume 20, Issue 3

Deadlines
For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: March 24, 1999

Invited Addresses
Raymundo Bautista, UNAM, Title to be announced.
Jack K. Hale, Georgia Institute of Technology, Title to be announced.
Onesimo Hernandez-Lerma, CINVESTAV del IPN, Title to be announced.

Melbourne, Australia
Melbourne, Australia
July 12-16, 1999

Meeting #945
First International Joint Meeting of the American Mathematical Society and the Australian Mathematical Society
Associate secretary: Susan J. Friedlander
Announcement issue of Notices: To be announced
Program issue of 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

Invited Addresses
Jennifer Chayes, Microsoft, Title to be announced.
Michael Eastwood, University of Adelaide, Title to be announced.
Gerhard Huisken, University of Tuebingen, Title to be announced.
Vaughan Jones, University of California, Berkeley, Title to be announced.
Hyam Rubinstein, Melbourne University, Title to be announced.
Richard M. Schoen, Stanford University, Title to be announced.
Neil Trudinger, Australian National University, Title to be announced.

Special Sessions
Fluid Dynamics (Code: AMS SS C1), Susan Friedlander, Northwestern University, and Roger H. J. Grimshaw, Monash University.
Geometric Group Theory (Code: AMS SS K1), Swarup Gadde and Walter Neumann, University of Melbourne.
Geometric Themes in Group Theory (Code: AMS SS A1), Gustav I. Lehrer, University of Sydney, Cheryl E. Praeger, University of Western Australia, and Stephen D. Smith, University of Illinois, Chicago.
Group Actions (Code: AMS SS H1), Marston Conder, Gaven Martin, and Eamonn O'Brien, University of Auckland.
Low Dimensional Topology (Code: AMS SS D1), William H. Jaco, Oklahoma State University, and Hyam Rubinstein, Melbourne University.
Mathematical Physics: Many Body Systems (Code: AMS SS B1), Alan L. Carey, University of Adelaide, Paul A. Pearce, University of Melbourne, and Mary Beth Ruskai, University of Massachusetts, Lowell.
Mathematics Learning Centers (Code: AMS SS G1), Judith Baxter, University of Illinois, Chicago, Jackie Nicholas, University of Sydney, and Jeanne Wald, Michigan State University.
Moduli Spaces of Riemann Surfaces, Mapping Class Groups and Invariants of 3-Manifolds (Code: AMS SS F1), Ezra Getzler, Northwestern University, and Richard Hain, Duke University.
Probability Theory and Its Applications (Code: AMS SS E1), Timothy Brown, University of Melbourne, Phil Pollett, University of Queensland, and Ruth J. Williams, University of California, San Diego.
Recent Trends in Operator Theory and Harmonic Analysis (Code: AMS SS J1), Michael T. Lacey, Georgia Institute of Technology, and Alan G. R. McIntosh, Macquarie University.
Meetings & Conferences

Providence, Rhode Island
Providence College
October 2-3, 1999
Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of Notices: To be announced
Program issue of Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: January 6, 1999
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Special Sessions
Algebraic and Geometric Combinatorics (Code: AMS SS A1),
Vesselin N. Gasharov, Cornell University, and Ira M. Gessel, Brandeis University.

Austin, Texas
University of Texas, Austin
October 8-10, 1999
Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of Notices: To be announced
Program issue of Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: January 6, 1999
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Invited Addresses
Mikhail Kapranov, Northwestern University, Title to be announced.
John Roe, Oxford University and Pennsylvania State University, Title to be announced.
Catherine Sulem, University of Toronto, Title to be announced.
Tatiana Toro, University of Washington, Title to be announced.

Special Sessions
Harmonic Analysis and PDEs (Code: AMS SS C1), William Beckner and Luis A. Caffarelli, University of Texas, Austin.

Charlotte, North Carolina
University of North Carolina, Charlotte
October 15-17, 1999
Southeastern Section
Associate secretary: Announcement issue of Notices: August 1999
Program issue of Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: January 20, 1999
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Special Sessions

Washington, District of Columbia
Marriott Wardman Park Hotel and Omni Shoreham Hotel
January 19-22, 2000
Joint Mathematics Meetings, including the 106th Annual Meeting of the AMS, 83rd Meeting of the Mathematical Association of America (MAA), with minisymposia and other special events contributed by the Society for Industrial and Applied Mathematics (SIAM), and the annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM).
Associate secretary: Robert M. Fossum
Announcement issue of Notices: To be announced
Program issue of Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: April 20, 1999
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
Lowell, Massachusetts
University of Massachusetts, Lowell
April 1-2, 2000
Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of Notices: To be announced
Program issue of Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: July 1, 1999
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Notre Dame, Indiana
University of Notre Dame
April 7-9, 2000
Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of Notices: To be announced
Program issue of Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: July 7, 1999
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Lafayette, Louisiana
University of Southwestern Louisiana
April 14-16, 2000
Southeastern Section
Associate secretary: Robert J. Daverman
Announcement issue of Notices: To be announced
Program issue of Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: July 14, 1999
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Odense, Denmark
Location to be announced
June 12-15, 2000
First AMS-Scandinavian International Mathematics Meeting.
Sponsored by the AMS, Dansk Matematisk Forening, Suomen matemaattinen yhdistys, Icelandic Mathematical Society, Norsk Matematisk Forening, and Svenska matematik-samfundet.
Associate secretary: Robert M. Fossum
Announcement issue of Notices: To be announced
Program issue of 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

Toronto, Ontario, Canada
University of Toronto
September 22-24, 2000
Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of Notices: To be announced
Program issue of 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

New York, New York
Columbia University
November 3-5, 2000
Associate secretary: Lesley M. Sibner
Announcement issue of Notices: To be announced
Program issue of Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: February 3, 2000
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
New Orleans, Louisiana

New Orleans Marriott and ITT Sheraton New Orleans Hotel

January 10-13, 2001

Joint Mathematics Meetings, including the 107th Annual Meeting of the AMS, 84th 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).

Associate secretary: Lesley M. Sibner

Announcement issue of Notices: To be announced
Program issue of Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: April 11, 2000
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

Columbia, South Carolina
University of South Carolina

March 16–18, 2001
Southeastern Section
Associate secretary: Robert J. Daverman

Announcement issue of Notices: To be announced
Program issue of Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: June 15, 2000
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Diego, California
San Diego Convention Center

January 6–9, 2002

Joint Mathematics Meetings, including the 108th Annual Meeting of the AMS and 85th Meeting of the Mathematical Association of America (MAA).

Associate secretary: Robert J. Daverman

Announcement issue of Notices: To be announced
Program issue of Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: April 4, 2001
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

Williamstown, Massachusetts
Williams College

October 13–14, 2001

Eastern Section
Associate secretary: Lesley M. Sibner

Announcement issue of Notices: To be announced
Program issue of Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: January 11, 2001
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Hoboken, New Jersey
Stevens Institute of Technology

April 28–29, 2001
Associate secretary: Lesley M. Sibner

Announcement issue of Notices: To be announced
Program issue of Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: July 28, 2000
Presenters of Papers

Chicago, Illinois; September 12-13, 1998

Numbers following the name indicate the speaker's position on the program.

• AMS Invited Lecturer, * Special Session Speaker, ▼ Graduate Student

* Abramovich, D. .......... 41
* Abramovich, D. .......... 202
* Adams, T. M. .......... 195
^ Alvarez, J. .......... 47
* Andersen, J. L. .......... 59
* Avramov, L. L. .......... 131
* Baldwin, J. .......... 20
* Bannai, E. .......... 11
* Bannai, E. .......... 156
* Barg, A. .......... 24
* Bauer, R. O. .......... 144
* Becker, E. L. .......... 90
* Beckmann, C. E. .......... 60
* Bergelson, V. .......... 179
* Bernstein, D. J. .......... 141
* Bhattacharya, R. .......... 134
* Blau, H. I. .......... 134
* Boston, N. .......... 168
* Boyd, D. A. .......... 198
* Bray, W. O. .......... 178
* Burger, E. B. .......... 37
* Burns, K. .......... 203
** Butkevich, S. C. .......... 1
* Carlson, S. C. .......... 130
* Chen, X. .......... 17
* Clair, B. F. .......... 163
* Connor, J. .......... 149
* Conrad, K. .......... 85
* Crass, S. .......... 82
* Culler, M. .......... 192
* Cutkosky, S. D. .......... 91
* D'Aristotle, A. .......... 121
* Davis, B. J. .......... 54
** Devadoss, S. L. .......... 53
* Dinwoodie, I. H. .......... 56
* Doud, D. M. .......... 167
** Dunfield, N. M. .......... 191
* Dutta, S. P. .......... 128
* Egge, E. S. .......... 212
* Eigen, S. J. .......... 76
* Eskin, A. .......... 139
* Farb, A. .......... 29
* Farb, B. .......... 140
* Feichtner, E. E. .......... 126
* Felicitas, C. S. .......... 122
* Ferenc, R. .......... 206
* Fischer, K. G. .......... 127
** Fisher, M. .......... 139
* Flach, M. .......... 199
* Fonda, A. .......... 42
* Fornaess, J. E. .......... 83
* Frid, H., Neto .......... 116
* Friedland, S. .......... 165
* Gaborit, P. .......... 183
* Galperin, G. .......... 4
* Gaspar, V. .......... 92
* Gaspar, G. .......... 69
* Gavosto, A. E. .......... 33
* Geller, W. .......... 166
* Gerber, M. .......... 96
* Gosechowdhury, S. .......... 74
* Gidea, M. .......... 97
* Gill, R. V. .......... 123
* Gillman, R. A. .......... 211
* Godsil, C. D. .......... 132
* Grant, D. R. .......... 201
* Gutierrez, C. E. .......... 111
* Gutkin, E. .......... 3
* Haaland, I. J. .......... 197
* Handjani, S. J. .......... 18
* Harel, G. .......... 23
* Heicklen, D. W. .......... 195
* Helleseth, T. .......... 158
* Hirashaka, M. .......... 105
* Hoffman, C. E. .......... 194
* Hong, S. .......... 189
* Hou, X.-d. .......... 64
* Ismail, M. E. .......... 108
* Jabon, D. .......... 147
* Jaffe, D. B. .......... 182
* Jerri, A. J. .......... 177
* Jiao, H. .......... 221
* Jin, S. .......... 118
* Johnson, K. W. .......... 136
* Jones, R. L. .......... 151
* del Junco, A. .......... 152
* Jurilčič, A. .......... 210
* Joyce, J. S. .......... 121
* Kantorovitz, M. .......... 186
* Kasube, H. E. .......... 148
* Katok, A. .......... 101
* Katsoulakis, M. A. .......... 175
* Katz, S. .......... 180
* Kauffman, L. H. .......... 30
* Kaufman, R. .......... 72
* Kenig, C. E. .......... 48
* Key, J. D. .......... 63
* Keyfitz, B. L. .......... 114
* Khots, B. S. .......... 124
* Kim, M. .......... 200
* Knudson, K. P. .......... 66
* Knuth, E. A. .......... 109
* Koch, J. H. .......... 89
* Komlós, I. .......... 154
* Krasny, R. .......... 216
* Lai, S. P. .......... 145
* Lang, M. .......... 106
* Larick, P. G. .......... 78
* Larsen, M. J. .......... 87
* Laubenthächer, R. G. .......... 7
* Laugesen, R. S. .......... 120
* Lee, T.-Y. .......... 52
* LeFloch, P. G. .......... 44
* Libgober, A. .......... 172
* Lindenstrauss, A. .......... 67
* Litsyn, S. .......... 25
* Lu, G. .......... 73
* Lyons, R. D. .......... 16
* Maher, R. J. .......... 146
* Manickam, N. .......... 107
* Margulis, G. A. .......... 138
* Martin, W. J. .......... 13
* Masur, H. .......... 208
* Mavlyutov, A. R. .......... 40
* McCutcheon, R. G. .......... 79
* McEliece, R. J. .......... 26
* Meyerowitz, A. D. .......... 213
* Mistsurewicz, M. .......... 5
* Mitra, S. .......... 81
* Monsky, P. .......... 129
* Montgomery-Smith, S. J. .......... 190
* Mumemasa, A. .......... 14
* Nabutovsky, A. .......... 162
* Nagel, A. J. .......... 46
* Nie, Q. .......... 219
* Nitsiu, V. .......... 99
* Oh, H. .......... 207
* Olsen, J. R. .......... 21
* Ovsyannikov, S. S. .......... 93
* Pan, J. A. .......... 72
* Pan, J. A. .......... 72
* Parshin, O. .......... 160
* Pearlstein, G. J. .......... 112
* Pearson, K. .......... 68
* Pelant, R. .......... 51
* Pilgrim, K. M. .......... 34
* Mohr, B. J. .......... 45
* Polishchuk, A. .......... 171
* Pollack, D. .......... 170
* Popescu, S. E. .......... 8
* Pustejovsky, S. F. .......... 62
* Quiroug, R. .......... 204
* Ramachandran, A. .......... 205
* Ramachandran, N. .......... 185
* Ray-Chaudhuri, D. K. .......... 102
* Reid, K. .......... 77
* Renardy, M. .......... 174
* Reznikov, L. F. .......... 143
* Roos, J. E. .......... 88
* Rosales, R. R. .......... 215
* Rosenblatt, J. .......... 2
* Romani, J. J. .......... 58
* Rothaus, C. .......... 93
* Sahin, A. A. .......... 153
* Sankey, A. D. .......... 12
* Scharaschkin, V. .......... 125
* Schenck, H. K. .......... 94
* Schwartz, A. L. .......... 187
* Seeger, A. .......... 70
* Sethuraman, S. .......... 19
* Shalen, P. B. .......... 193
* Shearer, M. .......... 43
* Shirokova, N. K. .......... 32
* Silva, C. E. .......... 75
* Smith, J. D. .......... 137
* Smith, S. D. .......... 15
* Smoller, J. A. .......... 173
* Solé, P. .......... 157
* Song, R. .......... 55
* Song, S.-Y. .......... 214
* Souganidis, E. .......... 115
* Spitzer, J. R. .......... 49
* Srinivasan, H. .......... 9
* Suzuki, M. .......... 133
* Swanson, I. .......... 95
* Talbert, R. N. .......... 28
* Tchernev, A. B. .......... 6
* Teitelbaum, J. T. .......... 169
* Terwilliger, P. M. .......... 209
* Török, A. .......... 100
* Tóth, B. .......... 184
* Tschinkel, Y. .......... 36
* Tzavaras, A. E. .......... 117
* Uhr, J. .......... 57
* Ullman, D. .......... 86
* Vagi, S. .......... 188
* Voevodsky, Y. .......... 50

1422 NOTICES OF THE AMS VOLUME 45, NUMBER 10
Probability Theory: Collection of Problems
A. Ya. Dorogovtsev, Kiev, Ukraine, D. S. Silvestrov, Kiev State University, Ukraine,
A. V. Skorokhod, Ukrainian Academy of Sciences, Kiev, and M. I. Yadrenko,
Kiev State University, Ukraine
This book is intended for students in pure and applied mathematics. There are problems in traditional areas of probability theory and problems in the theory of stochastic processes, which has wide applications in the theory of automatic control, queueing and reliability theories, and many other modern science and engineering fields. Answers to most of the problems are given, and for more complicated problems, the book provides hints and solutions.

Translations of Mathematical Monographs, Volume 163; 1997; 347 pages; Hardcover; ISBN 0-8218-0372-7; List $81; Individual member $71; Order code MMONO/163NA

Sign-Based Methods in Linear Statistical Models
M. V. Boldin, G. I. Simonova, and Yu. N. Tyurin, Moscow State University, Russia
For nonparametric statistics, the last half of this century was the time when rank-based methods originated, were vigorously developed, reached maturity, and received wide recognition. The rank-based approach in statistics consists in ranking the observed values and using only the ranks rather than the original numerical data. In fitting relationships to observed data, the ranks of residuals from the fitted dependence are used.
The ranked-based approach is based on the assumption that random errors take positive or negative values with equal probabilities. Under this assumption, the sign procedures are distribution-free. These procedures are robust to violations of model assumptions, for instance, to even a considerable number of gross errors in observations. In addition, sign procedures, have fairly high relative asymptotic efficiency, in spite of the obvious loss of information incurred by the use of signs instead of the corresponding numerical values.
In this work, sign-based methods in the framework of linear models are developed. In the first part of the book, there are linear and factor models involving independent observations. In the second part, linear models of time series, primarily autoregressive models, are considered.

Translations of Mathematical Monographs, Volume 162; 1997; 234 pages; Hardcover; ISBN 0-8218-0371-9; List $89; Individual member $85; Order code MMONO/162NA
Program of the Sessions
Chicago, Illinois, September 12-13, 1998

Saturday, September 12

**Meeting Registration**
7:30 AM - 5:00 PM Lobby (8th floor), Lewis Center

**AMS Exhibit and Book Sale**
7:30 AM - 5:00 PM Lobby (8th floor), Lewis Center

**Special Session on Ergodic Theory and Topological Dynamics, I**
8:30 AM - 10:50 AM Room to be announced, either the DePaul Center or the Lewis Center
Organizers: Roger L. Jones, DePaul University
Randall McCutcheon, Wesleyan College

8:30AM Joint ergodicity along sequences of intervals.
(1) Preliminary report.
Sergey G. Butkevich, The Ohio State University (935-28-214)

9:00AM The worst sums in ergodic theory.
(2) Preliminary report.
Mustafa Akcoglu, University of Toronto, Roger Jones, DePaul University, Joseph Rosenblatt*, University of Illinois, and Mate Wierdl, University of Memphis (935-28-34)

9:30AM Ergodicity and periodic orbits for billiards in polygons.
(3) Eugene Gutkin, USC (935-58-17)

10:00AM The uncertainty principle for polygonal billiards and geodesics on the surface of polyhedra. Preliminary report.
Gregory Galperin, Eastern Illinois University (935-58-167)

10:30AM Rotation numbers for maps of the n-od. Preliminary report.
Alexander Blokh, University of Alabama in Birmingham, and Michal Misiurewicz*, IUPUI (935-58-188)

**Special Session on Commutative Algebra, I**
8:30 AM - 10:50 AM Room to be announced, either the DePaul Center or the Lewis Center
Organizers: Irena V. Peeva, Massachusetts Institute of Technology
Michael Stillman, Cornell University

8:30AM A criterion for equality of radicals of ideals, and some applications.
(6) Preliminary report.
Alexandre B. Tchernev, Purdue University (935-13-181)

9:00AM Permanental ideals.
(7) Reinhard C. Laubenbacher* and Irena Swanson, New Mexico State University (935-13-180)

9:30AM Codimension three subcanonical schemes.
(8) Preliminary report.
David Eisenbud, University of California at Berkeley, Sorin E. Popescu*, Columbia University, and Charles Walter, Universite de Nice, France (935-14-220)

10:00AM Algebraic fundamental group of a curve singularity.
(9) Hema Srinivasan*, University of Missouri-Columbia, and Steven D. Cutkosky, University of Missouri (935-13-27)

10:30AM Indecomposable Gorenstein modules of odd rank.
(10) Christel Rotthaus, Michigan State University, Dana Weston, University of Missouri, and Roger Wiegand*, University of Nebraska (935-13-144)

**Special Session on Algebraic Combinatorics: Association Schemes and Related Topics, I**
8:30 AM - 10:50 AM Room to be announced, either the DePaul Center or the Lewis Center
Organizer: Sung Yell Song, Iowa State University

8:30AM Coherent configurations and 2-distance sets in real Euclidean spaces. Preliminary report.
Eiichi Bannai* and Etsuko Bannai, Kyushu University (935-05-125)

The time limit for each contributed paper in the sessions is ten minutes. In the Special Sessions the time limit varies from session to session and within sessions. To maintain the schedule, time limits will be strictly enforced.

For papers with more than one author, an asterisk follows the name of the author who plans to present the paper at the meeting.

Papers flagged with a solid triangle (>) have been designated by the author as being of possible interest to undergraduate students.

Abstracts of papers presented in the sessions at this meeting will be found in Volume 19, Issue 3 of Abstracts of papers presented to the American Mathematical Society, ordered according to the numbers in parentheses following the listings. The middle two digits, e.g., 897-20-1136, refer to the Mathematical Reviews subject classification assigned by the individual author. Groups of papers for each subject are listed chronologically in the Abstracts. The last one to four digits, e.g., 897-20-1136, refer to the receipt number of the abstract; abstracts are further sorted by the receipt number within each classification.
9:00AM - 10:45 AM Room to be announced, either the DePaul Center or the Lewis Center
Organizers: Kevin Knudson, Northwestern University
Mark Walker, University of Nebraska-Lincoln

9:00AM Transfer maps and algebraic K-theory.
(27) Bruce Williams, U. of Notre Dame (935-19-195)

9:00AM An isomorphism between Bredon and Quinn homology and the K-theoretic isomorphism conjecture. Preliminary report.
(28) Robert N. Talbert, Bethel College (IN) (935-19-118)

Special Session on Complexity of Geometric Structures on Manifolds, II

9:00AM - 10:50 AM Room to be announced, either the DePaul Center or the Lewis Center
Organizers: Melvin G. Rothenberg, University of Chicago
Shmuel Weinberger, University of Chicago

9:00AM Discrete groups acting on compact manifolds.
(29) Benson Farb*, University of Chicago, and Peter Shalen, University of Illinois at Chicago (935-57-224)

9:30AM Functional integrals and Vassiliev invariants.
(30) Preliminary report.
Louis H. Kauffman, University of Illinois at Chicago (935-55-129)

10:00AM Positive scalar curvature for complete manifolds of bounded geometry.
(31) Kevin M. Whyte, Univ. of Utah (935-57-204)

10:30AM Counterexamples to the equivariant Borel conjecture.
(32) Nadya K. Shirotova, University of Illinois, Urbana-Champaign (935-51-106)

Special Session on Complex Dynamics, I

9:00AM - 10:45 AM Room to be announced, either the DePaul Center or the Lewis Center
Organizer: Shmuel Friedland, University of Illinois at Chicago

9:00AM The Mandelbrot set for the complex Henon map.
(33) Preliminary report.
John E. Fornaess, University of Michigan, and Estela A. Gavosto*, University of Kansas (935-32-47)

10:00AM Dessins d'enfants and Hubbard trees. Preliminary report.
(34) Kevin M. Pilgrim, Univ. of Missouri, Rolla (935-11-16)
Program of the Sessions – Chicago, IL, Saturday, September 12 (cont’d.)

**Special Session on Number Theory, I**

9:00 AM – 10:50 AM Room to be announced, either the DePaul Center or the Lewis Center

Organizers: Jeremy T. Teitelbaum, University of Illinois at Chicago
Yuri Tschinkel, University of Illinois at Chicago

9:00 AM Simultaneous diagonal inequalities.

> (35) Scott T. Paresse, University of Michigan (935-11-23)

10:00 AM Arithmetic torsors.

> (36) Yuri Tschinkel, Univ. of Illinois at Chicago (935-11-132)

10:30 AM On simultaneous diophantine approximation in \( \mathbb{Q}^+ \cdot \mathbb{Q} \). Preliminary report.

Edward B. Burger, Williams College and The University of Colorado at Boulder (935-11-56)

**Special Session on Rigidity in Geometry and Dynamics, I**

9:00 AM – 10:50 AM Room to be announced, either the DePaul Center or the Lewis Center

Organizers: Steven E. Hurder, University of Illinois at Chicago
Ralf J. Spatzier, University of Michigan

9:00 AM Projective factors of group actions with stationary measure.

> (38) Robert J. Zimmer, The University of Chicago (935-22-30)

10:30 AM Arithmetic quotients and fundamental groups of manifolds admitting lattice actions. Preliminary report.

David M. Fisher, University of Chicago (935-53-221)

**Special Session on Algebraic Geometry and Mirror Symmetry, I**

9:00 AM – 10:40 AM Room to be announced, either the DePaul Center or the Lewis Center

Organizers: Ezra Getzler, Northwestern University
Mikhail Kapranov, Northwestern University
Sheldon Katz, Oklahoma State University

9:00 AM The topological cup product on semialpine hypersurfaces in toric varieties.

> (40) Anvar R. Mavlyutov, University of Massachusetts at Amherst (935-14-196)

10:00 AM Compactifying the space of stable maps.

> (41) Dan Abramovich*, Boston University, and Angelo Vistoli, Universita di Bologna (935-14-55)

**Special Session on Nonlinear Partial Differential Equations, I**

9:00 AM – 10:50 AM Room to be announced, either the DePaul Center or the Lewis Center

Organizers: Gui-Qiang Chen, Northwestern University
Konstantina Trivisa, Northwestern University

9:00 AM Weak continuity of minors in nonlinear elasticity. Preliminary report.

Irene Fonseca, Carnegie Mellon University (935-35-92)

9:30 AM Undercompressive shocks in a model of thin film motion.

Michael Shearer, North Carolina State University (935-35-238)

10:00 AM Existence of entropy solutions to the compressible Euler equations.

Philippe G. LeFloch, Ecole Polytechnique (935-35-232)

10:30 AM Bifurcation of nonclassical viscous shock profiles from the constant state.

Arthur V. Azevedo, Universidade de Brasilia, Dan Marchesin, Instituto de Matematica Pura e Aplicada, Bradley J. Plohr*, State University of New York at Stony Brook, and Kevin Zumbrun, Indiana University (935-35-203)

**Special Session on Fourier Analysis, I**

9:30 AM – 10:50 AM Room to be announced, either the DePaul Center or the Lewis Center

Organizers: Marshall Ash, DePaul University
Mark A. Pinsky, Northwestern University

9:30 AM The \( \mathcal{L}_p \) complex on certain quadratic CR submanifolds. Preliminary report.

Alexander J. Nagel, University of Wisconsin-Madison (935-42-93)

10:00 AM Central mean oscillation, Morrey spaces, and central Carleson measures.

Josefina Alvarez*, New Mexico State University, Martha Guzman-Partida, Universidad Nacional Autonoma de Mexico, and Joseph Lakey, New Mexico State University (935-42-123)


Carlos E. Kenig, University of Chicago (935-35-199)

**Invited Address**

11:00 AM – 11:50 AM Room 241, Lewis Center

(49) Rigidity phenomena in geometry and dynamics. Preliminary report.

Ralf J. Spatzier, University of Michigan (935-58-138)

**Invited Address**

1:30 PM – 2:20 PM Room 241, Lewis Center

(50) Motivic homotopy type?

Vladimir Voevodsky, Northwestern University

**Special Session on Stochastic Analysis, II**

3:00 PM – 5:50 PM Room to be announced, either the DePaul Center or the Lewis Center

Organizers: Richard B. Sowers, University of Illinois-Urbana
Elton P. Hsu, Northwestern University

3:00 PM Robustness of phase transition for general spherical models. Preliminary report.

Robin Pemantle*, Univ. of Wisconsin-Madison, and Jeff Steif, Chalmers Univ. (935-60-32)

3:30 PM Logarithmic Sobolev inequality for some models of random walks.

Tzong-Yow Lee*, University of Maryland, and Horng-Tzer Yau, New York University (935-60-35)

4:00 PM Stochastic curvature driven flows.

Nung Kwan Yip, University of Wisconsin-Madison (935-60-95)
4:30PM Doubly perturbed random walk and Brownian motion.
Burgess J. Davis, Purdue University (935-60-31)

5:00PM Martin boundary and integral representations for harmonic functions of symmetric stable processes.
Zhen-Qing Chen, Cornell University, and Renming Song*, University of Illinois at Urbana-Champaign (935-60-48)

5:30PM Problems of perturbation theory.
L. H. Dinwoodie, Tulane University (935-60-63)

Special Session on Topics in Mathematics and Curriculum Reform, II
Room to be announced, either the DePaul Center or the Lewis Center
Organizer: Richard J. Maher, Loyola University Chicago

3:00PM How to reinvigorate undergraduate mathematics education.
Jerry Uhl, University of Illinois (935-98-51)

3:30PM in praise of Thales. Preliminary report.
Joseph J. Rotman, University of Illinois, Urbana-Champaign (935-00-18)

4:00PM Forging connections between mathematics and science general education courses: Preliminary report.
Janet L. Andersen, Hope College (935-98-101)

4:30PM Problems that students must actually use calculus to solve. Preliminary report.
Charlene E. Beckmann, Grand Valley State University (935-98-208)

5:00PM Calculus assessment at the UIUC: The indicators project. Preliminary report.
Paul M. Weichsel, University of Illinois at Urbana-Champaign (935-98-52)

5:30PM Fostering effective communication in mathematics classes as a means for improving learning.
Susan F. Pustejovsky, Alverno College (935-98-131)

Special Session on Algebraic Coding, II
Room to be announced, either the DePaul Center or the Lewis Center
Organizers: William C. Huffman, Loyola University of Chicago
Vera S. Pless, University of Illinois at Chicago

3:00PM Some properties of geometric codes.
Jennifer D. Key, Clemson University, SC (935-05-127)

3:30PM New nonlinear codes constructed from Reed-Muller codes. Preliminary report.
Xiang-dong Hou, Wright State University (935-94-207)

4:00PM The presence of the all-1 vector.
Harold N. Ward, University of Virginia (935-94-112)

4:30PM Discussion

Special Session on K-Theory and Motivic Cohomology, II
Room to be announced, either the DePaul Center or the Lewis Center
Organizers: Kevin Knudson, Northwestern University
Mark Walker, University of Nebraska-Lincoln

3:00PM On the K-theory of elliptic curves.
Kevin P. Knudson, Northwestern University (935-19-122)

4:00PM Algebras satisfying the condition of Hochschild-Kostant-Rosenberg and their topological Hochschild homology.
Ayelet Lindenstrauss* and Michael Larsen, Indiana University (935-19-165)

5:00PM The lower algebraic K-theory of cocompact Fuchsian groups.
Ethan Berkove, United States Military Academy, Daniel Juan-Pineda, Instituto de Matemáticas-Unidad Morelia, and Kimberly Pearson*, Valparaiso University (935-19-116)

Special Session on Fourier Analysis, II
Room to be announced, either the DePaul Center or the Lewis Center
Organizers: Marshall Ash, DePaul University
Mark A. Pinsky, Northwestern University

3:00PM Applications of weighted Laguerre transplantation theorems.
George Gasper*, Northwestern University, and Walter Trebels, TU Darmstadt (935-42-86)

3:30PM Regularity properties of wave propagation on conic manifolds.
Detlef Müller, Christian-Albrechts-Universität Kiel, and Andreas Seeger*, University of Wisconsin-Madison (935-42-75)

4:00PM Nonuniqueness for a bounded, differentiable complete orthonormal system. Preliminary report.
Gang Wang* and J. Marshall Ash, DePaul University (935-42-74)

4:30PM Convolution squares of measures on surfaces.
Robert Kaufman, University of Illinois at Urbana-Champaign (935-42-45)

5:00PM Calderon reproducing formula and Hardy space theory on product spaces of stratified groups.
Yongsheng Han, Auburn University, and Guozhen Lu*, Wright State University (935-42-104)

5:30PM Grunsky transformation for the upper half plane.
Subhajit Ghosechowdhury, University of Missouri (935-42-230)

Special Session on Ergodic Theory and Topological Dynamics, II
Room to be announced, either the DePaul Center or the Lewis Center
Organizers: Roger L. Jones, DePaul University
Randall McCutcheon, Wesleyan College

3:00PM Staircase Actions.
Terrence Adams, Ohio State University, and Cesar E. Silva*, Williams College (935-28-191)

3:30PM On ergodic 2-to-1 endomorphisms. Preliminary report.
Stanley J. Eigen, Northeastern University (935-28-176)

4:00PM A problem in ergodic theory. Preliminary report.
Karin Reinhold, University at Albany, SUNY (935-28-169)

4:30PM Results in polynomial recurrence for actions of fields.
Paul G. Larick, The Ohio State University (935-46-58)
### Program of the Sessions – Chicago, IL, Saturday, September 12 (cont’d.)

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
</tr>
</thead>
<tbody>
<tr>
<td>5:00 PM</td>
<td>An infinitary polynomial Hales-Jewett theorem.</td>
</tr>
<tr>
<td>(79)</td>
<td>Randall G. McCutcheon, University of Maryland</td>
</tr>
<tr>
<td>(935-05-121)</td>
<td></td>
</tr>
<tr>
<td>5:30 PM</td>
<td>Recent problems I have not been able to solve.</td>
</tr>
<tr>
<td>(80)</td>
<td>Máté Wierdl, University of Memphis (935-28-77)</td>
</tr>
<tr>
<td>Special Session on Complex Dynamics, II</td>
<td></td>
</tr>
<tr>
<td>3:00 PM – 5:45 PM</td>
<td>Room to be announced, either the DePaul Center or the Lewis Center</td>
</tr>
<tr>
<td>Organizer:</td>
<td>Shmuel Friedland, University of Illinois at Chicago</td>
</tr>
<tr>
<td>3:00 PM</td>
<td>Universal holomorphic motion of a closed set in the Riemann sphere.</td>
</tr>
<tr>
<td>(81)</td>
<td>Sudeb Mitra, Cornell University (935-32-53)</td>
</tr>
<tr>
<td>4:00 PM</td>
<td>Maps on ( P^2 ) with the symmetries of the symmetric group ( S_3 ). Preliminary report.</td>
</tr>
<tr>
<td>(82)</td>
<td>Scott Crass, Buffalo State College (935-51-172)</td>
</tr>
<tr>
<td>5:00 PM</td>
<td>Remarks on complex dynamics.</td>
</tr>
<tr>
<td>(83)</td>
<td>John E. Fornaess, University of Michigan (935-32-241)</td>
</tr>
<tr>
<td>Special Session on Number Theory, II</td>
<td></td>
</tr>
<tr>
<td>3:00 PM – 4:50 PM</td>
<td>Room to be announced, either the DePaul Center or the Lewis Center</td>
</tr>
<tr>
<td>Organizers:</td>
<td>Jeremy T. Teitelbaum, University of Illinois</td>
</tr>
<tr>
<td>(935-11-126)</td>
<td>Yuri Tschinkel, University of Illinois at Chicago</td>
</tr>
<tr>
<td>3:00 PM</td>
<td>Estimating the speed of the quadratic sieve.</td>
</tr>
<tr>
<td>(84)</td>
<td>Preliminary report.</td>
</tr>
<tr>
<td>Daniel J. Bernstein, University of Illinois at Chicago (935-11-29)</td>
<td></td>
</tr>
<tr>
<td>3:30 PM</td>
<td>A ( q )-analogue of Mahler Expansions. Preliminary report.</td>
</tr>
<tr>
<td>(85)</td>
<td>Keith Conrad, Ohio State Univ. (935-11-168)</td>
</tr>
<tr>
<td>4:00 PM</td>
<td>Elliptic curves over function fields. Preliminary report.</td>
</tr>
<tr>
<td>Douglas Ulmer, University of Arizona (935-11-126)</td>
<td></td>
</tr>
<tr>
<td>4:30 PM</td>
<td>Jordan’s theorem in characteristic ( p ). Preliminary report.</td>
</tr>
<tr>
<td>(87)</td>
<td>Michael J. Larsen, University of Indiana (935-11-90)</td>
</tr>
<tr>
<td>Special Session on Commutative Algebra, II</td>
<td></td>
</tr>
<tr>
<td>3:00 PM – 6:50 PM</td>
<td>Room to be announced, either the DePaul Center or the Lewis Center</td>
</tr>
<tr>
<td>Organizers:</td>
<td>Irena V. Peeva, Massachusetts Institute of Technology</td>
</tr>
<tr>
<td>(935-05-121)</td>
<td>Michael Stillman, Cornell University</td>
</tr>
<tr>
<td>3:00 PM</td>
<td>Good and bad Koszul algebras.</td>
</tr>
<tr>
<td>(88)</td>
<td>Jan-Erik Roos, Stockholm University, Stockholm, Sweden (935-13-145)</td>
</tr>
<tr>
<td>(89)</td>
<td>Jee Heub Koh, Korea Institute for Advanced Study and Indiana University (935-13-141)</td>
</tr>
<tr>
<td>4:00 PM</td>
<td>Strictly positive regular functions on compact real varieties.</td>
</tr>
<tr>
<td>Eberhard Becker, Universität Dortmund (935-13-190)</td>
<td></td>
</tr>
<tr>
<td>4:30 PM</td>
<td>Simultaneous resolution.</td>
</tr>
<tr>
<td>(91)</td>
<td>Steven D. Cutkosky, University of Missouri-Columbia (935-14-26)</td>
</tr>
<tr>
<td>5:00 PM</td>
<td>Hilbert functions and homogeneous generic forms.</td>
</tr>
<tr>
<td>(92)</td>
<td>Vesselin Gasharov, Cornell University (935-13-202)</td>
</tr>
<tr>
<td>5:30 PM</td>
<td>Annihilators and associated primes of local cohomology modules. Preliminary report.</td>
</tr>
<tr>
<td>(93)</td>
<td>Christel Rotthaus*, Michigan State University, Markus Brodmann, Universität Zürich, and Rodney Sharp, University of Sheffield (935-13-69)</td>
</tr>
<tr>
<td>6:00 PM</td>
<td>The Chern polynomial of a three arrangement.</td>
</tr>
<tr>
<td>(94)</td>
<td>Henry K. Schenck, Northeastern University (935-14-113)</td>
</tr>
<tr>
<td>6:30 PM</td>
<td>Derivations and powers of ideals.</td>
</tr>
<tr>
<td>(95)</td>
<td>Reinhold Hübl, University of Regensburg, and Irena Swanson*, New Mexico State University (935-13-146)</td>
</tr>
<tr>
<td>Special Session on Rigidity in Geometry and Dynamics, II</td>
<td></td>
</tr>
<tr>
<td>3:00 PM – 6:15 PM</td>
<td>Room to be announced, either the DePaul Center or the Lewis Center</td>
</tr>
<tr>
<td>Organizers:</td>
<td>Steven E. Hurder, University of Illinois at Chicago</td>
</tr>
<tr>
<td>(96)</td>
<td>Ralf J. Spatzier, University of Michigan</td>
</tr>
<tr>
<td>3:00 PM</td>
<td>Hölder regularity of horocycle foliations.</td>
</tr>
<tr>
<td>(97)</td>
<td>Marlies Gerber*, Indiana University, and Amie Wilkinson, Northwestern University (935-53-177)</td>
</tr>
<tr>
<td>3:30 PM</td>
<td>Non-smooth dynamical systems that exhibit hyperbolic behavior. Preliminary report.</td>
</tr>
<tr>
<td>(98)</td>
<td>Marian Gidea, Loyola University (935-58-15)</td>
</tr>
<tr>
<td>4:00 PM</td>
<td>Genuine partial hyperbolicity in a stably Bernoullian diffeomorphism.</td>
</tr>
<tr>
<td>(99)</td>
<td>Michael Shub, IBM, and Amie Wilkinson*, Northwestern (935-58-229)</td>
</tr>
<tr>
<td>4:30 PM</td>
<td>An open dense set of stably ergodic diffeomorphisms in a neighborhood of a non-ergodic one.</td>
</tr>
<tr>
<td>(100)</td>
<td>Viorescu *, University of Notre Dame, and Andrei Torok, Princeton University (935-58-166)</td>
</tr>
<tr>
<td>5:00 PM</td>
<td>Rigidity of volume preserving partially hyperbolic actions of property (( T )) groups. Preliminary report.</td>
</tr>
<tr>
<td>(101)</td>
<td>Andrew Török, Princeton University (935-58-61)</td>
</tr>
<tr>
<td>5:30 PM</td>
<td>New results on rigidity of invariant measures for actions of higher rank abelian groups.</td>
</tr>
<tr>
<td>(102)</td>
<td>Anatole Katok, Pennsylvania State University (935-22-239)</td>
</tr>
<tr>
<td>Special Session on Algebraic Combinatorics: Association Schemes and Related Topics, II</td>
<td></td>
</tr>
<tr>
<td>3:00 PM – 5:50 PM</td>
<td>Room to be announced, either the DePaul Center or the Lewis Center</td>
</tr>
<tr>
<td>Organizer:</td>
<td>Sung Yell Song, Iowa State University Combinatorial inequalities for quasi-polynomial semiflattices.</td>
</tr>
<tr>
<td>(103)</td>
<td>Dijen K. Ray-Chaudhuri* and Jin Qian, Department of Mathematics The Ohio State University (935-05-156)</td>
</tr>
<tr>
<td>3:30 PM</td>
<td>On Cayley graphs of 3-transposition groups.</td>
</tr>
<tr>
<td>(104)</td>
<td>Preliminary report.</td>
</tr>
<tr>
<td>Norio Yamazaki, Imperial College, London (935-05-183)</td>
<td></td>
</tr>
<tr>
<td>4:00 PM</td>
<td>Superschemes and ( t )-vertex condition graphs.</td>
</tr>
<tr>
<td>(105)</td>
<td>Jerzy Wojdylo, Southeast Missouri State University (935-05-96)</td>
</tr>
<tr>
<td>4:30 PM</td>
<td>Association schemes with a nonsymmetric relation of valency two.</td>
</tr>
<tr>
<td>(106)</td>
<td>Mitsugu Hirakawa* and Mikhail Muzychuk, Bar-Ilan University (935-05-205)</td>
</tr>
</tbody>
</table>
Sunday, September 13

Meeting Registration
8:00 AM - 11:00 AM
Lobby (8th floor), Lewis Center

Special Session on Commutative Algebra, III
8:00 AM - 10:50 AM
Room to be announced, either the DePaul Center or the Lewis Center
Organizers: Irena V. Peeva, Massachusetts Institute of Technology
            Michael Stillman, Cornell University

3:00 PM - 6:20 PM
Room to be announced, either the DePaul Center or the Lewis Center
Organizers: Gui-Qiang Chen, Northwestern University
            Konstantina Trivisa, Northwestern University

3:00 PM
Michael Lang, University of Wisconsin-Madison (935-05-218)

5:30 PM
Distribution invariants of association schemes.
Nachimuthu Manickam, DePauw University (935-05-234)

Special Session on Orthogonal Polynomial Series, Summability and Conjugates, I
3:00 PM - 5:30 PM
Room to be announced, either the DePaul Center or the Lewis Center
Organizers: Calixto P. Calderon, University of Illinois at Chicago
Luis A. Caffarelli, University of Texas at Austin

3:00 PM
Difference equations and quantized discriminants for q-orthogonal polynomials. Preliminary report.
Mourad E.H. Ismail, University of South Florida (935-33-34)

4:20 PM
Singular integrals associated with surfaces of revolution.
Sarah N. Ziesler, Dominican University (935-42-128)

5:00 PM
Cristian E. Gutiérrez, Temple University (935-42-97)

Special Session on Algebraic Geometry and Mirror Symmetry, II
3:00 PM - 4:40 PM
Room to be announced, either the DePaul Center or the Lewis Center
Organizers: Ezra Getzler, Northwestern University
Mikhail Kapranov, Northwestern University
Sheldon Katz, Oklahoma State University

3:00 PM
Admissible variations of mixed Hodge structure.
Gregory J. Pearlstein, University of Massachusetts, Amherst, and Aroldo Kaplan, University of Massachusetts, Amherst (935-14-135)

4:00 PM
Tessellations of moduli spaces and the mosaic operad. Preliminary report.
Satyan L. Devadoss, Johns Hopkins University (935-14-79)

Special Session on Nonlinear Partial Differential Equations, II
3:00 PM - 6:20 PM
Room to be announced, either the DePaul Center or the Lewis Center
Organizers: Gui-Qiang Chen, Northwestern University
Konstantina Trivisa, Northwestern University

3:00 PM
A proof of existence of perturbed steady transonic shocks via a free boundary problem.
Suncica Canic, Barbara Lee Keyfitz, University of Houston, and Gary M. Lieberman, Iowa State University (935-35-60)

3:30 PM
Fully nonlinear stochastic partial differential equations. Preliminary report.
Panagiotis E. Souganidis, University of Wisconsin (935-35-91)

4:00 PM
On the asymptotic behavior of entropy solutions to hyperbolic conservation laws.
Herrano Fri D'Noto, Universidade Federal do Rio de Janeiro (935-35-114)

4:30 PM
Relaxation to the equations of isothermal elastodynamics.
Athanasios Tzavaras, Univ. of Wisconsin (935-35-98)

5:00 PM
Relaxation approximations to PDEs.
Shi Jin*, Georgia Institute of Technology, Markos Katsoulakis, University of Massachusetts, and Zhouping Xin, Courant Institute (935-65-198)

5:30 PM
Global solutions and asymptotic behavior of nonlinear magnetohydrodynamics.
Gui-Qiang Chen, Northwestern University, and Dehua Wang*, University of California at Santa Barbara (935-35-179)

6:00 PM
Thin film equations: Existence and properties of steady states.
Richard S. Laugesen*, University of Illinois, Urbana-Champaign, and Mary C. Pugh, University of Pennsylvania (935-35-22)

Session for Contributed Papers
3:00 PM - 4:10 PM
Room to be announced, either the DePaul Center or the Lewis Center

3:00 PM
An invariance principle for triangular.
Anthony D'Aristotle, SUNY (935-60-134)

3:15 PM
Enumerating unordered sets of finite size N.
C. S. Felicitas, Pan Asian Congress of Mathematicians (AmmerNV) (935-18-09)

3:30 PM
Posets from conjugacy classes of Coxeter groups. Preliminary report.
Robert V. Gill, University of Michigan (935-20-115)

3:45 PM
Analytical functions and infinite-dimensional P-groups. Preliminary report.
Boris S. Knis, Compressor Controls Corporation (935-46-14)

4:00 PM
The Hasse principle modulo Nth powers.
Victor Scharaschnik, University of Michigan (935-11-197)
Program of the Sessions – Chicago, IL, Sunday, September 13 (cont’d.)

9:00AM - 10:50AM

**Special Session on Rigidity in Geometry and Dynamics, III**

- A theorem on smoothness—Bass-Quillen, Chow groups and intersection multiplicity of Serre.
  - Sankar P. Dutta, University of Illinois at Urbana-Champaign (935-13-64)
- Sharper estimates for the Hilbert-Kunz function in dimension 2.
  - Paul Monsky, Brandeis University (935-13-10)
- Approximating discrete valuation rings by regular local rings.
  - William Heinzer, Purdue University, Christel Rotthaus, Michigan State University, and Sylvia Wiegand, University of Nebraska (935-13-143)
- Deviations of local homomorphisms and finiteness of André-Quillen homology.
  - Luchezar L. Avramov, Purdue University (935-13-189)

**Special Session on Algebraic Combinatorics: Association Schemes and Related Topics, III**

- Room to be announced, either the DePaul Center or the Lewis Center

  **Organizer:** Sung Yell Song, Iowa State University

- Rose-Mesner automorphisms and sub-schemes.
  - Preliminary report.
  - Chris D. Godsil, University of Waterloo (935-05-67)
- Character products and Q-polynomial group association schemes.
  - Hiroshi Suzuki, Department of Mathematics, International Christian University (935-05-85)
- Integral table algebras and commutative association schemes with a nonsymmetric relation of valency 3.
  - Preliminary report.
  - Harvey I. Blau, Northern Illinois University (935-05-70)
- Some remarks on a regular thin near 7-gon.
  - Andrew J. Woldar, Villanova University (935-05-187)
- Generalized classes in association schemes: arithmetic properties and a dual of a result of Burnside.
  - Kenneth W. Johnson, Penn State University, Abington College, and Eirini Pimenidou, New College of the University of South Florida.
  - Preliminary report.
  - Jonathan D. H. Smith, Iowa State University (935-05-108)

AMS Exhibit and Book Sale

8:00 AM - 11:00 AM

Lobby (8th floor), Lewis Center

**Special Session on Rigidity in Geometry and Dynamics, III**

- Room to be announced, either the DePaul Center or the Lewis Center

  **Organizers:** Steven E. Hurder, University of Illinois at Chicago
  - Ralf J. Spatzier, University of Michigan

- Rigidity of weakly hyperbolic actions of higher rank semisimple Lie groups and their lattices.
  - Gregory A. Margulis and Nantian Qian, Yale University (935-58-86)
- Some applications of the $SL(2,R)$ action on Teichmüller space.
  - Preliminary report.
  - Alex Eskin, University of Chicago (935-22-233)

10:30AM

- On the asymptotic geometry of abelian-by-cyclic groups.
  - Benson Farb, University of Chicago, and Lee Mosher, Rutgers University, Newark (935-20-222)

**Special Session on Stochastic Analysis, III**

8:30 AM - 10:50 AM

Room to be announced, either the DePaul Center or the Lewis Center

  **Organizers:** Richard B. Sowers, University of Illinois-Urbana
  - Elton P. Hsu, Northwestern University

- A class of multi-scale processes and their phase changes with time.
  - Rabi Bhattacharya, Indiana University (935-60-99)
- On the mixing rate of the Lagrangian velocity field.
  - Preliminary report.
  - Craig L. Zirbel, Bowling Green State University (935-60-102)
- Homogenization for Hamilton-Jacobi PDEs with random Hamiltonian.
  - Fraydoun Rezakhanlou, UC Berkeley (935-60-226)
- Yang-Mills fields and random holonomy in small geodesic balls.
  - Robert O. Bauer, Georgia Institute of Technology (935-60-57)
- Anisotropic stochastic growth models on trees.
  - Preliminary report.
  - Steven P. Lalley, Purdue University (935-60-120)

**Special Session on Topics in Mathematics and Curriculum Reform, III**

8:30 AM - 10:50 AM

Room to be announced, either the DePaul Center or the Lewis Center

  **Organizer:** Richard J. Maher, Loyola University Chicago

- Exactly what parts of the sky are falling?
  - Preliminary report.
  - Richard J. Maher, Loyola University Chicago (935-98-124)
  - Carolyn Narasimhan and David Jabon, DePaul University (935-98-49)
- The role of the history of mathematics in the reform movement.
  - Herbert E. Kasube, Bradley University (935-98-37)
- A geometry course for prospective secondary school teachers.
  - Preliminary report.
  - Jeff Connor and Barbara Grover, Ohio University (935-98-20)
- Curricular options for undergraduate topology.
  - Preliminary report.
  - Stephan C. Carlson, Rose-Hulman Inst. of Tech. (935-98-62)

**Special Session on Ergodic Theory and Topological Dynamics, III**

8:30 AM - 10:50 AM

Room to be announced, either the DePaul Center or the Lewis Center

  **Organizers:** Roger L. Jones, DePaul University
  - Randall McCutcheon, Wesleyan College

- Differential and ergodic transforms. Preliminary report.
  - Roger L. Jones, DePaul University, and Joseph Rosenblatt, University of Illinois at Urbana (935-26-38)
9:00AM Room to be announced, either the DePaul Center or the Lewis Center
Organizers: Kevin Knudson, Northwestern University
Mark Walker, University of Nebraska-Lincoln

9:00AM K-theory of complex varieties.
Claudio Pedrini, Universita di Genova, and Charles A. Weibel*, Rutgers University (935-19-173)

10:00AM On the category of mixed elliptic motives.
Preliminary report.
Owen Patashnick, University of Chicago (935-14-228)

Special Session on Orthogonal Polynomial Series, Summability and Conjugates, II
9:00AM Room to be announced, either the DePaul Center or the Lewis Center
Organizers: Calixto P. Calderon, University of Illinois at Chicago
Luis A. Caffarelli, University of Texas at Austin

9:00AM Discussion

Special Session on Algebraic Geometry and Mirror Symmetry, III
9:00AM Room to be announced, either the DePaul Center or the Lewis Center
Organizers: Ezra Getzler, Northwestern University
Mikhail Kapranov, Northwestern University
Sheldon Katz, Oklahoma State University
Program of the Sessions – Chicago, IL, Sunday, September 13 (cont’d.)

9:00 AM – 10:50 AM Room to be announced, either the DePaul Center or the Lewis Center
Organizers: Guo-Qiang Chen, Northwestern University
Konstantina Trivisa, Northwestern University

9:00 AM Shock waves, general relativity, and astrophysics.
Joel A. Smoller, University of Michigan (935-35-87)

9:30 AM Boundary formation in linear elasticity.
Michael Renardy* and David L. Russell, Virginia Tech (935-35-99)

10:00 AM Macroscopic dynamics of electro rheological suspensions, Preliminary report.
Markos A. Katsoulakis*, University of Massachusetts, and Fernando Reitich, University of Minnesota (935-35-216)

10:30 AM Liouville theorems for the degenerate Laplace equations and their applications.
James Serrin, University of Minnesota, and Henghui Zou*, University of Alabama at Birmingham (935-35-211)

Special Session on Fourier Analysis, III

9:30 AM – 10:50 AM Room to be announced, either the DePaul Center or the Lewis Center
Organizers: Marshall Ash, DePaul University
Mark A. Pinsky, Northwestern University

Abdul J. Jerri, Clarkson University (935-35-12)

William O. Bray, University of Maine (935-42-136)

Invited Address

11:00 AM – 11:50 AM Room 241, Lewis Center
Number theory, combinatorics and ergodic theorems along polynomials.
Vitaly Bergelson, Ohio State University

Invited Address

1:30 PM – 2:20 PM Room 241, Lewis Center
The mathematics and physics of mirror symmetry
Sheldon Katz, Oklahoma State University

Special Session on Algebraic Coding, IV

3:00 PM – 4:20 PM Room to be announced, either the DePaul Center or the Lewis Center
Organizers: William C. Huffman, Loyola University of Chicago

Vera S. Pless, University of Illinois at Chicago

3:00 PM Recent progress in the algebraic-geometric approach to codes over rings.
Judy L. Walker, University of Nebraska (935-94-219)

3:30 PM Optimal binary linear codes obtained from regular partitions of vector spaces.
David B. Jaffe, Un. of Nebraska - Lincoln (935-94-206)

4:00 PM On the classification of even extremal formally self-dual codes.
Joe E. Fields, University of Illinois at Chicago, Philippe Gaborit*, INRIA - University of Illinois at Chicago, William C. Huffman, Loyola University, and Vera Pless, University of Illinois at Chicago (935-05-130)

Special Session on K-Theory and Motivic Cohomology, IV

3:00 PM – 5:40 PM Room to be announced, either the DePaul Center or the Lewis Center
Organizers: Kevin Knudson, Northwestern University
Mark Walker, University of Nebraska-Lincoln

3:00 PM The Chow ring and motivic cohomology of classifying spaces.
Burt Totaro, University of Chicago (935-19-174)

4:00 PM A conjecture of Deline on one-motives.
Niranjan Ramachandran, University of Michigan (935-19-213)

5:00 PM An explicit description of the Dennis trace map.
Miriam Ruth Kantorovitz*, University of Illinois at Urbana-Champaign, and Claudia Miller, University of Michigan (935-19-150)

Special Session on Fourier Analysis, IV

3:00 PM – 4:50 PM Room to be announced, either the DePaul Center or the Lewis Center
Organizers: Marshall Ash, DePaul University
Mark A. Pinsky, Northwestern University

3:00 PM The harmonic analysis of a hypergroup depends on its center. Preliminary report.
Alan L. Schwartz*, University of Missouri-St. Louis, and Olivier Gebuhrer, Universite Louis Pasteur, Strasbourg, France (935-43-21)

3:30 PM On Sobolev spaces of fractional order and e-families of operators on spaces of homogeneous type.
A. E. Gatto and S. Vagi*, DePaul University (935-42-192)

4:00 PM Weak type estimates for cone multipliers on $H^p$ spaces, $p < 1$.
Sungbeum Hong, University of Wisconsin-Madison (935-42-40)

4:30 PM Endpoint Strichartz inequalities.
Stephen J. Montgomery-Smith, University of Missouri at Columbia (935-35-12)

Special Session on Complexity of Geometric Structures on Manifolds, III

3:00 PM – 4:20 PM Room to be announced, either the DePaul Center or the Lewis Center
Organizers: Melvin G. Rothenberg, University of Chicago
Special Session on Number Theory, IV

3:00 PM
Cyclic surgery, degrees of maps of character curves, and volume rigidity for hyperbolic manifolds.
Nathan M. Dunfield, University of Illinois at Chicago (935-57-71)

3:30 PM
Small Dehn surgeries, Part II. Preliminary report.
Steve Boyer, UQAM, Montreal, Canada, Marc Culler*, Peter B. Shalen, UIC, Chicago, IL, and Xingru Zhang, SUNY, Buffalo, NY (935-57-105)

4:00 PM
Small Dehn fillings, I. Preliminary report.
Steven P. Boyer, University of Quebec at Montreal, Marc Culler, Peter B. Shalen*, University of Illinois at Chicago, and Xingru Zhang, Oklahoma State University (935-57-103)

Special Session on Ergodic Theory and Topological Dynamics, IV

3:00 PM - 4:50 PM
Room to be announced, either the DePaul Center or the Lewis Center
Organizers: Roger L. Jones, DePaul University
Randall McCutcheon, Wesleyan College

3:00 PM
Processes which are one sidedly isomorphic to a Bernoulli shift.
Christopher E. Hoffman, University of Maryland (935-28-72)

3:30 PM
T⁻¹ is not standard.
Deborah W. Heicklen*, Berkeley, and Christopher E. Hoffman, University of Maryland (935-28-83)

4:00 PM
Uncommon types of mixing. Preliminary report.
Terrence M. Adams, Rhode Island College (935-28-194)

4:30 PM
Weakly mixing of all orders along generalized polynomials. Preliminary report.
Inger Johanne Håland, Agder College, Norway (935-28-201)

Special Session on Complex Dynamics, IV

3:00 PM - 3:45 PM
Room to be announced, either the DePaul Center or the Lewis Center
Organizer: Shmuel Friedland, University of Illinois at Chicago

3:00 PM
Translation invariant Julia sets.
David A. Boyd, Purdue University (935-30-171)

Special Session on Number Theory, IV

3:00 PM - 4:50 PM
Room to be announced, either the DePaul Center or the Lewis Center
Organizers: Jeremy T. Teitelbaum, University of Illinois at Chicago
Yuri Tschinkel, University of Illinois at Chicago

3:00 PM
Equivariant Tamagawa numbers.
Matthias Flach*, Caltech, and David Burns, King's College (935-06-65)

3:30 PM
ABC inequalities for some moduli spaces of log general type.
Minhyong Kim, University of Arizona (935-11-36)

4:00 PM
A bound on elliptic curves with exceptional primes.
David R. Grant, University of Colorado at Boulder (935-11-66)

4:30 PM
Semistable reduction in characteristic 0.
Dan Abramovich* and Kalle Karu, Boston University (935-14-54)

Special Session on Rigidity in Geometry and Dynamics, IV

3:00 PM - 6:00 PM
Room to be announced, either the DePaul Center or the Lewis Center
Organizers: Steven E. Hurder, University of Illinois at Chicago
Ralf J. Spatzier, University of Michigan

3:00 PM
Ergodicity of skew products.
Keith Burns* and Amie Wilkinson, Northwestern University (935-58-137)

3:30 PM
Fundamental groups of compact manifolds and symmetric geometry of noncompact type.
Alberto Candel, California Institute of Technology, and Raul Quiroga*, CINVESTAV-IPN (935-53-175)

4:00 PM
Finiteness and rigidity for complete Kahler manifolds.
Mohan Ramachandran, SUNY at Buffalo (935-58-215)

4:30 PM
Cartan geometries and superrigidity. Preliminary report.
Renato Feres, Washington University, St. Louis (935-53-161)

5:00 PM
Cartan decomposition subgroups and compact quotients of SO(2,n)/H.
Hee Oh*, University of Chicago, and Dave Witte, Oklahoma State University (935-22-231)

5:30 PM
Asymptotics for the number of saddle connections for a quadratic differential.
Howard Masur, University of Illinois at Chicago (935-22-240)

Special Session on Algebraic Combinatorics: Association Schemes and Related Topics, IV

3:00 PM - 5:50 PM
Room to be announced, either the DePaul Center or the Lewis Center
Organizer: Sung Yell Song, Iowa State University

3:00 PM
Leonard systems and the q-Racah polynomials. Preliminary report.
Paul M. Terwilliger, University of Wisconsin-Madison, WI (935-05-225)

3:30 PM
Tight distance-regular graphs.
Aleksandar Jurišić*, IMFM, Jack Koolen, University of Eindhoven, and Paul Terwilliger, University of Wisconsin (935-05-159)

4:00 PM
The Terwilliger algebra of the hypercube Q₂ⁿ. Preliminary report.
Junie T. Go, University of Wisconsin-Madison (935-05-186)

4:30 PM
A generalization of the Terwilliger algebra.
Eric S. Egge, University of Wisconsin at Madison (935-05-158)

5:00 PM
Tiling the integers with translates of one finite set.
(213) Preliminary report.
Aaron D. Meyerowitz*, Florida Atlantic University, and Ethan M. Coven, Wesleyan University (935-05-235)

5:30 PM
Sung-Yell Song, Iowa State University (935-05-157)

Special Session on Nonlinear Partial Differential Equations.

3:00 PM - 6:20 PM
Room to be announced, either the DePaul Center or the Lewis Center
Organizers: Gui-Qiang Chen, Northwestern University
Free Probability Theory

Dan-Virgil Voiculescu,
University of California, Berkeley

Free probability theory is a highly noncommutative probability theory, with independence based on free products instead of tensor products. The theory models random matrices in the large $N$ limit and operator algebra free products. It has led to a surge of new results on the von Neumann algebras of free groups.

This is a volume of papers from a workshop on Random Matrices and Operator Algebra Free Products, held at the Fields Institute for Research in the Mathematical Sciences in March 1995. Over the last few years, there has been much progress on the operator algebra and noncommutative probability sides of the subject. New links with the physics of masterfields and the combinatorics of non-crossing partitions have emerged. Moreover there is a growing free entropy theory. The idea of this workshop was to bring together people working in all these directions and from an even broader free products area where future developments might lead.

Fields Institute Communications, Volume 12; 1997; 312 pages; Hardcover; ISBN 0-8218-0676-0; List $79; Individual member $47; order code FIC/12NA

Hommage à P.A. Meyer et J. Neveu

This tribute to Paul André Meyer and Jacques Neveu displays their wide influence on modern probability theory by gathering nineteen original research papers, drawn from a large range of topics: potential theory, classical stochastic processes and their laws, non-commutative probability, estimates of heat kernels, entropy, ergodic theory, phase transition, stochastic models in financial markets, and excursion theory.

Titles in this series are published by the Société Mathématique de France and 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 9, 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.

Asterisque, Number 236; 1996; 308 pages; Softcover; List $68; Individual member $61; order code AST/236NA

AMS
American Mathematical Society

Program of Sessions

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3:00PM</td>
<td>Konstantina Trivisa, Northwestern University</td>
</tr>
<tr>
<td></td>
<td>Large amplitude nonlinear acoustic waves without shocks.</td>
</tr>
<tr>
<td></td>
<td>Rodolfo R. Rosales, MIT (935-35-205)</td>
</tr>
<tr>
<td>3:30PM</td>
<td>Robert Krasny*, University of Michigan, and Monika Nitsche, Tufts University (935-76-107)</td>
</tr>
<tr>
<td>4:00PM</td>
<td>Continuum mechanics, exterior calculus, and hyperelasticity, Preliminary report.</td>
</tr>
<tr>
<td></td>
<td>David H. Wagner, University of Houston (935-73-217)</td>
</tr>
<tr>
<td>4:30PM</td>
<td>Mathematical modeling of frontal polymerization.</td>
</tr>
<tr>
<td></td>
<td>Vladimir A. Volpert, Northwestern University (935-35-200)</td>
</tr>
<tr>
<td>5:00PM</td>
<td>Interface dynamics in microstructure evolution.</td>
</tr>
<tr>
<td></td>
<td>Qing Nie, U. of Chicago (935-65-212)</td>
</tr>
<tr>
<td>5:30PM</td>
<td>A unified construction of variational methods for the nonlinear Schrödinger equation.</td>
</tr>
<tr>
<td></td>
<td>Alexander L. Zubarev*, Purdue University, and Yeong E. Kim, Purdue University (935-82-50)</td>
</tr>
<tr>
<td>6:00PM</td>
<td>Blow-up of solutions to semilinear wave equations in high space dimensions.</td>
</tr>
<tr>
<td></td>
<td>Hengli Jiao, Jackson (935-35-153)</td>
</tr>
</tbody>
</table>

Susan J. Friedlander
Associate Secretary
Chicago, Illinois
Joint Summer Research Conferences in the Mathematical Sciences

University of Colorado
Boulder, Colorado
June 13-July 1, 1999

The 1999 Joint Summer Research Conferences will be held at the University of Colorado, Boulder, Colorado, from June 13-July 1, 1999. The topics and organizers for the seven conferences were selected by a committee representing the AMS, the Institute of Mathematical Sciences (IMS), and the Society for Industrial and Applied Mathematics (SIAM), whose members at the time were Alejandro Adem, David Brydges, Percy Deift, James W. Demmel, Dipak Dey, Tom Dicicco, Steven Hurder, Alan F. Karr, Barbara Keyfitz, W. Brent Lindquist, Andre Manitius, and Bart Ng.

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 (women and minorities are especially encouraged) should request an invitation by sending the following information to: Summer Research Conferences Coordinator, American Mathematical Society, P.O. Box 6887, Providence, RI 02940, or by e-mail to wsd@ams.org no later than March 3, 1999.

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 7/1/93.
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 dormitories 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.

Lectures begin on Sunday morning and run through Thursday. Check-in for housing begins on Saturday. No lectures are held on Saturday.

From Manifolds to Singular Varieties
Sunday, June 13–Thursday, June 17, 1999

Sylvain E. Cappell, Courant Institute
Ronnie Lee, Yale University
Wolfgang Lück, Westfälische Wilhelms-Universität Münster

Recently, researchers in topology, geometry and global analysis have been encountering some related issues in attempts to extend classical methods and results from manifolds to more general settings of singular varieties. These are needed for applications because many of the natural spaces that are the focus of current investigations are usually singular. Examples include: representation spaces, such as those of fundamental groups of Riemann surfaces arising in the study of low dimensional manifolds; moduli space constructions in algebraic geometry; the singular spaces which arise in trying to study and classify general finite or compact group actions on manifolds; and spaces produced in a variety of contexts by natural compactification procedures.

The object of this conference will be to describe some recent advances in this general area and to discuss and compare questions, methods, and applications from a variety of perspectives. Among other subjects, the conference will include talks on the following topics:

1. Topological invariants and classifications of singular varieties. A topological motivation for studying singular varieties is the study of group actions, because their orbit spaces are stratified spaces. A goal is to make some powerful new classification methods more accessible and applicable by considering spaces arising from natural contexts. A natural question, which can be approached from...
several viewpoints, is: what can be said about topological classification of algebraic varieties?

Important recent developments in the theory of singular varieties are related to the study of their characteristic classes. There are, in fact, several closely related theories of characteristic classes developed by a number of workers. Among questions to be addressed are: What are the relations between different theories of characteristic classes and what do they reveal about geometric and analytic structures of the varieties? When can such classes, which for singular varieties generally take values in homology, be lifted back at least partially towards cohomology of other theories; and what additional structures are necessary for such refinements?

Intersection homology theory has been a powerful tool for the investigation of intersection theories and numbers in singular varieties. But its functoriality, analytical interpretation, e.g., its relation to $L^2$ cohomology, as well as other issues are still not fully understood. Moreover, it doesn’t cover all the now needed settings, e.g., in symplectic geometry. This meeting will be a forum for such new issues in intersection theory.

2. $3$-manifold invariants and moduli spaces. Some subtle invariants of $3$-manifolds are related to representation spaces. But extensions of Casson’s SU(2) ideas to more general Lie groups encounter difficulties due to the more singular nature of the representation varieties and require investigations of Lagrangian subvarieties in singular symplectic varieties. These invariants should be compared with combinatorial invariants, e.g., those related to Vassiliev’s perspective on knot theory and to “finite type invariants” of $3$-manifolds.

Representation varieties have been investigated by algebraic geometers as moduli spaces of holomorphic $G$-bundles over a Riemann surface. Related moduli objects (e.g., of Higgs bundles, of the moduli spaces of stable k-pairs, etc.) arise through interactions with physics. Such moduli spaces exhibit similar symplectic and Kahler structures as well as gauge theory interpretations. It will be desirable to compare different treatments of singularities.

3. $L^2$-Betti numbers and $L^2$-torsions. $L^2$-invariants such as $L^2$-Betti numbers, Novikov-Shubin invariants, $L^2$-torsions can be defined analytically in terms of the heat kernel of the universal covering as well as topologically. This gives fruitful links between analysis and topology with applications in differential geometry, topology, group theory and algebraic K-theory.

Connections to the first topic come from the relation of intersection homology and $L^2$-cohomology. The Cheeger-Goresky-MacPherson Conjecture and the Zucker Conjecture link the $L^2$-cohomology of the regular part with the intersection homology of an algebraic variety. For applications in group theory and algebraic K-theory it was necessary to define $L^2$-Betti numbers for “very singular” spaces. This suggests extending results from actions of finite groups to (proper) actions of discrete groups.

$L^2$-Betti numbers, Novikov-Shubin invariants and $L^2$-torsion have been studied for $3$-manifolds and are linked to other invariants, e.g., volume of hyperbolic manifolds and Gromov’s simplicial volume. Open questions include the Atiyah conjecture, the Singer Conjecture and the zero-in-the-spectrum conjecture which are related to algebraic K-theory, global analysis, and topological rigidity conjectures.

Computability Theory and Applications
Sunday, June 13–Thursday, June 17, 1999

Peter Cholak, University of Notre Dame
Steffen Lempp, University of Wisconsin (co-chair)
Manuel Lerman, University of Connecticut (co-chair)
Richard Shore, Cornell University (co-chair)

Computability theory (or recursion theory) is an area of mathematical logic dealing with the theoretical bounds on and structure of computability and with the interplay between computability and definability in mathematical languages and structures. The field started in the 1930s with ground-breaking work of Gödel and Turing and has developed into a rich theory with applications and connections to areas ranging from computer science to descriptive set theory as well as more traditional branches of mathematics, including algebra, analysis, and combinatorics. The meeting will focus on classical computability theory, an area in which many recent advances have been made, and those applications which currently seem most directly connected to and most likely to benefit from these advances. In particular, applications in algebra, model theory, and proof theory will be highlighted. Lectures will stress open problems, their relationship to some of the recent advances, and further obstacles which need to be overcome to solve the problems. Problems, primarily from the following areas, will be discussed.

1. Classical computability theory. There have been a number of major advances in the understanding of substructures of the Turing degrees in the past few years, including a phenomenal number of solutions to diverse problems that had been open for decades and had always been considered very hard. In addition, substantial progress has been made towards the solution of other problems. Results have been obtained about automorphisms of these structures, characterizing definable sets and relations, and decidability and undecidability of fragments of elementary theories of the structures. These results will be discussed with an eye towards the limitations of the methods and the obstacles which need to be overcome in order to solve other problems of a similar nature.

2. Computable mathematics. The area of applied computability theory on which we propose to concentrate is computable mathematics. Generally speaking, one wishes to investigate the effective content of mathematical constructions and theorems, that is, to determine which procedures or relations are computable and the relative complexity of those that are not. The problems which we will address deal with determining properties of computable structures which can be decided effectively from their presentations and, if not, on the possible limits on their complexity.
Reverse mathematics is a proof-theoretic and foundational investigation into the axiom systems needed to prove standard theorems of classical mathematics, but many of its arguments and results can also be viewed as belonging to computable mathematics. There is an almost perfect translation between the proof-theoretic systems used and the levels of complexity in computability. Each approach contributes its own techniques, which often produce results with overlapping but supplementary content. An important foundational issue is the existence of classical theorems not equivalent to any of the standard systems. It seems likely that further computability theory analyses using more delicate techniques can shed light on this area.

**Homotopy Methods in Algebraic Topology**

**Sunday, June 20—Thursday, June 24, 1999**

Robert Bruner, Wayne State University (co-chair)
Anthony Elmendorf, Purdue University, Calumet
John Greenlees, Sheffield University (England)
Nicholas J. Kuhn, University of Virginia (co-chair)
James McClure, Purdue University, West Lafayette

Algebraic topology has continually developed sophisticated new homological and homotopical methods, which have then been exported to algebraic settings such as representation theory, group theory, ring theory, and algebraic geometry. Topology currently seems to be going through a period in which much of the most striking work involves such interfacing with algebra. The primary purpose of the conference will be to present a broad range of current work in this direction, with talks in each of five general areas.

**Localization Methods and Group Cohomology**

There has been a renaissance of interest in the axiomatics of triangulated categories and their localizations. Results familiar in algebraic topology such as Brown representability and Bousfield localization have been refined and extended and then fruitfully transported into new algebraic settings such as algebraic geometry and group cohomology. Corresponding computational results include the recent computation of the cohomology of the Steenrod algebra up to $F$-isomorphism and new work on the cohomology of various arithmetic groups.

**Homology Operations, Combinatorics, and Ring Theory**

An ongoing theme in algebraic topology has been the development of the algebraic machinery necessary to efficiently encode information about various sorts of homology operations. Recently this machinery has been used in a number of distinctly purely algebraic settings. Examples include the use of Steenrod algebra technology to prove the Stong-Landweber Conjecture about the depth of rings of invariants, the Manchester school's work relating algebras of operations arising in topology to fundamental combinatorial structures, and new studies on deformations of Hopf algebras arising in topology.

**New Approaches to Homotopy Theory**

A closed model category is a category with structure allowing one to do homotopy theory satisfying expected properties. Voevodsky, Morel, and others have led major developments in the construction of such structures in algebro-geometric settings. One expects that this ongoing work will feed back into classic topology in much the way that the development of étale homotopy did two decades before.

Related to this is recent work on the foundations of stable homotopy. Jeff Smith and his collaborators have developed the theory of symmetric spectra, and the Chicago school, led by J. Peter May, has used modern operadic methods to develop the theory of $S$-modules. Both of these underlie the stable category, and both are influencing, and are influenced by, nearby areas of mathematics.

Goodwillie's theory of polynomial resolutions of homotopy functors, originally developed to answer questions in algebraic $K$-theory, is now being employed in classical homotopy with ever more success, including applications to $v_n$-homotopy and Hopf invariants and to general homological algebra.

**Cobordism and Homotopy Theory**

By connecting the geometry of manifolds, homotopy theory, and the study of formal groups, cobordism theory plays a pivotal and beautiful role in topology. The MIT school has been using algebro-geometric methods to explain and generalize new invariants of manifolds (e.g., Witten's elliptic genus) while simultaneously illuminating algebraic results in the theory of modular forms. The demands of this work also provided significant motivation for the new results on the foundations of the stable category described above.

There are ongoing fundamental questions about good geometric models for cobordism theories, such as elliptic cohomology, which have height greater than one. There has been slow but steady progress towards answering these, involving work in disparate areas: equivariant formal group laws, the effect of Tate cohomology on periodic theories, and connections with differential geometry.

**Historical Talks**

There will be a few historical talks by mathematicians with broad interests who have been major contributors to algebraic topology during the last two decades.

**Preliminary List of Speakers**

Jeanne Duflot, Colorado State University; William Dwyer, University of Notre Dame; Michael Hopkins, MIT; Igor Kriz, University of Michigan, Ann Arbor; Ib Madsen, Aarhus University (Denmark); Randy McCarthy, University of Illinois, Urbana; James McClure, Purdue University, West Lafayette; Fabien Morel, École Polytechniques (France); John Palmieri, University of Notre Dame; Nigel Ray, University of Manchester (England); Jeremy Rickard, University of Bristol (England); Hal Sadofsky, University of Oregon; Stephan Stolz, University of Notre Dame; and Said Zarati, University of Tunis (Tunisia).
Wave Phenomena in Complex Media
Sunday, June 20–Thursday, June 24, 1999

Michael Aizenman, Princeton University
Alexander Figotin, University of North Carolina, Charlotte
Svetlana Jitomirskaya, University of California, Irvine
Abel Klein, University of California, Irvine (chair)
Stephanos Venakides, Duke University

The conference will bring together researchers with interests and experience in classical and quantum mechanical waves and in related aspects of complex media and make contact with recent developments in the theory of random matrices.

The topics discussed will include:
- Localization of classical and quantum mechanical waves in disordered systems
- Extended states in the presence of disorder
- Wave localization in nonlinear media
- Wave phenomena in composite media
- Localization and gap statistics
- Insights from random matrices

Wave phenomena in complex media is a subject of great interest. Periodic, perturbed periodic, or random media can be used to filter or amplify waves in a prescribed range of frequencies, to discriminate waves propagating in chosen directions, and more. Phenomena as the existence of spectral gaps for periodic composite materials or Anderson localization for disordered materials are expected to have important new applications, especially in the case of classical waves, which have not been studied as intensively in these types of medium. The utilization of these properties in composite dielectric materials such as photonic crystals can lead to new optical devices: optical transistors, high-efficiency lasers, laser diodes, mirrors, antennas, switches, memories, and more. The quantitative mathematical theory of photonic band structures and disordered dielectrics ought to be advanced in order to fully utilize the potential suggested by the rather qualitative arguments developed up to now. The mathematical theory will play an important role in the existing effort to tailor the optical properties of the materials to our technological needs.

One focus of the conference will be classical waves in complex media. Classical waves can exhibit phenomena normally associated with quantum mechanical electron waves. The quantum mechanical wave nature of electrons has been studied based on an analogy with the scattering and interference of classical waves. But only recently has the analogy been reversed and such phenomena as the localization of classical waves started to be investigated. There is now intensive research on this subject, driven in part by the interest in optical materials that would lead to "lighttronics" (optical transistors, etc.), a development with tremendous technological applications. But while electronic bound states, the simplest example of a localized electron wave, are ubiquitous in nature, the analogous phenomena for light are not commonly observed, even if theoretically possible. Mathematics plays an important role in the design of appropriate materials exhibiting localization of light and other classical waves.

Another focus of the conference will be Schrödinger operators in complex media. Localization of Schrödinger operators in disordered media has been an area of intensive mathematical research. Recently, progress was made in applying the mathematical ideas developed in that context to classical waves. Maxwell's and acoustic equations can be rewritten as first-order conservative systems, resembling Schrödinger's equation. Spectral theory becomes relevant, and the methods developed for Schrödinger operators can be transported to the study of Maxwell and acoustic operators. These methods are also relevant to elastic waves. But the analogy is not complete, and there are important technical differences. In particular, the analogy is with localization of Schrödinger operators in spectral gaps, not at the bottom of the spectrum. This analogy will be one of the main themes of the conference.

In addition to localization, the phenomenon of conduction through extended states continues to present a major mathematical challenge. An interesting possibility is that relevant insight can be obtained by analyzing the related issues in the context of random matrices. Different methods are available in that field; however, it seems possible that both areas could be enriched through cross-comparisons.

The preliminary list of speakers includes Michael Aizenman, Princeton University; Carlo Beenakker, Leiden University; Percy Deift, Courant Institute; Alexander Figotin, University of North Carolina, Charlotte; Rainer Hempel, Technische Universität Braunschweig; Peter Hislop, University of Kentucky; Svetlana Jitomirskaya, University of California, Irvine; Yulia Karpeshina, University of Alabama, Birmingham; Abel Klein, University of California, Irvine; Werner Kohler, Virginia Polytechnic Institute; Peter Kuchment, Wichita State University; Ken McLaughlin, University of Arizona; Graeme Milton, University of Utah; George Papanicolaou, Stanford University; Leonid Pastur, University of Paris VII; Israel Sigal, University of Toronto; Alexander Soshnikov, CALTECH; Stephanos Venakides, Duke University; Eugene Wayne, Boston University; and Michael Weinstein, University of Michigan.

Groupoids in Physics, Analysis and Geometry
Sunday June 20–Thursday, June 24, 1999

Jerome Kaminker, Indiana University-Purdue University at Indianapolis (co-chair)
Arlan B. Ramsay, University of Colorado (chair)
Jean Renault, Université d’Orleans (co-chair)
Alan D. Weinstein, University of California, Berkeley (co-chair)

Groupoids have recently been used in essential ways in several areas, providing a unifying theme for seemingly diverse topics. It is the goal of this Joint Summer Research Conference to bring together a broad group of researchers to
discuss the ways in which the use of groupoids in each of their areas leads to interesting results. The title tells the focus areas.

The uses of groupoids in physics come from two main sources. The first is Alain Connes' theory of noncommutative geometry, in which groupoids are a main source of examples of noncommutative spaces. This theory is being studied very actively by physicists, and by mathematicians. Bellisard's work studying the quantum Hall effect via noncommutative geometry has led to the study of connections between solid state physics and noncommutative geometry models associated with tilings.

The second major source of the use of groupoids in physics is the general theory of quantization in mathematical physics. A theory of quantization has been introduced by V. Maslov and A. Karasev, and a version due to Alan Weinstein has been actively developed by him and his collaborators. One step in this program is to associate a symplectic groupoid to a given Poisson manifold.

Differential groupoids and their associated Lie algebroids have proved to be a valuable ingredient in the work of Richard Melrose and Victor Nistor on partial differential equations on manifolds with corners. Further, the approach to quantization based on deformations of symplectic manifolds, introduced by Fedosov and developed by Ryszard Nest and Boris Tzygan, makes strong use of Lie algebroids.

An early use of groupoids was in the approach to group representations due to George Mackey. This provided one link to ergodic theory and von Neumann algebras. A different viewpoint appears in the fundamental paper of Alain Connes on noncommutative integration, which influences much of the work on groupoids in analysis.

Another connection between groupoids and von Neumann algebras appears in recent work by Masamichi Takesaki and his collaborators. Groupoids have played a major role in $C^*$-algebras since the thesis of Jean Renault. An important current direction is the connection between dynamics and $C^*$-algebras as seen in the work of Ian Putnam and Jean Renault and their collaborators.

Finally, the work of Jean-Luc Brylinski and his collaborators using groupoids to understand Deligne cohomology from a geometric point of view has substantial connections and roots in problems in mathematical physics.

**Differential Geometric Methods in the Control of Partial Differential Equations**

*Sunday, June 27–Thursday, July 1, 1999*

Robert D. Gulliver, University of Minnesota, Minneapolis (co-chair)
Walter Littman, University of Minnesota, Minneapolis (co-chair)
Roberto Triggiani, University of Virginia (co-chair)

The proposed conference seeks to explore the infusion of differential geometric methods into the analysis of control theory problems for partial differential equations (P.D.E.s). Very recent research supports the expectation that Bochner techniques in differential geometry, when brought to bear on the classes of P.D.E.s modelling and control problems discussed below, will yield significant mathematical advances. These include:

(a) Intrinsic, coordinate-free models of (nonlinear) shells equations, more suitable for mathematical investigation than present, exceedingly complicated, coordinate-based models, mostly derived in the mechanical literature.

(b) A priori direct (trace regularity) and reverse (continuous observability) inequalities for mixed problems for second order hyperbolic P.D.E.s, Maxwell equations, plate-like equations, Schrodinger P.D.E.s (Petrowski-type) etc., defined on a multidimensional Euclidean domain, with emphasis on the variable coefficient case. In the case of dissipative systems, reverse inequalities, which are generally more challenging to achieve, yield energy decay (stabilization) results.

(c) Establishment of direct and reverse a priori inequalities for highly coupled systems of P.D.E.s arising in modern technological applications, such as: shell models and thermoelastic models defined on 2-dimensional surface-like domains; structurally acoustic models defined on acoustic 3-dimensional chambers with curved walls, possibly subject to thermoelastic effects; etc.

These three groups of results are of fundamental importance, because they constitute necessary prerequisites for well-posedness and solvability of control and stabilization problems for the P.D.E.s systems described above. The class of problems on shells listed in (a) is entirely open; and so are, as a consequence, many of those listed in (c), which depend on the solution of shell problems in (a). As to the problems listed in (b), while a wealth of results has already been obtained, however, they refer so far to the constant coefficient case or, in the available cases of variable coefficients, the conditions are not readily verifiable and the proofs are highly technical. Very recent research indicates that, in the general case of (space) variable coefficients, differential (Riemann) geometric methods have the potential to enhance and simplify the presently available theory, as well as to extend it by overcoming remaining difficulties. The time is ripe and propitious, therefore, to further explore in a systematic way new advances along this line of research. Thus, the aim is to organize an exploratory, focused, research conference, which involves control theory and P.D.E. experts as well as differential geometers interested in P.D.E.s.

As to (a), the role of Riemann geometry is expected to be paramount in capturing geometric features of general shells, both static and dynamic; to express, in intrinsic form, the correct boundary conditions; and to establish the required estimates.

As to (b), very recent research has indicated that Riemann geometric methods can profitably be used to complement and extend known analysis-based methods of proving the
a priori reverse inequalities in the general case of variable coefficients. Riemann geometric methods appear to bring a few advantages: (i) they essentially reduce the analysis to the constant coefficient principal part case, where strategies are well understood; (ii) they ultimately provide easier-to-verify conditions, with a distinct geometric flavor involving notions such as convexity in the Riemann metric and gaussian curvature; (iii) they require only a finite, natural degree of smoothness, rather than high smoothness as in pseudo-differential analysis.

As to (c), the overall system may consist either of two P.D.E.s of the same type (hyperbolic/hyperbolic coupling), or else of different type (hyperbolic/parabolic coupling), possibly defined on different contiguous domains, and with strong, possibly boundary, coupling. For example the elastic wall of an acoustic chamber may be subject to high internal damping, whereby the original plate equation becomes parabolic-like. This is a vastly open research topic for basic P.D.E.s theory in general, and for control and optimization theory in particular. Because of their original description on curved domains (manifolds), these problems appear particularly well suited for differential geometric methods to supplement analytic approaches, at the level of both modeling and analysis, including notions such as operators on manifolds, forms, gaussian curvature of the domain, etc. Here the difficulties are compounded over those described in point a) above for a single shell, since the shell may be just one component of a composite, highly coupled system.

The proposed exploratory conference will show once more that mathematical research knows no boundaries between specific disciplines—analysis versus differential geometry; and that potentially productive interactions may take place between P.D.E. control theory and differential geometry. These will be well served by expanding the traditionally analysis-based P.D.E.s approaches into fields such as Riemannian (and, in the time variable case, Lorentzian) geometry.

Of course, the introduction and use of differential geometric methods in more general P.D.E.s theory has long been established. However, the use and role of differential geometric methods toward the solution of any of the modeling, control, and optimization problems mentioned in points a), b), c) above is largely unexplored. It opens up a highly promising area of research.

By contrast, the introduction of differential geometric methods in the study of control problems (such as exact controllability, feedback stabilization, optimization, filtering, etc.) for dynamical systems modeled by ordinary differential equations (O.D.E.s) dates as far back as the early 1970s.

In keeping with the stated character and goals, the proposed conference is intended to be highly focused and exploratory. The conference will feature high caliber speakers from both fields, geometry and P.D.E.s, and seeks likewise to attract a mixed audience of geometers and P.D.E. control theorists. A particular effort will be made to include a representative group of young mathematicians from both fields. The conference's distinctive theme will be "control of P.D.E.s opened to geometry, and geometry infused into P.D.E.s control".

### Structured Matrices in Operator Theory, Numerical Analysis, Control, Signal and Image Processing

**Sunday, June 27-Thursday, July 1, 1999**

Richard Brualdi, University of Wisconsin, Madison
Gene Golub, Stanford University
Franklin Luk, Rensselaer Polytechnic Institute
Vadim Olshevsky, Georgia State University (chair)

**Introduction**

Many important problems in pure and applied mathematics and engineering can be reduced to linear algebra problems. Unfortunately, practical circumstances impose limitations on the use of available standard linear algebra methods. For example, in many applications the size of the associated matrices is prohibitively large, so the available standard methods often require an extremely large amount of arithmetic operations.

This is one reason why one seeks in various applications to identify special/characteristic structures that may be assumed in order to speed-up computations. Such additional assumptions are often provided by particular physical properties leading to various structured matrices, such as Toeplitz, Hankel, Vandermonde, Cauchy, Pick matrices, Bezoutians, and others. The *structure* of these dense matrices is understood in the sense that their $n^2$ entries are defined by a smaller number $O(n)$ of parameters. So exploiting such structures allows one to obtain nice solutions for many applied problems as well as to design efficient fast algorithms to compute these solutions.

Structured matrices are encountered in a surprising variety of areas and algorithms, including Pade approximations; continuous fractions; classical algorithms of Euclid, Schur, Nevanlinna, Lanzcos, Levinson; and their generalizations and applications.

**Two Examples**

1. **Operator theory.** In the classical Nevanlinna-Pick interpolation problem one seeks a rational interpolant whose norm is bounded by unity in the right half-plane. For this problem the well-known Pick solvability condition (1916) and the Nevanlinna algorithm (1919) both involve a certain structured matrix called the Pick matrix.

2. **Electrical engineering.** In the now classical N. Wiener monograph *Extrapolation, Interpolation and Smoothing of Stationary Time Series* a linear prediction problem was reduced to recursive, solving the so-called Yule-Walker equations whose coefficient matrix has the Toeplitz structure.

**Further Progress**

These problems were among those seeds that grew into deep studies of structured matrices in linear algebra, op-
The purpose of this conference is to foster integration between different areas and to bring together leading researchers working on all aspects of structured matrices.

### Interpolation

There is a vast operator theory literature on far-reaching generalizations of passive interpolation of the Nevanlinna-Pick type; we mention only that deep results were obtained in the frameworks of several "languages", including the band extension method, the Buerling-Lax-theorem approach, the state-space approach, and lifting-of-commutants method.

### Electrical Engineering

In the framework of system and circuit theories, interpolants arise as transfer functions, so passivity is naturally imposed by the conservation of energy. Thus, it is not surprising that fruitful connections to many applied areas were discovered. Many applications such as model reduction, sensitivity minimization, and robust stabilization have been addressed in this way.

### Matrix Analysis

It turns out that many nice results and especially many important fast algorithms that were initially obtained for specific patterns of structure can be naturally carried over to the more general important classes of matrices having what is now called displacement structure.

### Numerical Analysis

In floating point arithmetic, where the roundoff errors are present, the crucial factor that makes an algorithm practical is its numerical accuracy. Unfortunately, many fast algorithms suffer from often catastrophic propagation of roundoff errors, so one can say that they are often efficient ways to compute "garbage solutions". Moreover, these two targets have even been incorrectly regarded as being unattainable simultaneously, thus leading to the folk conjecture "one has to sacrifice accuracy for speed".

It is remarkable that the results of recent years reveal that the above two targets not only do not conflict with each other but in fact do just the opposite: proper and careful use of structure allows one to design more accurate fast algorithms that can be even better than the standard numerically stable algorithms.

### Conference Scope and Topics

Though special sessions and mini-symposia on structured matrices are usually included in the programs of the ILAS, SIAM, SPIE, and MTNS conferences, their narrow frameworks usually allow us to focus on one specific application only. The purpose of this conference is to foster integration between different areas and to bring together leading researchers working on all aspects of structured matrices.

There will be several invited tutorial lectures. Contributed talks will focus on recent advances in the following areas: fast algorithms for structured matrices, displacement structure, abstract interpolation, computer arithmetic, numerical accuracy, applications of structured matrices in system theory, circuits, signal processing, adaptive filtering, control, image processing, and preconditioning.

### Preliminary List of Invited Speakers

- Dario Bini, University of Pisa
- Patrick Dewilde, Delft University
- Israel Gohberg, Tel Aviv University
- George Heunig, Kuwait University
- Rien Kaashoek, Vrije University
- Amsterdam
- Tom Kallath, Stanford University
- Franklin Luk, Rensselaer Polytechnical Institute
- Valdim Olshevsky, Georgia State University
- Haesun Park, University of Minnesota
- Bob Plemmons, Wake Forest University
- Philip Regalia, Institut National des Telecommunications
- Lothar Reichel, Kent State University
- and Leiba Rodman, College of William and Mary.

For further information, call for papers, application deadline, and updates see the conference page http://www.cs.gsu.edu/~matviro/JSRC99.html.

### 1999 Summer Research Institute

**Smooth Ergodic Theory and Applications**

**University of Washington**

**Seattle, Washington**

**July 26—August 13, 1999**

The forty-fifth Summer Research Institute sponsored by the American Mathematical Society will be held at the University of Washington, Seattle, Washington. The topic was selected by the Committee on Summer Institutes and Special Symposia, whose members at the time included Michael D. Fried (chair), Robert Osserman, Jeffrey B. Rauch, Leon Takhtajan, and Ruth J. Williams.

### Organizing Committee

- Anatole Katok, Pennsylvania State University (co-chair)
- Rafael De La Llave, University of Texas (co-chair)
- Yakov Pesin, Pennsylvania State University (co-chair)
- Howard Weiss, Pennsylvania State University (co-chair)

Smooth ergodic theory deals with the study of invariant measures under differentiable mappings or flows. The relevance of invariant measures is that they describe the frequencies of visits for an orbit and hence they give a probabilistic description of the motion of a deterministic system. The fact that the system is differentiable allows one to use techniques from analysis and geometry. Much of the particular fascination of the field stems from the interaction between measure theory and geometry and the possibility of drawing geometric conclusions from measure theoretic facts and vice versa.

The study of transformations and their long-term behavior is ubiquitous in mathematics and the sciences. They arise not only in applications to the real world—the name "ergodic" was introduced by Boltzmann, who intended to use his "Ergodic Hypothesis" as a justification of thermo-
dynamics—but also to diverse mathematical disciplines, including number theory, Lie groups, algorithms, Riemannian geometry, etc. Hence smooth ergodic theory is the meeting ground of many different ideas in pure and applied mathematics.

The core of the theory includes the study of stochastic properties of the invariant measures of various kinds of systems with hyperbolic behavior (i.e., exponential growth of instabilities). The principal role of smooth ergodic theory is twofold:

1. It provides a paradigm for the rigorous study of complicated or chaotic behavior in deterministic systems. Smooth ergodic theory is an essential tool in the study of specific classes of dynamical systems, such as some low-dimensional systems with strange attractors, Hamiltonian systems, geodesic flows, and actions of higher-rank Abelian and semisimple Lie groups by diffeomorphisms.

2. It serves as the basis for applications both inside and outside the theory of dynamical systems. There are many striking applications that use this machinery to prove deep theorems in Riemannian geometry (solution of Klingenbergs conjecture on the existence of infinitely many closed geodesics on every convex surface, classification of manifolds of nonpositive curvature), number theory (solution of Oppenheim conjecture on the values of quadratic forms at primitive integral points), Lie groups (rigidity of smooth actions of many large groups, homogeneity of closures and equidistribution of individual orbits of one-parameter unipotent subgroups), statistical physics (substantial progress on the Boltzmann hypothesis on the ergodicity of the hard ball gas), and partial differential equations (ergodic properties of coupled map lattices, dimension estimates of the maximal attractor in certain partial differential equations, including the Navier-Stokes equation).

Because smooth ergodic theory overlaps many areas of mathematics and its arguments often cross category lines, it is difficult for a student, or even an established mathematician, to acquire a working knowledge of smooth ergodic theory and to learn how to use its tools. Given the very rapid development of smooth ergodic theory in recent years, it has been difficult, even for specialists in the field, to keep up with the many significant advances in the field.

The five main purposes of our proposed summer institute are: (i) to train young researchers (especially students and postdocs) interested in learning smooth ergodic theory, (ii) to teach mathematicians working in other fields the core machinery of smooth ergodic theory to use in their applications, (iii) to keep specialists in smooth ergodic theory knowledgeable of the current state of the subject and some of its new applications, (iv) to discuss major open problems and to help chart a course of research in the area for the early twenty-first century, and (v) to serve as an effective meeting ground for mathematicians at all stages in their careers, including experts and beginning graduate students.

Our proposed institute will focus on three broad areas of smooth ergodic theory: structural theory (both conservative and dissipative), dimension theory, and applications.

There will be three types of talks catering to the different possible audiences: (i) in-depth minicourses (taught by leading experts in the respective subjects) on both core material, recent exciting developments, open problems, and applications; (ii) survey lectures on the current state of the subject; and (iii) research talks on topics of current interest. Minicourses will usually be about a week long. Preliminary plans for the program are to have two or three minicourse lectures in the morning and two or three survey and research talks in the afternoon.

We plan to run minicourses in the following subjects (instructors’ names in parentheses):

2. Decay of Correlations and Zeta Functions (Baladi, Dolgopyat, Pollicott).
5. KAM Theory and Applications (Eliasson, De La Llave).
6. Applications of Ergodic Theory to Geometry of Manifolds of Nonpositive Curvature (Brin, Knieper, Ballmann).
7. Dimension Theory and Dynamics (Schmeling, Weiss).
8. Applications of Ergodic Theory to Number Theory (Eskin, Kleinbock).

Other minicourses may include Lyapunov Exponents and Their Estimation and Henon Attractors and Related Topics; others are still being developed.

Among the confirmed survey speakers are Ledrappier, Parry, Xia, and Yorke. Other confirmed participants include Avraimovitch, Burns, Eberlein, Fathi, Feres, Flaminio, Fornaess, Forni, Foulon, Gerber, Hamenstadt, Hasselblatt, Hunt, Jakobson, Kifer, Levi, Liverani, Przytycki, Rugh, Rychlik, Schmeling, Schmidt, Smillie, Spatzier, Swiatek, Szasz, Viana, and Young. There are still pending invitations.

Proceedings of the Institute will be published in the AMS series Proceedings of Symposia in Pure Mathematics.

It is anticipated that the Institute will be partially funded by a grant from the National Science Foundation and perhaps others. The organizers hope to be able to provide some support for subsistence for most of the participants. Special encouragement is extended to junior scientists to apply. Special encouragement is extended to junior scientists to apply. Special encouragement is extended to junior scientists to apply. Special encouragement is extended to junior scientists to apply. Special encouragement is extended to junior scientists to apply. Special encouragement is extended to junior scientists to apply. Special encouragement is extended to junior scientists to apply. Special encouragement is extended to junior scientists to apply. Special encouragement is extended to junior scientists to apply. Special encouragement is extended to junior scientists to apply. Special encouragement is extended to junior scientists to apply. Special encouragement is extended to junior scientists to apply. Special encouragement is extended to junior scientists to apply. Special encouragement is extended to junior scientists to apply. Special encouragement is extended to junior scientists to apply. Special encouragement is extended to junior scientists to apply. Special encouragement is extended to junior scientists to apply.

All persons who are interested in participating in the Institute should request an invitation. Applications should send the following information to: Summer Research Institute Coordinator, American Mathematical Society, P.O. Box 6887, Providence, RI 02940, or by e-mail to pop@ams.org no later than March 3, 1999.

Please type or print the following:

1. Full name.
2. Mailing address.
3. Phone numbers (including area code) for office, home, and fax.
Conferences

4. E-mail address.
5. Your anticipated arrival/departure dates.
6. Scientific background relevant to the Institute topics; please indicate if you are a student or if you received your Ph.D. on or after 7/1/93.
7. The amount of financial assistance requested (or indicate if no support is required).

All requests will be forwarded to the 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 dormitories and other local housing. All participants will be required to pay a nominal conference fee.

Questions concerning the scientific program should be addressed to hnw1@glue.umd.edu. Questions of a non-scientific nature should be directed to the Summer Institute coordinator at the address provided above.
Call for Topics for 2000 Conferences

Call for Proposals for the Year 2000 Joint Summer Research Conferences

Be part of World Mathematical Year 2000!

The AMS-IMS-SIAM Joint Summer Research Conferences have been a lively and meaningful series for more than 6,000 participants. For over fifteen years these conferences have played a vital role in disseminating information to researchers and students, spanning the breadth of the mathematical sciences.

In your area of research,
• are there new trends?
• what impact will new developments have on other disciplines?
• is there an advantage to bringing together those from related disciplines to work on a common problem?
• are there junior scientists who would benefit by exposure to an area of current research and who could work closely with leaders in the field?
• can you communicate clarity and focus and provide direction for future research efforts?

The Joint Summer Research Conferences welcome proposals from mathematicians, either singly or in groups, for conferences to take place in the summer of 2000. Individuals willing to serve as organizers should be aware that the administrative efforts of the sponsoring societies will be at their disposal for many of the logistical details of the management of the conference, thus making it possible for the organizers to focus on the scientific aspects of their conference.

An associate executive director at the AMS will prepare the grant application(s) to appropriate federal funding agencies and do follow-up correspondence until grant funds for partial participant support have been secured.

The professional conference coordinators in the AMS office will provide full support and assistance before, during, and after the conference, thereby freeing the organizers to concentrate on providing a high-quality program. They will also secure the site and all related goods and services.

It is not mandatory that proceedings of each conference be published; however, there are opportunities to publish with one of the sponsoring societies. A member of the Organizing Committee must be willing to serve as editor of the proceedings.

Conferences usually emulate the scientific structure of those held at Oberwolfach, although this structure is flexible. The proposals to be selected will represent diverse areas of mathematical activity, with emphasis on areas currently especially active. Conferences generally run for one week with forty-five to sixty-five participants. Two- and even three-week conferences are possible.

All proposals must include (1) the names and affiliations of proposed members and the chair of the Organizing Committee; (2) a two- to four-page description addressing the focus of the topic, including the importance and timeliness of the topic, and estimated attendance; (3) a list of the recent conferences in the same or closely related areas; (4) a tentative list of names and affiliations of the proposed principal speakers; and (5) a list of likely candidates who would be invited to participate and their current affiliations. Organizers are encouraged to make a strong attempt to include women, underrepresented minorities, and junior scientists in their proposals.

Recent conferences held in 1998 at Mount Holyoke College were $q$-Series, combinatorics, and computer algebra; Quantum cohomology; Geometric group theory and computer science; Mathematical methods in inverse problems.
for partial differential equations; and Nonlinear pde's, dynamics and continuum physics. The 1999 series, to be held at the University of Colorado, Boulder, includes From manifolds to singular varieties; Computability theory and applications, Homotopy methods in algebraic topology; Wave phenomena in complex media; Groupoids in physics, geometry and analysis; Differential geometric methods in the control of partial differential equations; and Structured matrices in operator theory, numerical analysis, control, signal and image processing.

Do you see being a conference organizer as part of your future? Think about preparing your proposal soon! Proposals will be considered by the AMS-IMS-SIAM Committee on Joint Summer Research Conferences in the Mathematical Sciences. Members of this committee are willing to provide guidance on the preparation of proposals. The committee is listed at http://www.ams.org/meetings/srcscomm.html. A recent example of a well-prepared proposal is also included on this Web site.

Start working on your proposal soon! The deadline for receipt of all proposals is February 1, 1999. The committee will make decisions on the slate of the year 2000 conferences in early spring 1999. Don’t be left out of this significant activity as the mathematical world prepares for its future.
Meetings and Conferences of the AMS

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. Up-to-date meeting and conference information is available on the World Wide Web at www.ams.org/meetings/.

Meetings:

1998
September 12-13 Chicago, Illinois p. 1414
October 9-10 Winston-Salem, No. Carolina p. 1414
October 24-25 State College, Pennsylvania p. 1414
November 14-15 Tucson, Arizona p. 1414

1999
January 13-16 San Antonio, Texas p. 1415
Annual Meeting
March 12-13 Gainesville, Florida p. 1415
March 18-21 Urbana, Illinois p. 1416
April 10-11 Las Vegas, Nevada p. 1417
April 24-25 Buffalo, New York p. 1417
May 19-22 Denton, Texas p. 1418
July 12-16 Melbourne, Australia p. 1418
October 2-3 Providence, Rhode Island p. 1419
October 8-10 Austin, Texas p. 1419
October 15-17 Charlotte, North Carolina p. 1419

2000
January 19-22 Washington, DC p. 1419
Annual Meeting
April 1-2 Lowell, Massachusetts p. 1420
April 7-9 Notre Dame, Indiana p. 1420
April 14-16 Lafayette, Louisiana p. 1420

Important Information Regarding AMS Meetings
Potential organizers, speakers, and hosts should refer to page 150 in the January 1998 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 TeX is necessary to submit an electronic form, although those who use LaTeX, or AMS-LaTeX may submit abstracts with TeX 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, and 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. 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.)

1999
Hotel Reservations

To ensure accurate assignments, please rank hotels in order of preference by writing 1, 2, 3, etc., in the spaces at the left of the form 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, etc.

Reservations at the following hotels must be made through the MMSB to receive the convention rates listed. All rates are subject to a 15% sales occupancy tax. Guarantee requirements: First night deposit by check (add to payment on reverse of form) or a credit card guarantee.

<table>
<thead>
<tr>
<th>Order of choice</th>
<th>Hotel</th>
<th>Single</th>
<th>Double 1 bed</th>
<th>Double 2 beds</th>
<th>Triple 2 beds</th>
<th>Triple 2 beds w/cot</th>
<th>Quad 2 beds</th>
<th>Quad 2 beds w/cot</th>
<th>Suites Starting rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marriott Rivercenter (co-headquarters)*</td>
<td>$121</td>
<td>$135</td>
<td>$135</td>
<td>$150</td>
<td>$150</td>
<td>$165</td>
<td>$165</td>
<td>$400</td>
<td></td>
</tr>
<tr>
<td>Students</td>
<td>$95</td>
<td>$95</td>
<td>$95</td>
<td>$110</td>
<td>$110</td>
<td>$125</td>
<td>$125</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Marriott Riverwalk (co-headquarters)*</td>
<td>$119</td>
<td>$119</td>
<td>$119</td>
<td>$134</td>
<td>$134</td>
<td>$149</td>
<td>$149</td>
<td>$500</td>
<td></td>
</tr>
<tr>
<td>Students</td>
<td>$91</td>
<td>$91</td>
<td>$91</td>
<td>$106</td>
<td>$106</td>
<td>$121</td>
<td>$121</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Hilton Palacio del Rio</td>
<td>$119</td>
<td>$119</td>
<td>$119</td>
<td>$139</td>
<td>$159**</td>
<td>$159</td>
<td>N/A</td>
<td>$500</td>
<td></td>
</tr>
<tr>
<td>Students</td>
<td>$109</td>
<td>$109</td>
<td>$109</td>
<td>$129</td>
<td>$149**</td>
<td>$149</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Ramada Emily Morgan Hotel</td>
<td>$95</td>
<td>$105</td>
<td>$105</td>
<td>$115</td>
<td>$125</td>
<td>$125</td>
<td>$135</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Students</td>
<td>$85</td>
<td>$85</td>
<td>$85</td>
<td>$105</td>
<td>$115</td>
<td>$115</td>
<td>$125</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>The Menger</td>
<td>$89</td>
<td>$89</td>
<td>$89</td>
<td>$99</td>
<td>$99</td>
<td>$99</td>
<td>$99</td>
<td>$186</td>
<td></td>
</tr>
<tr>
<td>Students</td>
<td>$79</td>
<td>$79</td>
<td>$79</td>
<td>$89</td>
<td>$89</td>
<td>$89</td>
<td>$89</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>La Quinta Convention Center</td>
<td>$89</td>
<td>$89</td>
<td>$89</td>
<td>$109</td>
<td>$119</td>
<td>$119</td>
<td>$119</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>The Crockett Hotel</td>
<td>$85</td>
<td>$85</td>
<td>$85</td>
<td>$95</td>
<td>$105**</td>
<td>$95</td>
<td>$105**</td>
<td>$149</td>
<td></td>
</tr>
<tr>
<td>Students</td>
<td>$75</td>
<td>$75</td>
<td>$75</td>
<td>$85</td>
<td>$85</td>
<td>$85</td>
<td>$85</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Holiday Inn Express Hotel &amp; Suites</td>
<td>$81</td>
<td>$81</td>
<td>$81</td>
<td>$81</td>
<td>N/A</td>
<td>$81</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Students</td>
<td>$79</td>
<td>$79</td>
<td>$79</td>
<td>$79</td>
<td>N/A</td>
<td>$79</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Hampton Inn</td>
<td>$75</td>
<td>$75</td>
<td>$75</td>
<td>$75</td>
<td>$85</td>
<td>$75</td>
<td>$85</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Students</td>
<td>$65</td>
<td>$65</td>
<td>$65</td>
<td>$65</td>
<td>$75</td>
<td>$65</td>
<td>$75</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Red Roof Inn</td>
<td>$64.99</td>
<td>$64.99</td>
<td>$64.99</td>
<td>$64.99</td>
<td>$69.99</td>
<td>$69.99</td>
<td>$69.99</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

*Please note that the AMS Council and MAA Board of Governors will meet at the Hilton, NOT at the co-headquarters hotels. Please check updated announcements and schedules for locations of other committee meetings.

**Limited Availability

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 reservations.
San Antonio Advance Registration/Housing Form

Name ____________________________
Mailing Address ____________________________
Telephone ______________________ Fax ___________
Email Address ____________________________ (Acknowledgment of this registration will be sent to the email address given here, unless you check the box to the right.)

Badge Information:
Name to appear on badge ____________________________
Affiliation for badge ____________________________
Nonmathematician guest badge (please note charge below) ____________________________

Registration Fees

Joint Meetings by Dec 21 at mtg Subtotal
□ Member AMS, ASL, CMS, MAA $100 $208
□ Nonmember $248 $322
□ Graduate Student $35 $45
□ Undergraduate $20 $26
□ High School Student $2 $5
□ Unemployed $35 $45
□ Temporarily Employed $120 $133
□ 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
□ Exhibitor $0 $0

AMS Short Course on Nonlinear Control (1/11-1/12)
□ Member, Nonmember $80 $95
□ Student, Unemployed, Emeritus $35 $45

MAA Short Course on Mathematics in Finance (1/11-1/12)
□ Member of MAA $125 $140
□ Nonmember $175 $190
□ Student, Unemployed, Emeritus $50 $60

MAA Minicourses (see listing on facing page)
I would like to attend: □ One Minicourse □ Two Minicourses
Please enroll me in MAA Minicourse(s) #____ and/or #____
In order of preference, my alternatives are: #____ and/or #____
Prices: $55 for Minicourses # 1, 3, 4, 6, 7, 8, 10, 12, 13, 15, 16
$75 for Minicourses # 2, 5, 9, 11, 14 (computer)

Employment Register
Applicant résumé forms and employer listing forms will be on e-MATH and in Notices in September and in Focus in October.
Employer—First Table $200 $250
□ Regular □ Self-scheduled □ Information Table
Employer—Second Table $50 $75
□ Regular □ Self-scheduled □ Information Table
Employer—Posting Only $50 N/A
□ Applicant $40 $75

Events with Tickets

AMS Banquet #___Regular #___Veg #___Kosher $39
MER Banquet #___Regular #___Veg #___Kosher $39
NAM Banquet #___Regular #___Veg #___Kosher $39

Student Activities (no charge):
□ Matchats

Total of Fees for Registrations & 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.)

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: ____________________________ (please enclose copy)

□ 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 Register.

Other Information

Mathematical Reviews field of interest # __________
How did you hear about this meeting? Check one:
□ Focus □ Notices □ WWW □ Colleague(s) □ Special mailing
□ 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

Deadlines

For room reservation only/resumés/job descriptions printed in the Winter Lists, return this form by: Nov. 9, 1998
For housing reservations, badges/programs mailed: Nov. 23, 1998
For housing changes/cancellations through MMSB: Dec. 1, 1998
For advance registration for the Joint Meetings, Employment Register, Short Courses, MAA Minicourses, & banquets: Dec. 21, 1998
For 50% refund on banquets, cancel by: Dec. 30, 1998*
For 50% refund on all advance registration, Minicourses & Short Courses, cancel by: Jan. 9, 1999*

*no refunds after this date
fascinating detours, this is the perfect text for popping up with Tristan Analysis this radical approach to the standard calculational complex analysis replaces complex analysis.

Although designed for use by undergraduates in mathematics and science, the novelty of the approach will also interest professional mathematicians.

From reviews of the hardback edition:
"If you have time for a year course, full of fascinating detours, this is the perfect text... I am tempted to hide the book from my own students, in order to appear the more clever for popping up with crisp historical anecdotes, great exercises, and pictures that explain things... I highly recommend it for your bookshelf!"

Frank A. Farris, American Mathematical Monthly

"essential reading for anybody with any interest at all in this absorbing area of mathematics."

The Times Higher Education Supplement

616 pp, January 1999

£28.00

NEW IN PAPERBACK

Wavelets
An Analysis Tool
Matthias Holschneider

Now available in paperback this popular book provides an explanation in elementary language of the mathematical foundations of the theory of wavelet analysis.

From reviews of the hardback edition:
"Holschneider has written a rich introduction to wavelet analysis" Mededelingen van het Wiskundig Genootschap

"This book is a self-contained and original text on the theory of wavelets!"

Physics World

448 pp, October 1998

£30.00

Prices and extents are subject to change.

OXFORD UNIVERSITY PRESS

Innovation • Excellence • Tradition
NEW GRADUATE TEXTS IN MATHEMATICS

AN INTRODUCTION TO BANACH SPACE THEORY

ROBERT E. MEGGINSON, University of Michigan, Ann Arbor

Contents: Basic Concepts • The Weak and Weak* Topologies • Linear Operators • Schauder Bases • Rotundity and Smoothness • Appendices: A. Prerequisites • B. Metric Spaces • C. The Spaces L∞ and L1, 1<p<∞ • D. Ultraproducts

1998 / PP. 616 / HARDCOVER / $64.95 / ISBN 0-387-98435-3
VOLUME 183

DINAKAR RAMAKrishnaN, California Institute of Technology, Pasadena and ROBERT J. VALENZA, Claremont McKenna College, Claremont, CA

FOURIER ANALYSIS ON NUMBER FIELDS

The central aim of this book is to provide a modern approach to number theory through a blending of complementary algebraic and analytic perspectives, emphasizing harmonic analysis on topological groups. The more particular goal is to cover John Tate's visionary thesis. The subject in real analysis, the book should appeal not only to number theorists, but also to students of harmonic analysis or the representation theory of Lie groups. It will, moreover, be a valuable text for working mathematicians interested in any of these fields.

Contents: Topological Groups • Some Representation Theory • Duality for Locally Compact Abelian Groups • The Structure of Arithmetic Fields • Adeles, Idèles, and the Class Groups • A Quick Tour of Class Field Theory • Tate's Thesis and Applications • A. Normed Linear Spaces • B. Dedekind Domains

VOLUME 184

TSIT-YUEN LAM, University of California, Berkeley

LECTURES ON MODULES AND RINGS

This long-awaited sequel to Lam's earlier GTM 131, A First Course in Noncommutative Ring Theory, can be read independently from the first volume and is intended to be used for lecturing, seminar- and self-study, and for general reference. It is focused more on specific topics in order to introduce the reader to a wealth of basic and useful ideas without the hindrance of heavy machinery or undue abstractions. This volume is particularly user-friendly with its abundance of examples illustrating the theory virtually at every step. A large number of carefully chosen exercises serves the dual purpose of providing practice to newcomers to the field, and offering a rich additional source of information to experts.

Contents: Free Modules • Projective and Injective Modules • Flat Modules and Homological Dimensions • More Module Theory • Rings of Quotients • More Rings of Quotients • Frobenius and Quasi-Frobenius Rings • Matrix Rings, Categories of Modules, and Morita Theory

VOLUME 189

MURRAY H. PROTTER, University of California, Berkeley

BASIC ELEMENTS OF REAL ANALYSIS

From the author of the highly acclaimed A First Course in Real Analysis comes a volume designed specifically for a short one-semester course. Many students of mathematics and those students who intend to study any of the physical sciences and computer science need a text that presents the most important material in a brief and elementary fashion. The author has included such elementary topics as the real number system, the theory of the basis of elementary calculus, the topology of metric spaces, and infinite series. Proofs of the basic theorems on limits occur at a deliberate and detailed pace. There are illustrative examples throughout with over 45 figures.

1998 / PP. 288 / 48 ILLUSTRATIONS / HARDCOVER / $39.95
ISBN 0-387-98479-8
UNDERGRADUATE TEXTS IN MATHEMATICS

ALBRECHT BÖTTCHER and BERND SILBERMANN, both of Technische Universität, Chemnitz, Germany

INTRODUCTION TO LARGE TRUNCATED TOEPLITZ MATRICES

This text contains results on the stability of projection methods, deals with asymptotic inverses and Moore-Penrose inversion of large Toeplitz matrices, and embarks on the asymptotic behavior of the norms of inverses, the pseudospectra, the singular values, and the eigenvalues of large Toeplitz matrices. The approach is heavily based on Banach algebra techniques and nicely demonstrates the usefulness of C*-algebras and local principles in numerical analysis. The book includes classical topics as well as results obtained and methods developed only in the last few years. Though employing modern tools, the exposition is elementary and aims at pointing out the mathematical background behind some interesting phenomena one encounters when working with large Toeplitz matrices.

1998 / PP. 272 / 62 ILLUSTRATIONS / HARDCOVER / $49.95
ISBN 0-387-98497-0
UNIVERSITEXT

Springer
http://www.springer-ny.com

Order Today!
Call: 1-800-SPRINGER or Fax: (201)-348-4505
Write: Springer-Verlag New York, Inc., Dept. 5266, PO Box 2485, Secaucus, NJ 07096-2485
Visit: Your local technical bookstore
E-mail: orders@springer-ny.com

Instructors: Call or write for information on textbook exam copies

YOUR 30-DAY RETURN PRIVILEGE IS ALWAYS GUARANTEED!