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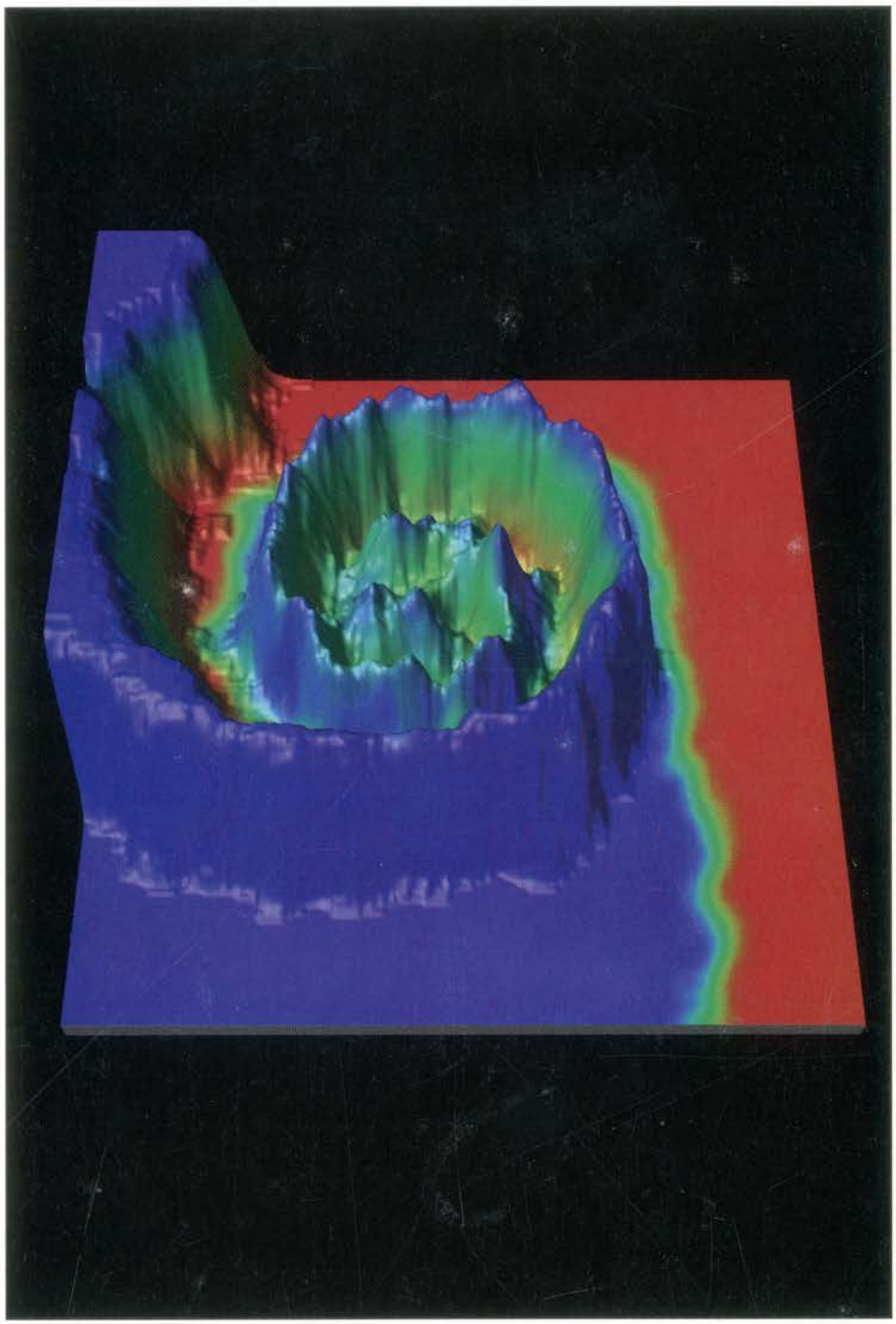

Spiral Wave in an Ecological Model *(See page 1429)*

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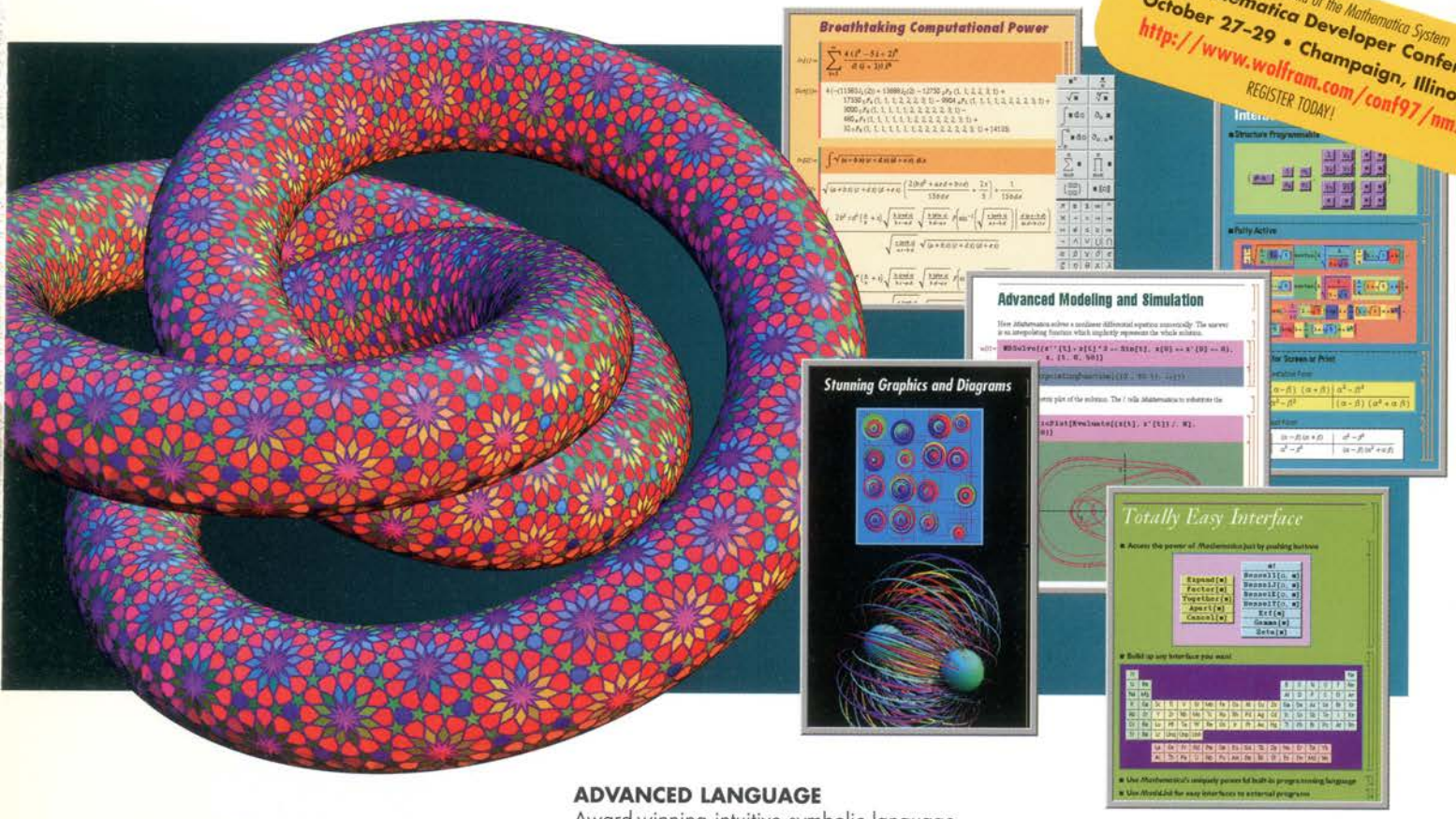

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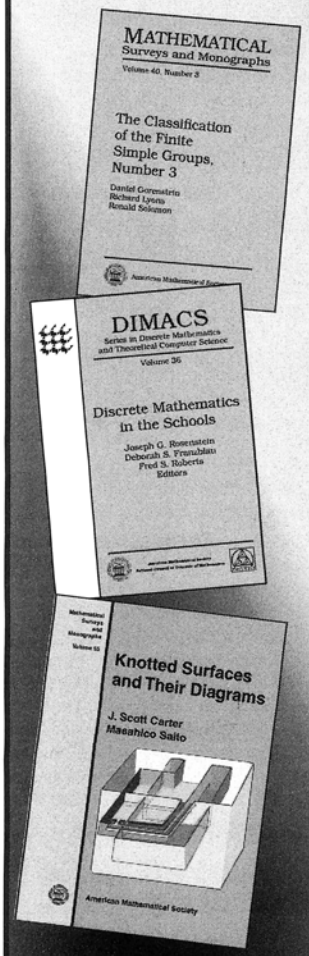

American Mathematical Society

New Titles from the AMS

The Classification of the Finite Simple Groups, Number 3

Daniel Gorenstein, **Richard Lyons**, *Rutgers University, New Brunswick, NJ*, and **Ronald Solomon**, *Ohio State University, Columbus*

This book offers a single source of basic facts about the structure of the finite simple groups with emphasis on a detailed description of their local subgroup structures, coverings and automorphisms. The method is by examination of the specific groups, rather than by the development of an abstract theory of simple groups. While the purpose of the book is to provide the background for the proof of the classification of the finite simple groups—dictating the choice of topics—the subject matter is covered in such depth and detail that the book should be of interest to anyone seeking information about the structure of the finite simple groups.

Mathematical Surveys and Monographs, Volume 40; 1998; 419 pages; Hardcover; ISBN 0-8218-0391-3; List $79; Individual member $47; Order code SURV/40.3NT712

Discrete Mathematics in the Schools

Joseph G. Rosenstein, *Rutgers University, New Brunswick, NJ*, **Deborah S. Franzblau**, *City University of New York (CUNY), Staten Island*, and **Fred S. Roberts**, *Rutgers University, New Brunswick, NJ*, Editors

This volume is a collection of articles written by experienced primary, secondary, and collegiate educators. The book explains why discrete mathematics should be taught in K–12 classrooms and offers practical guidance on how to do so.

Features:

- Classroom activities and an annotated list of resources.
- Authors who are directors of innovative programs and who are well known for their work.
- A description of discrete mathematics providing the opportunity for a fresh start for students who have been previously unsuccessful in mathematics.
- Discussion on discrete mathematics as it is used to achieve the goals of the current effort to improve mathematics education.
- Guidance on topics, resources and teaching; a valuable guide for both pre-service and in-service professional development.

This volume is co-published with the National Council of Teachers of Mathematics (NCTM), Reston, VA.

DIMACS: Series in Discrete Mathematics and Theoretical Computer Science, Volume 36; 1997; 452 pages; Hardcover; ISBN 0-8218-0448-0; List $30; All AMS members $24; Order code DIMACS/36NT712

Homeomorphisms in Analysis

Casper Goffman, *Purdue University, West Lafayette, IN*, **Togo Nishiura**, *Wayne State University, Detroit, MI*, and **Daniel Waterman**, *Syracuse University, NY*

The book is well written, packed with information and makes a novel contribution to the literature. Much of what is in the book is important material that is now for the first time readily accessible … readers will appreciate the many comments that provide historical or motivational perspectives.

—Professor Andrew Bruckner, University of California, Santa Barbara

This book features the interplay of two main branches of mathematics: topology and real analysis. The material of the book is largely contained in the research publications of the authors and their students from the past 50 years. Parts of analysis are touched upon in a unique way, for example, Lebesgue measurability, Baire classes of functions, differentiability, C^n and C^∞ functions, the Blumberg theorem, bounded variation in the sense of Cesari, and various theorems on Fourier series and generalized bounded variation of a function.

Mathematical Surveys and Monographs, Volume 54; 1997; 216 pages; Hardcover; ISBN 0-8218-0614-9; List $69; Individual member $41; Order code SURV/54NT712

Knotted Surfaces and Their Diagrams

J. Scott Carter, *University of South Alabama, Mobile*, and **Masahico Saito**, *University of South Florida, Tampa*

In this book the authors develop the theory of knotted surfaces in analogy with the classical case of knotted curves in 3-dimensional space.

The book contains over 200 illustrations that illuminate the text. Examples are worked out in detail, and readers have the opportunity to learn first-hand a series of remarkable geometric techniques.

Mathematical Surveys and Monographs, Volume 55; 1998; 258 pages; Hardcover; ISBN 0-8218-0593-2; List $69; Individual member $41; Order code SURV/55NT712

Mathematical Hierarchies and Biology

Boris Mirkin, *DIMACS, Rutgers University, Piscataway, NJ*, **F. R. McMorris**, *University of Louisville, KY*, **Fred S. Roberts**, *Rutgers University, New Brunswick, NJ*, and **Andrey Rzhetsky**, *Columbia University, New York, NY*, Editors

The mathematical approach to the study of hierarchies presents the theoretical basis for many important areas of current scientific investigation. Biology has benefited from this research and has also stimulated the mathematical study of hierarchies.

The papers in this volume provide a contemporary sample of many new results in hierarchy theory with applications in biology, psychology, data analysis, and systems engineering.

DIMACS: Series in Discrete Mathematics and Theoretical Computer Science, Volume 37; 1997; 388 pages; Hardcover; ISBN 0-8218-0762-5; List $79; Individual member $47; Order code DIMACS/37NT712

Proceedings of the Ashkelon Workshop on Complex Function Theory (May 1996)

Lawrence Zalcman, *Bar-Ilan University, Ramat-Gan, Israel*, Editor

This volume of proceedings presents a snapshot view of current Israeli activity in complex function and provides impressive evidence of the vigor, enthusiasm, and success with which classical complex analysis is cultivated in Israel today.

Israel Mathematical Conference Proceedings, Volume 11; 1997; 245 pages; Softcover; List $59; Individual member $35; Order code IMCP/11NT712

Supplementary Reading

Second Order Equations of Elliptic and Parabolic Type

E. M. Landis, *Moscow State University, Russia*

Most books on elliptic and parabolic equations emphasize existence and uniqueness of solutions. By contrast, this book focuses on the qualitative properties of solutions. In addition to the discussion of classical results for equations with smooth coefficients (Schauder estimates and the solvability of the Dirichlet problem for elliptic equations; the Dirichlet problem for the heat equation), the book describes properties of solutions to second order elliptic and parabolic equations with measurable coefficients near the boundary and at infinity.

The book presents a fine elementary introduction to the theory of elliptic and parabolic equations of second order. The precise and clear exposition is suitable for graduate students as well as for research mathematicians who want to get acquainted with this area of the theory of partial differential equations.

Translations of Mathematical Monographs, Volume 171; 1997; 203 pages; Hardcover; ISBN 0-8218-0857-5; List $99; Individual member $59; Order code MMONO/171NT712

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 02206-5904, USA. For credit card orders, fax (401) 455-4046 or call toll free 800-321-4AMS (4267) in the U. S. and Canada, (401) 455-4000 worldwide. Or place your order through the AMS bookstore at http://www.ams.org/bookstore/. Residents of Canada, please include 7% GST.

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Global Aspects of Classical Integrable Systems

R.H. Cushman, *Univ. of Utrecht* & L.M. Bates, *Univ. of Calgary*

This unique book gives a complete description of the geometry of the energy momentum mapping of five classical integrable systems: the 2-dimensional harmonic oscillator, the geodesic flow on the 3-sphere, the Euler top, the spherical pendulum and the Lagrange top. It presents for the first time, a general theory of symmetry reduction which allows one to reduce the symmetries in the spherical pendulum and the Lagrange top. Also the monodromy obstruction to the existence of global action angle coordinates is calculated for the spherical pendulum and the Lagrange top.

Contents: The harmonic oscillator • Geodesics on S^3 • The Euler top • The spherical pendulum • The Lagrange top • Appendix A. Fundamental concepts • Appendix B. Systems with symmetry • Appendix C. Ehresmann connections • Appendix D. Action angle coordinates • Appendix E. Basic Morse theory • Notes • References • Acknowledgements • Index

1997 448 pp. Hardcover $54.95 ISBN 3-7643-5485-2

Metric Structures for Riemannian and Non-Riemannian Spaces

Revised and Updated from the French by M. Gromov, *IHES, France*

Edited by J. Lafontaine & P. Pansu; Translated from French by S. Bates; With appendices by M. Katz, P. Pansu & S. Semmes

The metric theory covers a domain between the fields of topology and global Riemannian geometry. The boundary of this domain has dramatically exploded since 1979 and, in the course of this translation from the 1979 French version, the book has undergone substantial revisions and additions, much of which links geometry and probability theory. Further links are made to analysis thanks to the masterful exposition of Semmes, who makes key ideas of real analysis accessible to geometers.

Contents: Length structures: Path metric spaces • Degree and dilatation • Metric structures • Loewner rediscovered • Manifolds with bounded Ricci curvature • Isoperimetric inequalities and amenability • Morse theory and minimal models • Pinching and collapse • Appendix A. "Quasiconvex" domains in $\mathbb{R}^n$ • Appendix B. Metric spaces and mappings seen at many scales • Appendix C. Paul Levy's isoperimetric inequality

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Progress in Mathematics

Fatou Type Theorems

Maximal Functions and Approach Regions

F. Di Biase, *Princeton University, NJ & University of Roma, Italy*

One of the basic issues involved in the understanding of the boundary behavior of harmonic (holomorphic) functions, defined on domains in real (complex) Euclidean spaces and subject to certain growth conditions, is the description of the regions of approach to the boundary, along which the functions converge almost everywhere to their boundary values.

Contents: I. Background • Prelude • Preliminary Results • The Geometric Contexts • II. Exotic Approach Regions • Approach Regions For Trees • Embedding The Tree • Applications • Notes • List of Figures • Guide to Notation • Index • Bibliography

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Progress in Mathematics, Volume 147

Locally Conformal Kähler Geometry

S. Dragomir, *Università degli Studi della Basilicata, Italy* &
L. Ornea, *University of Bucharest, Romania*

This unique monograph is a differential geometric study of l.c.K. manifolds (i.e., manifolds carrying some l.c.K. metric) and their submanifolds. While the latest results on Vaisman's conjectures, spectral geometry of generalized Hopf manifolds, harmonic and holomorphic forms of l.c.K. manifolds, and pseudoharmonic maps of Hermitian surfaces are reviewed throughout mathematics literature, here they are presented in a systematic manner. The latest topics are addressed, bringing us to the cutting edge in the mathematics of locally conformal Kähler (l.c.K.) manifold theory.

Contents: l.c.K. manifolds • Fundamental properties • Examples • Generalized Hopf manifolds • Distributions on a g.H. manifold • Structure theorems • Harmonic and holomorphic forms • Hermitian surfaces • Holomorphic maps • l.c.K. submersions • l.c. hyperkähler manifolds • Submanifolds • Extrinsic spheres • Real hypersurfaces • Complex submanifolds • Integral formulae • Miscellanea • A. Boothby-Wang fibrations • B. Riemannian submersions

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Progress In Mathematics, Volume 155

Geometry of Foliations

P. Tondeur, *University of Illinois, Urbana*

This volume describes research on the differential geometry of foliations, in particular Riemannian foliations, done over the last few years. It can be read by graduate students and researchers with a background in differential geometry and Riemannian geometry. Of particular interest will be the Hodge theory for the transversal Laplacian, and applications of heat equations method to Riemannian foliations.

Contents: Examples and Definition of Foliations • Foliations of Codimension One • Holonomy, Second Fundamental Form, Mean Curvature • Basic Forms, Spectral Sequence, Characteristic Form • Transversal Riemannian Geometry • Flows • Hodge Theory for the Transversal Laplacian • Cohomology Vanishing and Tautness • Lie Foliations • Structure of Riemannian Foliations • Spectral Geometry of Riemannian Foliations • Foliations as Noncommutative Spaces • Infinite Dimensional Riemannian Foliations • References on Riemannian Foliations • Appendix A. Books and Surveys on Particular Aspects of Foliations • Appendix B. Proceedings of Conferences and Symposia devoted to Foliations • Appendix C. Bibliography on Foliations • Appendix D. Numbers of Papers on Foliations • Index of Subjects • Index of Notations

1997 312 pp. Hardcover $98.00 ISBN 3-7643-5741-X
Monographs in Mathematics, Volume 90

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Advances in Ring Theory

S.K. Jain, *Ohio University, Athens, Ohio* & S.T. Rizvi, *Ohio State University at Lima, Lima, Ohio (Eds.)*

This invaluable, informative volume examines wide-ranging developments in ring theory and provides a variety methodologies which will be useful to students and researchers. The articles give the latest developments and trends in Classical Ring Theory.

Contents: Kasch Modules • Compactness in Categories and Interpretations • A Ring of Morita Context in which Eve Right Ideal is Weakly Self-injective • Splitting Theorems an a Problem of Müller • Decomposition of D1 Modules • Righ Cones in Groups • On Extensions of Regular Rings of Finit Index by Central Elements • Intersections of Modules • Minimal Cogenerators over Osofsky and Camillo Rings • Uniform Modules over Goldie Prime Serial Rings • Co- Versus Contravariant Finiteness of Categories of Representations • Monomials and the Lexicographic Orde • Rings over which Direct Sums of CS Modules are CS • Exchange Properties and the Total • Local Bijective Gabri Correspondence and Torsion Theoretic FBN Rings • Normalizing Extensions and the Second Layer Condition • Generators of Subgroups of Finite Index in $GL_n(ZG)$ • We Relative Injective M-Subgenerated Modules • Direct Produ and Power Series Formations over 2-Primal Rings • Localization in Noetherian Rings • Projective Dimension Ideals in Von Neumann Regular Rings • Homological Properties of Color Lie Superalgebras • Indecomposable Modules over Artinian Right Serial Rings • Nonsingular Extending Modules • Right Hereditary, Right Perfect Rings are Semiprimary • On the Endomorphism Ring of Discrete Module: A Theorem of F. Kasch • Nonsingular Rings with Finite Type Dimension

1997 344 pp. Hardcover $85.00 ISBN 0-8176-3969-1
Trends in Mathematics

Foliations on Riemannian Manifolds and Submanifolds

V. Rovenskii, *Pedagogical Institute, Russia*

This volume focuses on the role of a Riemannian curvature in studies of foliations on manifolds and submanifolds.

The book focuses on the author's own investigations in the Riemannian geometry of foliations and submanifolds with generators having nonnegative curvature. The main id is that such manifolds are decomposed into a direct produ when the dimension of leaves is sufficiently large.

Contents: *Part I: Foliations* • Foliations on manifolds • Local Riemannian geometry of foliations • T-parallel vecto fields and mixed curvature • Rigidity and splitting of foliations • *Part II: Applications to Submanifolds* • Submanifolds with generators • Decompostition of ruled submanifolds • Decomposition of parabolic submanifolds • Appendix A. Great sphere foliations and manifolds with curvature bounded above • Appendix B. Submersions of Riemannian manifolds with compact leaves • Appendix C. Foliations closed geodesics with positive mixed sectional curvature • Bibliography • Subject Index

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Table of Contents

December 1997

Articles

Communications

Departments

Commentary

From the AMS

Notices

of the American Mathematical Society

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A Community in Crisis

As I write this, the revitalizing effect of a summer of travel and research is fading in the face of disquieting memos, messages, and news reports. Despite numerous retirements, our department has neither new faculty nor authorization to recruit. N sections of courses are being taught by engineering faculty, while even more are staffed by part-time adjuncts. The underfunding of state-supported higher education is now accompanied by proposals that would shift students from state universities to two-year colleges. Many deserving mathematicians were unable to obtain NSF grants, while those of us who did had budgets cut to the bone. And far too many good young mathematicians are unable to find secure employment in which their talents can flourish.

The mathematics community is in a state of crisis. The success of the heroic efforts to restore the Rochester Ph.D. program should not obscure the fact that many issues continue to threaten mathematics departments across the country. The underfunding of scientific research and of higher education also affects other groups. Rather than squabble over pieces of a shrinking pie, we must collaborate with other departments and disciplines to create a climate in which investments in research and in education are each valued enough to make the necessary funding a political necessity as well. Within the mathematics community we must recognize the need to support a variety of research and educational activities so that we can present a united front in Washington—not a false facade that masks dissension, but the result of healthy professional debate in which differences are sorted out to achieve a consensus position that benefits the entire community.

Although the problems are pervasive, some especially threaten the mathematics community. A shift in calculus enrollment from four-year to two-year institutions, or to technology-based "distance-learning", changes both the character and number of positions. The position of mathematics as the foundation of science and engineering has been turned on its head as administrators switch from viewing it as an essential discipline to a superfluous one which is implicit in others. How shall we respond? Not by acting as if mathematics Ph.D.s are the anointed ones in whom the ability to teach calculus is exclusively invested. How can we make such a claim when, for many years, some of the top mathematics research departments at institutions with prestigious undergraduate programs employed people with master's degrees to teach and/or coordinate calculus? Is viewing a lecture on a remote screen worse than doing so in a large room with 500 students? Nor can we fail to recognize that many faculty in engineering, physics, economics, and other disciplines are also doing good mathematics.

Why do universities have separate departments when there is so much overlap? Physics, chemistry, and mathematics were once grouped together under the rubric "natural philosophy". Now, some institutions even have departments for biophysics, statistics, operations research, etc. The departmental divisions necessitated by growth and specialization also create artificial boundaries. I would argue that educational quality demands that one group, the "mathematics faculty", be entrusted with the responsibility for mathematics instruction. It is far too important to be taught as a sideline by those committed to other disciplines. However, as articulated in Richard Maher's letter in the August 1997 *Notices*, we must take this responsibility seriously enough to replace the name-calling of the calculus reform debate by thoughtful curriculum development and evaluation.

One politician, instead of delineating the role of two-year colleges within a comprehensive educational system, argued for free tuition by asserting that community colleges primarily served poor and immigrant students. This attitude only extends the gap between elite high schools which offer calculus and those from which some graduates didn't learn to add fractions. There is more to a college education than an accumulation of course credits. Opportunities to interact with upper-division students, with research faculty, and with specialists in fields not represented at two-year colleges are valuable. Such benefits of a four-year educational experience should not be reserved for the affluent.

These are difficult problems. They will not be resolved by a "business as usual" or "we need better P.R." attitude. Only if we provide a quality mathematics education, whether to aspiring mathematicians or to students from other fields, can we hope to convince administrators, politicians, and tuition-paying parents that mathematics faculty are a necessity, not a luxury.

—Mary Beth Ruskai

Letters to the Editor

Objection to "Hoax" Accusation

I am writing to express my dismay at the use of the word *hoax* in Shlomo Sternberg's "Comments on the *Bible Code*" in the September 1997 *Notices*. According to my dictionary a hoax is a type of deception and to deceive is to deliberately mislead. One could argue that accusations of hoax never belong in the *Notices*, but even if one believes that such accusations may appear, one must demand they be accompanied by compelling evidence that the accused have indeed intended deliberate deception.

But in this case not a shred of evidence is provided that any deception was intended. Rather, Professor Sternberg gives us strong arguments that the accused (Professor Rips and Mr. Witztum) are wrong in their various publications on the subject. To be wrong is not to be guilty of perpetrating a hoax.

In connection with writing a piece for *Jewish Action* (the magazine of the OU, the largest Orthodox Jewish organization in the United States) entitled "A Skeptical Look at the Codes", I have looked at the *Statistical Science* article and many commentaries on the subject and had discussions with Professor Rips and some of the authors of the code-debunking papers. I share Professor Sternberg's opinion as to the correctness of the arguments of Professor Rips and Mr. Witztum, but I have not seen any convincing evidence of deliberate doctoring.

I might add that having had the pleasure of spending time with Professor Rips, I was struck by his gentleness and decency, and I find it impossible to conceive of his presenting any ideas that he doesn't believe in himself.

An accusation this serious without any proof is irresponsible. I believe both Professor Sternberg and the *Notices* owe Professor Rips and Mr. Witztum an apology.

Barry Simon
California Institute of Technology

(Received August 25, 1997)

In Praise of Epsilon/Delta

The epsilon-delta definition of the limit is one of the greatest achievements of the human mind. It provides the answers to ancient paradoxes involving infinity, it allows us to discover which analytical ideas are true and which are false, and it gives us reliable methods of knowing what control over an input will produce the desired accuracy in the output.

The Greek letters epsilon and delta are better than the Latin letters e and d because (1) e and d are busy representing other things and (2) epsilon and delta have entered our common language. "We are within epsilon of solving the problem." "Houston, what's our delta v?" (In the latter example, the delta is a capital delta, but lowercase delta is just an upper bound on capital delta.)

Like the Hollywood screenwriters who attempt to rewrite *Hamlet* (to make it easier), all attempts I have seen to rewrite the epsilon-delta definition of the limit make things more confusing. "We get really, really, really very, very close." The original is crystal clear and in plain language says exactly this: A function has a limit at an input number x if and only if for any positive epsilon there is a delta that allows us to control the output of the function. Keeping the input within delta of x but not allowing the input to equal x forces the output to be within epsilon of the limit.

Students easily understand why it is a good thing to control output. A few examples show them why we sometimes want to avoid inputting x itself. A function is continuous at exactly those inputs where inputting x gives us the limit.

Most of the trouble my students have with epsilon-delta does not arise from not understanding what epsilon and delta are. They even appreciate the mathematical shorthand. The biggest problem they have is that they don't really understand subtraction and have never been told what the absolute value function is good for. Once they understand that a distance is the absolute value of a difference (highway mileage signs are a good way to make that clear), epsilon-delta is smooth sailing.

Rick Norwood
East Tennessee State University

(Received August 26, 1997)

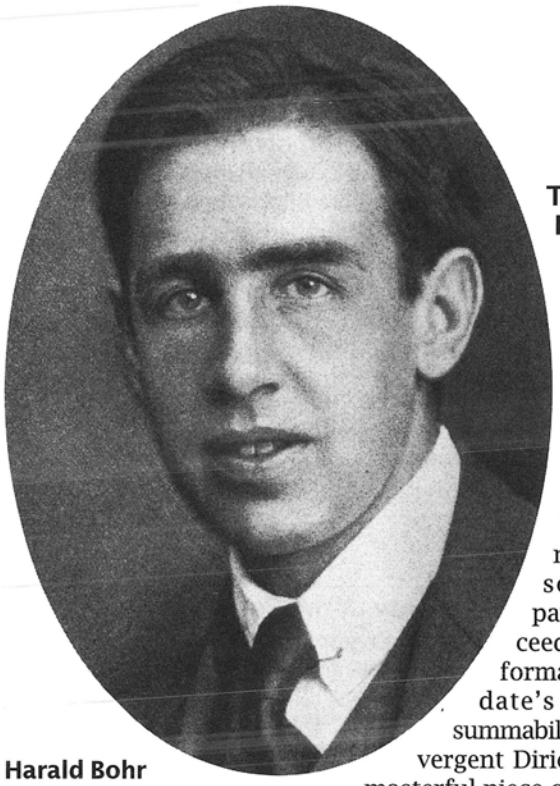
About the Cover

The figure shows a simulation of a three-species competition system with a cyclic relationship: $1 > 2$, $2 > 3$, and $3 > 1$ where $>$ is short for outcompetes. The underlying model takes place on a 300 x 300 grid with each site being in state 1, 2, or 3. In the image the height represents the density of type 1 and the color the density of type 2 in an 11 x 11 window centered at the point. The initial state of the simulation consisted of three sectors, each occupied by one of the types. This spiral wave forms in the early stages of convergence to a spatially structured equilibrium state.

A report on this joint research of Richard Durrett, a Cornell mathematician, and Simon Levin, a Princeton mathematician biologist, can be found in *J. Theor. Biol.* **185** (1997), 165–171, or at `http://math.cornell.edu/~durrett/`. Linda Buttell performed the simulations on the Cornell supercomputer. The visualization using Data Explorer was done by Catherine Devine, a former employee of the now defunct Cornell National Supercomputer Facility.

The Football Player and the Infinite Series

Harold P. Boas



Harald Bohr

The Football Player

The air buzzed with anticipation as the football team crowded excitedly into the lecture hall. The country's top halfback was about to defend his Ph.D. thesis in mathematics! It soon became apparent that the proceedings were a mere formality, as the candidate's dissertation on summability methods for divergent Dirichlet series was a masterful piece of work.

This scenario is no fantasy from a 1990s television sitcom; it is a true story. The place was Copenhagen, the year was 1910, and the sport was "football" as the word is understood internationally ("soccer" in American lingo). The star halfback played in the 1908 Olympics on Denmark's silver-medal football team, a team that is still in the record books [21, p. 172] for the most goals scored in a single game. (Denmark defeated France by the lopsided score of 17 to 1.) The dissertation title was *Contributions to the Theory of Dirichlet Series* (well, actually *Bidrag til de Dirichlet'ske Rækkers Theori*), and the candidate's name was Harald Bohr.

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(Devotees of American football remember Frank Ryan, who wrote his Ph.D. dissertation [23, 24] on geometric function theory while quarterback for the Cleveland Browns, champions of the National Football League at the time. But that's another story [18, 22].)

Among mathematicians, Harald Bohr is best remembered today for his theory of almost periodic functions [10]; students of complex analysis also know him for the Bohr-Mollerup theorem (see, for example, [3, Theorem 2.1], [12, §§274–275]) that characterizes the Γ function on the positive real axis as the unique positive, logarithmically convex function f such that $f(x+1) = xf(x)$ for all x and $f(1) = 1$. In his native land Bohr's early fame as a sports hero and his subsequent prominence as a distinguished academician were eclipsed by his status as the kid brother of Niels Bohr. Brother Niels, a prime architect of modern atomic theory and recipient of the Nobel prize for physics in 1922, was Denmark's most honored citizen during his lifetime.

The Infinite Series

Like many others before and after him, Harald Bohr wanted to decide the truth or falsity of the Riemann hypothesis, one of the most famous unsolved problems of mathematics. Bohr was unsuccessful, but much of his mathematical work was motivated by trying to understand the Riemann zeta-function ζ:

$$\zeta(s) = \sum_{n=1}^{\infty} \frac{1}{n^s}, \qquad \operatorname{Re} s > 1.$$

It is easy to see that the infinite series on the right-hand side converges absolutely in the half-plane where the real part of the complex variable s exceeds 1, for $|1/n^s| = 1/n^{\operatorname{Re} s}$, and $\sum_{n=1}^{\infty} 1/n^x$ converges when $x > 1$. On the other hand, there is no

larger open half-plane where the series converges (even conditionally), because when $s = 1$ the series reduces to the divergent harmonic series.

It is a natural idea to try to understand the Riemann ζ-function by studying the more general *Dirichlet series* of the form $\sum_{n=1}^{\infty} a_n/n^s$, the coefficients a_n being complex constants. (These are *ordinary* Dirichlet series; for a wider class see, for example, [2, 16].) A simple example of a Dirichlet series is $\sum_{n=1}^{\infty}(-1)^{n+1}/n^s$, which is the ζ-function series with alternating signs. Evidently this series converges absolutely in exactly the same half-plane as the ζ-function series does: $\operatorname{Re} s > 1$.

However, this new series converges conditionally (but not absolutely) in the larger half-plane where $\operatorname{Re} s > 0$. The convergence follows from the Abel-Dirichlet-Dedekind generalization of the alternating series test (see, for example, [15, §143], [20, §5.5]), which implies that if $\{b_n\}$ is a sequence tending to 0 and of bounded variation (meaning that $\sum_n |b_n - b_{n+1}|$ converges), then $\sum_n (-1)^n b_n$ converges. The sequence $\{1/n^s\}$ has bounded variation when $\operatorname{Re} s > 0$ since $|1/n^s - 1/(n+1)^s| = O(1/n^{1+\operatorname{Re} s})$.

This phenomenon of conditional convergence is contrary to our experience with ordinary power series $\sum_{n=1}^{\infty} c_n z^n$, for a power series converges absolutely at all points of its open disk of convergence. A Dirichlet series can converge nonabsolutely (that is, conditionally) in a vertical strip, and the above example shows that the width of such a strip can be as large as 1. The width of the strip of conditional, nonabsolute convergence cannot, however, exceed 1. Indeed, if the Dirichlet series $\sum_{n=1}^{\infty} a_n/n^s$ converges for a certain s, then the individual terms tend to 0 and in particular are bounded in absolute value by some constant M; now if z is a complex number such that $\operatorname{Re} z > 1 + \operatorname{Re} s$, then $\sum_{n=1}^{\infty} |a_n/n^z| \le M \sum_{n=1}^{\infty} 1/n^{\operatorname{Re}(z-s)} < \infty$.

Incidentally, the series $\sum_{n=1}^{\infty}(-1)^{n+1}/n^s$ is closely related to the ζ-function. When $\operatorname{Re} s > 1$, we can rearrange the terms of the absolutely convergent series however we like, so by separating the sum over odd integers from the sum over even integers, we find that

$$\sum_{n=1}^{\infty} \frac{(-1)^{n+1}}{n^s} = \sum_{n=1}^{\infty} \frac{1}{n^s} - 2\sum_{k=1}^{\infty} \frac{1}{(2k)^s} = \zeta(s)(1 - 2^{1-s}).$$

Thus, the function $(1 - 2^{1-s})^{-1} \sum_{n=1}^{\infty}(-1)^{n+1}/n^s$ serves to extend the definition of the ζ-function from the half-plane where $\operatorname{Re} s > 1$ to the half-plane where $\operatorname{Re} s > 0$. Bohr observed in [6] that one way to extend the ζ-function to the whole plane is to take iterated Cesàro averages of the series $\sum_{n=1}^{\infty}(-1)^{n+1}/n^s$, thereby producing equivalent series that converge in progressively larger half-planes. The famous Riemann hypothesis can be formulated as the statement that the zeroes of the function $\sum_{n=1}^{\infty}(-1)^{n+1}/n^s$ in the right half-plane all lie on the vertical line where $\operatorname{Re} s = 1/2$ (aside from trivial zeroes where $1 - s$ is a nonzero integral multiple of $2\pi i/\log 2$).

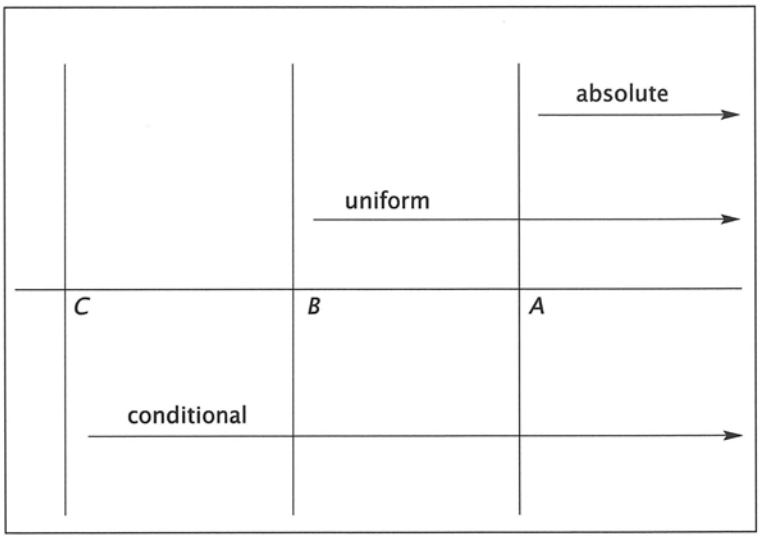

Figure 1. Convergence regions for Dirichlet series.

The Question

What about uniform convergence of Dirichlet series? An ordinary power series converges uniformly on each closed disk inside its open disk of convergence, but this gives no hint about what might be true for Dirichlet series (as we have already seen in the case of conditional convergence).

Since $|1/n^s|$ does not depend on the imaginary part of s, it is clear that if a Dirichlet series $\sum_{n=1}^{\infty} a_n/n^s$ converges absolutely in a half-plane where $\operatorname{Re} s > A$, then it converges uniformly in each closed half-plane $\{s : \operatorname{Re} s \ge A + \epsilon\}$, where ϵ can be any positive number. Having just seen that there may be an abscissa C to the left of A such that the series converges conditionally when $\operatorname{Re} s > C$, we might anticipate that there is an intermediate abscissa B, as indicated in Figure 1, such that the Dirichlet series converges uniformly in each closed half-plane $\{s : \operatorname{Re} s \ge B + \epsilon\}$, where $\epsilon > 0$. Harald Bohr introduced this notion of a line of uniform convergence in [7].

In [8, p. 446] Bohr asked, What is the maximal possible width $A - B$ of the vertical strip of uniform, but not absolute, convergence of a Dirichlet series? We saw above that $A - C \le 1$, so certainly $A - B$ cannot exceed 1. It turns out that $A - B$ cannot exceed $1/2$, and this value is sharp.

Although Bohr knew that $A - B \le 1/2$, he could not produce a single example of a Dirichlet series for which $A - B > 0$. In a companion paper [26] in the same volume, Otto Toeplitz gave examples showing that the upper cutoff for $A - B$ is no smaller than $1/4$. It was nearly two decades later that H. F. Bohnenblust and Einar Hille finally proved $1/2$ to be the right value in an article [5] that Henry Helson, commenting in a collection of Hille's papers, termed "a re-

markable piece of work" [19, p. 664]. The result was rediscovered by Seán Dineen and Richard M. Timoney more than half a century later [14], with a new proof based on the relationship [13] between nuclearity and the existence of absolute bases in certain locally convex spaces.

My aim here is to make the theorem accessible to a wide audience by presenting a relatively elementary proof using only methods that have existed in textbook form since I was in high school. (I hesitate to call the methods "classical", however. The technique of random polynomials discussed below was not available to Bohr.) My attention was directed to this theorem by Henry Helson when I lectured at Berkeley about some joint work with Dmitry Khavinson [4] concerning another problem of Bohr.

The Upper Bound

Suppose that a Dirichlet series $\sum_{n=1}^{\infty} a_n/n^s$ converges uniformly on a vertical line where $\operatorname{Re} s = b$. I claim that if ϵ is an arbitrary positive number, then the series converges absolutely when $\operatorname{Re} s \ge b + \epsilon + 1/2$; that is, $\sum_{n=1}^{\infty} |a_n|/n^{b+\epsilon+1/2} < \infty$. In other words, the width $A - B$ is no larger than $1/2$.

Observe that by the Cauchy-Schwarz inequality, $\sum_{n=1}^{\infty} |a_n|/n^{b+\epsilon+1/2}$ is at most $(\sum_{n=1}^{\infty} |a_n|^2/n^{2b})^{1/2} \times (\sum_{n=1}^{\infty} 1/n^{1+2\epsilon})^{1/2}$. Since $\sum_{n=1}^{\infty} 1/n^{1+2\epsilon}$ converges, the claim will follow if I show that $\sum_{n=1}^{\infty} |a_n|^2/n^{2b}$ converges.

Since each finite partial sum $\sum_{n=1}^{N} a_n/n^s$ is bounded on the line where $\operatorname{Re} s = b$, and since (by hypothesis) the partial sums converge uniformly on this line, the partial sums must be uniformly bounded on the line, say by a constant M. Then for every positive integer N and every real number t we have the inequality

$$M^2 \ge \left| \sum_{n=1}^{N} \frac{a_n}{n^{b+it}} \right|^2 = \sum_{n=1}^{N} \frac{|a_n|^2}{n^{2b}} + 2\operatorname{Re} \sum_{1 \le n < m \le N} \frac{a_n \overline{a}_m}{(nm)^b (n/m)^{it}}.$$

Taking the average value with respect to t by integrating from $-T$ to T and dividing by $2T$, we find that

$$M^2 \ge \sum_{n=1}^{N} \frac{|a_n|^2}{n^{2b}} + 2\operatorname{Re} \sum_{1 \le n < m \le N} \frac{a_n \overline{a}_m}{(nm)^b} \frac{\sin(T \log(m/n))}{T \log(m/n)}.$$

Taking the limit as $T \to \infty$ shows that $M^2 \ge \sum_{n=1}^{N} |a_n|^2/n^{2b}$. Since N is arbitrary, this means that $\sum_{n=1}^{\infty} |a_n|^2/n^{2b}$ does converge.

This confirms that the maximal width $A - B$ of the strip of uniform but not absolute convergence of a Dirichlet series is at most $1/2$. Next I want to show that the cutoff value for this width is no smaller than $1/2$.

The Lower Bound

I will construct a Dirichlet series $\sum_{n=1}^{\infty} a_n/n^s$ that converges uniformly in every half-plane $\{s : \operatorname{Re} s \ge \delta + \frac{1}{2}\}$, where $\delta > 0$, but that does not converge absolutely when $\operatorname{Re} s < 1$. This example demonstrates that no number smaller than $1/2$ will serve as a cutoff for the maximal width of the strip of uniform nonabsolute convergence of Dirichlet series.

Tools

The construction uses off-the-shelf technology: elementary counting, the prime number theorem, and the theory of random Fourier series. There is enough slack in the method that I do not need particularly sharp implementations of these tools. The theory of analytic functions of an infinite number of variables, central to Harald Bohr's approach, is hiding in the background, but I shall not need to make explicit reference to it.

Nonetheless, the philosophy of the construction is very much that of Bohr. Namely, I choose to view an object such as $1/45^s$, not as the reciprocal of a power of an integer, but as the value of the monomial $z_1^2 z_2$ when $z_1 = 1/3^s$ and $z_2 = 1/5^s$. Thus, the problem becomes separated from number theory and turns into a problem about polynomials.

The prime number theorem

The most familiar version of the prime number theorem says that the number of primes less than x is asymptotic to $x/\log x$ when $x \to \infty$. An equivalent statement is that if the prime numbers are arranged in increasing order ($p_1 = 2$, $p_2 = 3$, $p_3 = 5$, and so on), then the size of the nth prime p_n is asymptotic to $n \log n$. I need only the weaker statement that there is a constant c_1 such that $1/c_1 < p_n/(n \log n) < c_1$ when $n > 1$; this is rather easier to prove than the full-blown prime number theorem (see, for example, [1, §4.5]).

Counting monomials

I need simple bounds on the number of monomials of degree m in n variables: objects of the form $z_1^{\alpha_1} z_2^{\alpha_2} \dots z_n^{\alpha_n}$, where the α_j are nonnegative integers whose sum is m. Viewing such a monomial as a product of m nontrivial factors, where there are n choices for each factor, gives a count of n^m, but this count is too big, since it takes account of the order of the terms. No particular product of terms has more than $m!$ rearrangements, and some products have fewer rearrangements, so $n^m/m!$ is an undercount. Thus the number of distinct monomials of degree m in n variables is between $n^m/m!$ and n^m. It is easy to show that the precise count is the binomial coefficient $\binom{n+m-1}{m}$, but I shall not need this exact value.

Random polynomials

Consider a homogeneous polynomial of degree m in n complex variables with coefficients ± 1, that is, an object of the form

$$\sum_{\alpha_1+\alpha_2+\cdots+\alpha_n=m} \pm z_1^{\alpha_1} z_2^{\alpha_2} \dots z_n^{\alpha_n}.$$

To avoid trivialities, I assume that m and n are both at least 2. What can be said about the supremum of the modulus of such a polynomial when every coordinate z_j lies in the unit disk? Since each term has modulus at most 1, the maximum modulus is certainly no more than the total number of terms, which according to the preceding paragraph is less than n^m. On the other hand, the maximum modulus is at least as big as the root mean square average on the torus where each variable has modulus 1; by orthogonality, this average equals the square-root of the total number of terms and thus exceeds $n^{m/2}/\sqrt{m!}$ (again, by the count in the preceding paragraph). What will be significant below is the exponent of n.

It turns out that typically the maximum modulus of such a polynomial is nearly as small as it can be. According to the theory of random trigonometric polynomials (see, for example, [17, Theorem 4 of Chapter 6]) there is a constant c_2 such that if the $\pm$ signs are assigned at random, then with high probability the maximum modulus of the resulting polynomial is less than $c_2 n^{(m+1)/2}\sqrt{\log m}$. Although there consequently are many polynomials satisfying this bound, all I need is the existence of one for each m and n.

The Construction

I will construct a Dirichlet series $\sum_{n=1}^{\infty} a_n/n^s$ for which every coefficient a_n is either 0, +1, or −1, and I will show that for every positive δ this Dirichlet series converges uniformly when $\operatorname{Re} s \geq \delta + \frac{1}{2}$, yet the series does not converge absolutely when $\operatorname{Re} s < 1$.

I construct the terms of the series in groups. To build the kth group (starting with $k = 2$), choose a random homogeneous polynomial of degree k in 2^k variables with coefficients ± 1 (as described above). List the 2^k consecutive prime numbers starting with the 2^kth prime, and for each such prime p substitute $1/p^s$ for the corresponding variable in the polynomial. This converts the sum of monomials $\pm z_1^{\alpha_1} z_2^{\alpha_2} \dots z_{2^k}^{\alpha_{2^k}}$ into a sum of terms $\pm 1/n^s$, where each integer n is the product of exactly k primes (counting repeated factors with their multiplicities) from the block of 2^k primes starting at the 2^kth prime. The uniqueness of prime factorization implies that no integer n appears more than once.

For every integer n not arising in the above process, I set $a_n = 0$. The first integer n for which $a_n \neq 0$ is 49, for this is the smallest integer that is the product of two primes taken from the set of 2^2 consecutive primes starting with $p_4 = 7$.

Now I verify that the constructed Dirichlet series has the required properties. First consider the question of absolute convergence of $\sum_{n=49}^{\infty} a_n/n^s$. The counting argument above implies that the number of integers n formed from products of k primes in the block from the 2^kth prime to the 2^{k+1}th prime exceeds $2^{k^2}/k^k$. By the prime number theorem the 2^{k+1}th prime is bounded above by $3c_1 k 2^k$, so such integers n are bounded above by $(3c_1 k)^k 2^{k^2}$. Hence $\sum_{n=49}^{\infty} |a_n/n^s|$ exceeds $\sum_{k=2}^{\infty} 2^{k^2(1-\operatorname{Re} s)}/(3c_1 k)^{k(1+\operatorname{Re} s)}$. Evidently the latter sum diverges when $\operatorname{Re} s < 1$, so our Dirichlet series fails to converge absolutely when $\operatorname{Re} s < 1$. (On the other hand, since the coefficients a_n are bounded, it is evident that our Dirichlet series does converge absolutely when $\operatorname{Re} s > 1$.)

Next consider the question of uniform convergence of our Dirichlet series. I wish to estimate the modulus of the sum of the terms in the kth block. This piece of the Dirichlet series equals the value of our random polynomial when we substitute for each variable the reciprocal of the corresponding prime number raised to the power s. Since the polynomial is homogeneous of degree k, the supremum of its modulus when the variables have modulus at most $|1/p^s|$ is $1/p^{k\operatorname{Re} s}$ times the bound $c_2 2^{k(k+1)/2}\sqrt{\log k}$ coming from the paragraph "Random polynomials". Since the 2^kth prime is bounded below by $k2^k/2c_1$, this chunk of the Dirichlet series is bounded above by $c_2 2^{k(k+1)/2}\sqrt{\log k}/(k2^k/2c_1)^{k\operatorname{Re} s}$. The Weierstrass M-test and the root test now imply that the series of blocks converges uniformly when $\operatorname{Re} s \geq 1/2$.

The proof is now finished modulo a technical (but nontrivial) point. I have showed that the constructed Dirichlet series converges uniformly for $\operatorname{Re} s \geq 1/2$ if the series is summed in appropriate blocks; however, I need to show that the Dirichlet series converges uniformly when summed in its natural order, without grouping. (That there truly is something to check here is indicated already by the alternating version of the ζ-function series $\sum_{n=1}^{\infty}(-1)^{n+1}/n^s$, which when $s = 0$ converges if summed by pairs of terms, yet diverges when summed in the ordinary way.) The convergence we need follows from a general lemma, essentially due to Bohr [9, Hilfssatz 2].

Lemma. Suppose that a Dirichlet series $\sum_{n=1}^{\infty} b_n/n^s$ converges absolutely when $\operatorname{Re} s > a$ and that the analytic function $f(s)$ which it represents continues analytically to the half-plane where $\operatorname{Re} s > c$. If $c < b < a$, and if f is bounded on the half-plane where $\operatorname{Re} s \geq b$, then for every positive δ the Dirichlet series converges uniformly on the half-plane where $\operatorname{Re} s \geq b + \delta$.

In our situation the series summed in blocks converges uniformly in the closed half-plane where $\operatorname{Re} s \geq \frac{1}{2}$ to a bounded function f that is analytic in the open half-plane. When $\operatorname{Re} s > 1$, this function f does equal the sum of the Dirichlet series (summed in any order, since in that region the series converges absolutely). Consequently, the lemma implies that the Dirichlet series converges uniformly to f in each half-plane where $\operatorname{Re} s \geq \delta + \frac{1}{2}$.

Proof of the Lemma

The lemma follows from a technique that Bohr attributed to his contemporary W. Schnee, who wrote his dissertation in Berlin in 1908 under the influence (although not the formal tutelage) of the famous Edmund Landau. Soon after receiving his master's degree in 1909 Bohr himself began a collaboration with Landau, who had just been appointed Minkowski's successor at the University of Göttingen. In his reminiscences [11, p. xxvi] Bohr remarked on Landau's unexcelled zeal:

> When Landau and I thought that an oral conference on our work was needed, I caught the train to Göttingen for a few days' stay. No one could be in such an excellent mood for work as Landau, and his speed and perseverance were sometimes quite breathtaking. In order to show me at once that the time had come for serious work, he had instituted the tradition of ringing the bell immediately, as soon as I had arrived at his house after the long and somewhat tiring journey and had set foot inside his study, and of requesting the entering maid to inform the kitchen that "tonight at 2 AM a very strong cup of coffee is to be served to both of us."

The idea of the proof is easier to describe than to implement: integrate over a vertical contour, and use Cauchy's integral formula to push the contour to the right into the region where the Dirichlet series is already known to converge uniformly. The technique is still the standard one employed to derive Perron's formula for the partial sums of Dirichlet series (see, for example, [1, §11.12], [25, §9.42]). This shows that contour integration remains useful, even though symbolic computation software packages such as *Mathematica* and *Maple* can now calculate all the real integrals that are given in complex analysis textbooks as the main applications of contour integration.

To begin the proof, let K denote an upper bound for f in the half-plane where $\operatorname{Re} s \geq b$, and fix a positive δ (which we may as well assume is less than 1). I aim to show that if $\operatorname{Re} s \geq b+\delta$, then $|f(s) - \sum_{n=1}^{M} b_n/n^s|$ is bounded by a constant times $M^{-\delta}\log M$, where the constant depends on K and δ but is independent of s and M. Consequently, the Dirichlet series will converge uniformly to f in the half-plane where $\operatorname{Re} s \geq b+\delta$, as claimed.

Viewing s and M as fixed for the moment, with $\operatorname{Re} s \geq b+\delta$, consider integrating $f(z)(M+\frac{1}{2})^{z-s}/(z-s)$ as a function of z around the rectangular contour shown in Figure 2 with vertices at $s-\delta-iM^{a-b+2}$, $s+a-b-iM^{a-b+2}$, $s+a-b+iM^{a-b+2}$, and $s-\delta+iM^{a-b+2}$. By Cauchy's integral formula this integral equals $2\pi i f(s)$. The integral over the left-hand edge of the rectangle has modulus bounded by $KM^{-\delta}\int_{-M^{a-b+2}}^{M^{a-b+2}}(\delta^2+y^2)^{-1/2}\,dy$, and hence by a constant (depending on δ and K) times $M^{-\delta}\log M$. The integrals over the top and bottom edges of the rectangle are each bounded by

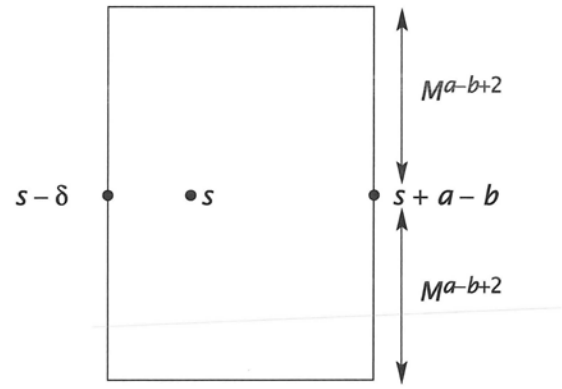

Figure 2. Integration contour.

$$KM^{-(a-b+2)}\int_{-\delta+\operatorname{Re} s}^{a-b+\operatorname{Re} s}(M+\tfrac{1}{2})^{x-\operatorname{Re} s}\,dx,$$

and hence by a constant times M^{-2}. Consequently, $2\pi i f(s)$ differs by $O(M^{-\delta}\log M)$ from the integral over the right-hand edge of the rectangle.

Since the right-hand edge of the contour is in the region where the Dirichlet series is known to converge uniformly to f, we may replace $f(z)$ by $\sum_{n=1}^{\infty} b_n/n^z$ in the remaining integral and interchange the order of summation and integration. We now have that $2\pi i f(s)$ differs from

$$(1)\quad \sum_{n=1}^{\infty}\frac{b_n}{n^s}\int_{s+a-b-iM^{a-b+2}}^{s+a-b+iM^{a-b+2}}\left(\frac{M+\frac{1}{2}}{n}\right)^{z-s}\frac{1}{z-s}\,dz$$

by $O(M^{-\delta}\log M)$. To evaluate the integrals in this sum, we must distinguish between the cases $n \geq M+1$ and $n \leq M$.

When $n \geq M+1$, build a new rectangular contour whose left-hand edge is the given vertical line segment with abscissa $a-b+\operatorname{Re} s$ and whose right-hand edge has very large abscissa. The integrand has no singularities inside this contour, so the integral over the left-hand side equals the negative of the sum of the integrals over the other three sides. Since $((M+\frac{1}{2})/n)^{z-s}$ is decaying exponentially when $\operatorname{Re} z$ becomes large, we may push the right-hand edge of the contour off to $+\infty$. The integrals over the top and bottom sides are each bounded by $M^{-(a-b+2)}\int_{a-b}^{\infty}((M+\frac{1}{2})/n)^x\,dx$. Hence the terms for which $n \geq M+1$ make a total contribution to the sum in (1) not exceeding twice

$$\sum_{n\ge M+1} \frac{|b_n|}{n^{\operatorname{Re} s}} M^{-(a-b+2)} \left(\frac{M+\frac{1}{2}}{n}\right)^{a-b} \times \left|\log \frac{M+\frac{1}{2}}{n}\right|^{-1}.$$

Observe that $|\log(M+\frac{1}{2})/n|$ is smallest when $(M+\frac{1}{2})/n$ is closest to 1, which happens when $n = M+1$. In this case, the absolute value of the logarithm is

$$-\log\frac{2M+1}{2M+2} = -\log\left(1-\frac{1}{2M+2}\right) > \frac{1}{2M+2}.$$

Since the series $\sum_{n=1}^{\infty} |b_n|/n^{a-b+\operatorname{Re} s}$ is uniformly bounded above by $\sum_{n=1}^{\infty} |b_n|/n^{a+\delta}$, which converges by hypothesis, it follows that the terms in (1) with $n \ge M+1$ have a sum bounded by a constant times $1/M$.

For the terms with $n \le M$, we may similarly build a rectangular contour whose right-end edge is the vertical line with abscissa $a-b+\operatorname{Re} s$ and which extends to the left toward $-\infty$. The integral over this contour picks up a contribution $2\pi i$ from the simple pole at $z = s$ with residue 1, while the integrals over the top and bottom edges admit estimates analogous to the previous case. Consequently,

$$\left| f(s) - \sum_{n=1}^{M} \frac{b_n}{n^s} \right| = O(M^{-\delta}\log M)$$

uniformly with respect to s when $\operatorname{Re} s \ge b+\delta$. This completes the proof of the lemma.

Envoi

We have seen an example of a Dirichlet series $f(s)$ whose strip of uniform, but not absolute, convergence attains the maximal possible width of $1/2$. On the other hand, for the Riemann zeta function ζ, the width of this strip is 0. Bohnenblust and Hille went to some trouble in [5, pp. 618–620] to demonstrate that if λ is any real number between 0 and $1/2$, then there is a Dirichlet series whose strip of uniform, nonabsolute convergence has width precisely λ. Harald Bohr [5, p. 622 footnote] cut through this problem with a knife: the Dirichlet series for $f(s)+\zeta(s+\lambda)$ does the job.

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A Generalization of Fermat's Last Theorem: The Beal Conjecture and Prize Problem

R. Daniel Mauldin

Andrew Beal is a Dallas banker who has a general interest in mathematics and its status within our culture. He also has a personal interest in the discipline. In fact, he has formulated a conjecture in number theory on which he has been working for several years. It is remarkable that occasionally someone working in isolation and with no connections to the mathematical world formulates a problem so close to current research activity.

The Beal Conjecture

Let A, B, C, x, y, and z be positive integers with $x, y, z > 2$. If $A^x + B^y = C^z$, then A, B, and C have a common factor.

Or, slightly restated:

The equation $A^x + B^y = C^z$ has no solution in positive integers A, B, C, x, y, and z with x, y, and z at least 3 and A, B, and C coprime.

It turns out that very similar conjectures have been made over the years. In fact, Brun in his 1914 paper states several similar problems [1]. However, it is very timely that this problem be raised now, since Fermat's Last Theorem has just recently been proved (or re-proved) by Wiles [6]. Some of the significant advances made on some problems closely related to the prize problem by Darmon and Granville [2] are indicated below. Darmon and Granville in their article also discuss some related conjectures along this line and provide many relevant references.

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The prize. Andrew Beal is very generously offering a prize of $5,000 for the solution of this problem. The value of the prize will increase by $5,000 per year up to $50,000 until it is solved. The prize committee consists of Charles Fefferman, Ron Graham, and R. Daniel Mauldin, who will act as the chair of the committee. All proposed solutions and inquiries about the prize should be sent to Mauldin.

The abc conjecture. During the 1980s a conjectured diophantine inequality, the "abc conjecture", with many applications was formulated by Masser, Oesterle, and Szpiro. A survey of this idea has been given by Lang [5] and an elementary discussion by Goldfeld [4]. This inequality can be stated in very simple terms, and it can be applied to Beal's problem. To state the abc conjecture, let us say that if a, b, and c are positive integers, then $N(a,b,c)$ denotes the square free part of the product abc. In other words, $N(a,b,c)$ is the product of the prime divisors of a, b, and c with each divisor counted only once. The abc conjecture can be formulated as follows:

For each $\epsilon > 0$, there is a constant $\mu > 1$ such that if a and b are relatively prime (or coprime) and c = a+b, then

$$\max(|a|, |b|, |c|) \leq \mu N(a, b, c)^{1+\epsilon}.$$

Now let us show that *if the abc conjecture holds, then there are no solutions to the prize problem when the exponents are large enough.*

Let $k = \log \mu / \log 2 + (3 + 3\epsilon)$. Let $\min(x, y, z) > k$. Assume A, B, and C are positive integers with A and B relatively prime and such that $A^x + B^y = C^z$. Setting $a = A^x$ and $b = B^y$, we have

$c = a + b = C^z$. From the abc conjecture and the fact that $N(A^x, B^y, C^z) \le ABC$, we have

$$\max(A^x, B^y, C^z) \le \mu(ABC)^{1+\epsilon}.$$

If $\max(A, B, C) = A$, then we would have

$$A^x \le \mu A^{3+3\epsilon}$$

or

$$x \le \frac{\log \mu}{\log A} + 3 + 3\epsilon \le k,$$

which is not the case. A similar argument for the other two possibilities for the maximum shows that our original assumption is impossible.

Next let us give an explicit version of the abc conjecture: If a and b are coprime positive integers and $c = a+b$, then $c \le (N(a,b,c))^2$. Let us see what this implies for the prize problem. Suppose $A^x + B^y = C^z$, with $x \le y \le z$. Again, since A^x and B^y are coprime,

$$C^z \le (N(A^x B^y C^z))^2 \le (ABC)^2 < C^{2(z/x+z/y+1)}.$$

So $1/2 < 1/x + 1/y + 1/z$. Since x, y, and z are greater than 2, we have the following possibilities for (x,y,z): $(3,3,z>3), (3,4,z\ge 4), (3,5,z\ge 5), (3,6,z\ge 7), (4,4,z\ge 5)$, and a finite list of other cases.

There are only finitely many possible solutions. In 1995 Darmon and Granville [2] showed that if the positive integers x, y, and z are such that $1/x + 1/y + 1/z < 1$, then there are only finitely many triples of coprime integers A, B, C satisfying $A^x + B^y = C^z$. Since each of x, y, and z is greater than 2, then $1/x + 1/y + 1/z < 1$ unless $x = y = z = 3$. But Euler and possibly Fermat knew there are no solutions in this case. So for each triple x, y, and z, all greater than 2, there can be only finitely many solutions to the diophantine equation $A^x + B^y = C^z$.

Related problems. What happens if it is only required that x, y, and z be ≥ 2 and at least one of them is greater than 2 and A, B, and C are coprime? There is a detailed analysis in [2] of those cases where $x, y, z \ge 2$ and $1/x + 1/y + 1/z > 1$.

What happens if we require only that $1/x + 1/y + 1/z < 1$ and A, B, and C are coprime? This problem is also discussed by Darmon and Granville. In fact, they have formulated

The Fermat-Catalan Conjecture. There are only finitely many triples of coprime integer powers x^p, y^q, z^r for which

$$x^p + y^q = z^r \text{ with } \frac{1}{p} + \frac{1}{q} + \frac{1}{r} < 1.$$

So far, as mentioned in [2], ten solutions have been found. The first five are small solutions. They are $1 + 2^3 = 3^2, 2^5 + 7^2 = 3^4, 7^3 + 13^2 = 2^9, 2^7 + 17^3 = 71^2, 3^5 + 11^4 = 122^2$.

Also five large solutions have been found: $17^7 + 76271^3 = 21063928^2$, $1414^3 + 2213459^2 = 65^7$, $9262^3 + 15312283^2 = 113^7$, $43^8 + 96222^3 = 30042907^2$, $33^8 + 1549034^2 = 15613^3$. The last five big solutions were found by Beukers and Zagier.

Recently Darmon and Merel have shown that there are no coprime solutions with exponents $(x, x, 3)$ with $x \ge 3$ [3].

Acknowledgment. Since I am not an expert in this field, I would like to thank Andrew Granville and Richard Guy for their expert help in preparing this note.

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Andrew Beal is a number theory enthusiast residing in Dallas, Texas. He grew up in Lansing, Michigan, and attended Michigan State University. He has a particular interest in some of Fermat's work and has spent many, many hours thinking about Fermat's Last Theorem. He believes that Fermat did possess a relatively simple non-geometry-based proof for FLT, and he continues to search for it. He also believes that Fermat had a method of solution for Pell's equation that remains unknown and that was a function of the squares whose sum equals the coefficient.

Andrew is forty-four years old. He and his wife, Simona, have five children. He is the founder/chairman/owner of Beal Bank, Dallas's largest locally owned bank. He is also the recent founder/CEO/owner of Beal Aerospace, which is designing and building a next-generation rocket for launching satellites into earth orbits.

Beal Bank, Toyota, and the Dallas Morning News *are the primary sponsors of the Dallas Regional Science and Engineering Fair. Beal Bank is also a primary sponsor of the Dallas Area Odyssey of the Mind Competition. Andrew Beal has been a major benefactor for the mathematics program at the University of North Texas through his substantial scholarships for graduate students and for students in the Texas Academy of Mathematics and Science.*

Garrett Birkhoff and the *Survey of Modern Algebra*

Saunders Mac Lane

Garrett Birkhoff became fascinated with finite groups when he was an undergraduate major in mathematics at Harvard. Upon graduation in 1932, at the age of nineteen, he traveled in Europe with a Henry fellowship. There he studied Speiser's book on group theory and van der Waerden on modern algebra. At Cambridge University he was impressed by the elegant group theoretic ideas of Philip Hall. Then Garrett also discovered the idea of a lattice—a poset with both lower and upper bounds (only later did it turn out that this structure had been found by Dedekind, in a little noted study of what he called a "dual group"). While in Cambridge, Garrett also conceived the idea that there could be a real "universal algebra" and realized this idea by proving what is now known as Birkhoff's theorem, characterizing varieties of algebras.

He considered algebras given by a set with specified operations (unary, binary, etc.) which satisfy a given list of identities. All such constitute a "variety". Birkhoff's theorem states that a class of algebras is such a variety if and only if it is closed under the formation of subalgebras, direct products, and homomorphic images. This result became the starting point for the subsequent active development of universal algebra.

After holding a Junior Fellowship at Harvard 1933–36, Garrett became an instructor in 1936. At that time Harvard provided a full year undergraduate course in geometry; Garrett advocated the establishment of a corresponding full year course in algebra, to be called Mathematics 6. He taught the first version of this course in 1937–38, emphasizing Boolean algebra, set theory, vectors and group theory; he prepared notes of his course. I taught a somewhat different version of Mathematics 6 in the next year, 1939–40, after I joined the Harvard faculty in 1938; I also provided typed notes of my version of the course. In the subsequent years Garrett and I combined our preliminary notes to publish with MacMillan in 1941 our joint book, *Survey of Modern Algebra*. It provided a clear and enthusiastic emphasis on the then new modern and axiomatic view of algebra, as advocated by Emmy Noether, Emil Artin, van der Waerden, and Philip Hall. We aimed to combine the abstract ideas with suitable emphasis on examples and illustrations. Groups were started by examples such as the group of symmetries of the square. Vector spaces were introduced by axioms, but with n-tuples of numbers as illustrations. The chapter on matrices began with linear transformations and explained matrix multiplication in terms of the composition of the corresponding linear transformations. The Galois theory was presented with the conceptual ideas of Emil Artin, which made the Galois correspondence (subgroups to subfields) vivid. In brief, the emphasis was axiomatic and abstract, but built on examples.

At that time one of my good midwestern friends told me that our survey "would not fly beyond the Charles River." For a year or two this was perhaps so. But American mathematics, spurred by the in-

Editor's Note: Garrett Birkhoff passed away on November 11, 1996, at the age of 85.

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fluence of refugees from Europe and the urgent needs of war research, was rapidly developing. Throughout mathematics, ideas in their abstract form mattered. Our *Survey* was at hand and provided these ideas with examples. It soon became, and was for many years, the text of choice for an undergraduate course in algebra. We were fortunate to be there, young and enthusiastic, at the time when new views of algebra came to fruition. And these ideas are still there; Garrett and I were both pleased with the recent publication of the fifth edition of *Survey* (A. K. Peters, 1996).

We enjoyed teaching and writing algebra because it was clear, exciting, and fun to present. The book was prepared at a time when both of us were assistant professors, so without tenure. Yes, we did know then that research mattered for tenure, but our joy in teaching was somehow connected with our respective research. Also, the mathematics department at Harvard both emphasized research and expected all faculty members to be steadily active in teaching undergraduates. These responsibilities were in effect combined in our activity. Then and later we took part in the flow of new ideas from discovery to use and to present to students.

Garrett's own research was involved. It was then primarily in lattice theory and universal algebra. His original slim colloquium volume on lattice theory was later expanded to a much more comprehensive version, reflecting the growth in this field. During the war Garrett's interests grew to include hydrodynamics and other applied mathematics—with an occasional pause to prepare revised editions of *Survey*. On the fiftieth anniversary of its publication, the *Mathematical Intelligencer*, in its column "Years Ago", edited by Karen V. H. Parshall, gave a description of *Survey*, complete with pictures of the authors (vol. 14, no. 1, 1992, 26–31 pp.).

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The Many Lives of Lattice Theory

Gian-Carlo Rota

Introduction

Never in the history of mathematics has a mathematical theory been the object of such vociferous vituperation as lattice theory. Dedekind, Jónsson, Kurosh, Malcev, Ore, von Neumann, Tarski, and most prominently Garrett Birkhoff have contributed a new vision of mathematics, a vision that has been cursed by a conjunction of misunderstandings, resentment, and raw prejudice.

The hostility towards lattice theory began when Dedekind published the two fundamental papers that brought the theory to life well over one hundred years ago. Kronecker in one of his letters accused Dedekind of "losing his mind in abstractions," or something to that effect.

I took a course in lattice theory from Oystein Ore while a graduate student at Yale in the fall of 1954. The lectures were scheduled at 8 a.m., and only one other student attended besides me—María Wonenburger. It is the only course I have ever attended that met at 8 o'clock in the morning. The first lecture was somewhat of a letdown, beginning with the words: "I think lattice theory is played out" (Ore's words have remained imprinted in my mind).

For some years I did not come back to lattice theory. In 1963, when I taught my first course in combinatorics, I was amazed to find that lattice theory fit combinatorics like a shoe. The temptation is strong to spend the next fifty minutes on the mutual stimulation of lattice theory and combinatorics of the last thirty-five years. I will, however, deal with other aspects of lattice theory, those that were dear to Garrett Birkhoff and which bring together ideas from different areas of mathematics.

Lattices are partially ordered sets in which least upper bounds and greatest lower bounds of any two elements exist. Dedekind discovered that this property may be axiomatized by identities. A lattice is a set on which two operations are defined, called join and meet and denoted by $\vee$ and $\wedge$, which satisfy the idempotent, commutative and associative laws, as well as the absorption laws:

$$a \vee (b \wedge a) = a$$
$$a \wedge (b \vee a) = a.$$

Lattices are better behaved than partially ordered sets lacking upper or lower bounds. The contrast is evident in the examples of the lattice of partitions of a set and the partially ordered set of partitions of a number. The family of all partitions of a set (also called equivalence relations) is a lattice when partitions are ordered by refinement. The lattice of partitions of a set remains to this day rich in pleasant surprises. On the other hand, the partially ordered set of partitions of an integer, ordered by refinement, is not a lattice and is fraught with pathological properties.

Distributive Lattices

A distributive lattice is a lattice that satisfies the distributive law:

$$a \vee (b \wedge c) = (a \wedge b) \vee (a \wedge c).$$

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This article is based on an invited address delivered at the Garrett Birkhoff Memorial Conference, Harvard University, April 1, 1997.

For a long time a great many people believed that every lattice is distributive. This misunderstanding was finally cleared up when Garrett Birkhoff, in the early thirties, proved a fundamental theorem, which we summarize next.

There is a standard way of constructing distributive lattices. One takes all the order ideals of a partially ordered set P. An order ideal is a subset of P with the property that if $x \in P$ and $y \leq x$, then $y \in P$. Union and intersection of order ideals are order ideals. In other words, the set of all order ideals of a partially ordered set is a distributive lattice.

Garrett Birkhoff proved the converse of this statement: every finite distributive lattice is isomorphic to the lattice of order ideals of some partially ordered set. The resulting contravariant functor from the category of partially ordered sets to the category of distributive lattices, known as the "Birkhoff transform", provides a systematic and useful translation of the combinatorics of partially ordered sets into the algebra of distributive lattices.

The definitive generalization of Birkhoff's theorem to arbitrary distributive lattices was obtained in the sixties by Ann Priestley. Briefly, there is a nontrivial extension of the notion of topological space that takes order into account, defined by Leopoldo Nachbin in his thesis. Distributive lattices are represented as lattices of closed order ideals on such ordered topological spaces. Point set topology has been nontrivially extended to ordered topological spaces, but this extension has remained largely unknown. Dieudonné was taken with it after he read the copy of Nachbin's thesis that the author, working in total isolation, sent him from Rio de Janeiro. Dieudonné tried to drum up some interest in ordered topological spaces without success.

It is a miracle that families of sets closed under unions and intersections can be characterized solely by the distributive law and by some simple identities. Jaded as we are, we tend to take Birkhoff's discovery for granted and to forget that it was a fundamental step forward in mathematics.

Modular Lattices

Modular lattices are lattices that satisfy the following identity, discovered by Dedekind:

$$(c \wedge (a \vee b)) \vee b = (c \vee b) \wedge (a \vee b).$$

This identity is customarily recast in user-friendlier ways. Examples of modular lattices are lattices of subspaces of vector spaces, lattices of ideals of a ring, lattices of submodules of a module over a ring, and lattices of normal subgroups of a group. For example, in the lattice of subspaces of a vector space the meet of two subspaces is their set theoretic intersection, and the join of two subspaces is the subspace spanned by the two subspaces. Join and meet of linear varieties in projective space are algebraic renderings of projection and section of synthetic projective geometry. Synthetic projective geometry, relying as it does on axioms of incidence and refusing any appeal to coordinates, is best understood in the language of modular lattices.

But synthetic geometry acquired a bad name after algebraic geometers declared themselves unable to prove their theorems by synthetic methods. The synthetic presentation of geometry has become in the latter half of this century a curiosity, cultivated by Italians and by Professor Coxeter. Modular lattices were dismissed without a hearing as a curious outgrowth of a curiosity.

Garrett once described to me his first meeting with von Neumann. After exchanging a few words they quickly got down to their common interest in lattice theory, and von Neumann asked Garrett, "Do you know how many subspaces you get when you take all joins and meets of three subspaces of a vector space in general position?" Garrett immediately answered, "Twenty-eight!", and their collaboration began at that moment.

The free modular lattice with three generators, which indeed has twenty-eight elements, is a beautiful construct that is presently exiled from textbooks in linear algebra. Too bad, because the elements of this lattice explicitly describe all projective invariants of three subspaces.

One of Garrett's theorems on modular lattices states that the free modular lattice generated by two linearly ordered sets (or chains) is distributive. This result has been shamelessly restated without credit in disparate mathematical languages.

The core of the theory of modular lattices is the generalization of the theory of linear dependence of sets of vectors in a vector space to sets of linear subspaces of any dimension. Dilworth, Kurosh, Ore, and several others defined an extended concept of basis, and they established invariance of dimension and exchange properties of bases. The translation of their results into coordinate language is only now being carried out.

Two recent developments in modular lattices are:

First, the discovery of 2-distributive lattices by the Hungarian mathematician Andras Huhn. A 2-distributive lattice is a lattice that satisfies the identity

$$a \vee (x \wedge y \wedge z) =$$
$$(a \wedge (x \vee y)) \vee (a \wedge (x \vee y)) \vee (a \vee (y \wedge z)).$$

This improbable identity implies that the lattice is modular and much more. It has been shown by Bjarni Jónsson, J. B. Nation, and several others that 2-distributive lattices are precisely those lattices that are isomorphically embeddable into the lattice of subspaces of a vector space over any

field whatsoever, subject only to cardinality restrictions. Thus, 2-distributive lattices come close to realizing the ideal of a universal synthetic geometry, at least for linear varieties. They have a rich combinatorial structure.

Second, the theory of semiprimary lattices. These lattices were given their unfortunate name by Reinhold Baer, but, again, only recently has their importance been realized in the work of such young mathematicians as Franco Regonati and Glenn Tesler. Examples of semiprimary lattices are the lattice of subgroups of a finite Abelian group and the lattice of invariant subspaces of a nilpotent matrix. Semiprimary lattices are modular, and hence every element is endowed with a rank or dimension. However, the elements of semiprimary lattices are additionally endowed with a finer type of rank, which is a partitition of an integer, or a Young shape, as we say in combinatorics. For the lattice of subgroups of an Abelian group such a partition comes from the structure theorem for finite Abelian groups; for the invariant subspaces of nilpotent matrices the partition comes from the Jordan canonical form.

This finer notion of dimension leads to a refinement of the theory of linear dependence. One major result, due to Robert Steinberg, is the following. Consider a complete chain in a semi-primary lattice. Two successive elements of the chain differ by one dimension, but much more is true. As we wind up the chain, we fill a Young shape with integers corresponding to the positions of each element of the chain, and thus every complete chain is made to correspond to a standard Young tableau.

Now take two complete chains in a semiprimary lattice. It is easy to see that a pair of complete chains in a modular lattice determines a permutation of basis vectors. In a semiprimary lattice each of the two chains is associated with a standard Young tableau, hence we obtain the statement and proof of the Schensted algorithm, which precisely associates a pair of standard Young tableaux to every permutation.

Lattice of Ideals

Dedekind outlined the program of studying the ideals of a commutative ring by lattice-theoretic methods, but the relevance of lattice theory in commutative algebra was not appreciated by algebraists until the sixties, when Grothendieck demanded that the prime ideals of a ring should be granted equal rights with maximal ideals. Those mathematicians who knew some lattice theory watched with amazement as the algebraic geometers of the Grothendieck school clumsily reinvented the rudiments of lattice theory in their own language. To this day lattice theory has not made much of a dent in the sect of algebraic geometers; if ever it does, it will contribute new insights. One elementary instance: the Chinese remainder theorem. Necessary and sufficient conditions on a commutative ring are known that insure the validity of the Chinese remainder theorem. There is, however, one necessary and sufficient condition that places the theorem in proper perspective. It states that the Chinese remainder theorem holds in a commutative ring if and only if the lattice of ideals of the ring is distributive.

The theory of ideals in polynomial rings was given an abstract setting by Emmy Noether and her school. Noetherian rings were defined, together with prime and primary ideals, and fundamental factorization theorems for ideals were proved. It does not seem outrageous to go one step further in Dedekind's footsteps and extend these theorems to modular lattices. This program was initiated by Oystein Ore and developed by Morgan Ward of Caltech and by his student, Bob Dilworth. Dilworth worked at this program on and off all his life, and in his last paper on the subject, published in 1961, he finally obtained a lattice theoretic formulation of the Noetherian theory of ideals. I quote from the introduction of Dilworth's paper:

> The difficulty [of the lattice theory of ideals] occurred in treating the Noether theorem on decompositon into primary ideals. ... In this paper, I give a new and stronger formulation for the notion of a "principal element" and...prove a [lattice theoretic] version of the Krull Principal Ideal Theorem. Since there are generally many non-principal ideals of a commutative ring which are "principal elements" in the lattice of ideals, the [lattice theoretic] theorem represents a considerable strengthening of the classical Krull result.

Forgive my presumptuousness for making a prediction about the future of the theory of commutative rings, a subject in which I have never worked. The theory of commutative rings has been torn by two customers: number theory and geometry.

Our concern here is the relationship between commutative rings and geometry, not number theory. In the latter part of this century algebra has so overwhelmed geometry that geometry has come to be viewed as a mere "façon de parler". Sooner or later geometry in the synthetic vein will reassert its rights, and the lattice theory of ideals will be its venue. We intuitively feel that there is a geometry, projective, algebraic, or whatever, whose statements hold independently of the choice of a base field. Desargues's theorem is the simplest theorem of such a "universal" geometry. A new class of commutative rings remains to be discovered that will be completely determined by their lattice of ideals. Von Neumann found a class of noncom-

mutative rings that are determined by their lattices of ideals, as we will shortly see, but the problem for commutative rings seems more difficult. A first step in this direction was taken by Hochster. Algebraic geometry done with such rings might be a candidate for "universal geometry".

Commutative rings set the pace for a wide class of algebraic systems in the sense of Garrett Birkhoff's universal algebra. The lattice of congruences of an algebraic system generalizes the lattice of ideals, and this analogy allows us to translate facts about commutative rings into facts about more general algebraic systems. An example of successful translation is the Chinese remainder theorem in its lattice theoretic formulation, which has been proved for general algebras. The work of Richard Herrmann and his school has gone far in this direction. In view of the abundance of new algebraic structures that are being born out of wedlock in computer science, this translation is likely to bear fruit.

Linear Lattices

Having argued for modular lattices, let me now argue against them.

It turns out that all modular lattices that occur in algebra are endowed with a richer structure. They are lattices of commuting equivalence relations. What are commuting equivalence relations?

Two equivalence relations on a set are said to be independent when every equivalence class of the first meets every equivalence class of the second. This notion of independence originated in information theory and has the following intuitive interpretation. In the problem of searching for an unknown element, an equivalence relation can be viewed as a question whose answer will tell to which equivalence class the unknown element belongs. Two equivalence relations are independent when the answer to either question gives no information on the possible answer to the other question.

Philosophers have gone wild over the mathematical definition of independence. Unfortunately, in mathematics philosophy is permanently condemned to play second fiddle to algebra. The pairs of equivalence relations that occur in algebra are seldom independent; instead, they satisfy a sophisticated variant of independence that has yet to be philosophically understood—they commute.

Two equivalence relations are said to commute when the underlying set may be partitioned into disjoint blocks and the restriction of the pair of equivalence relations to each of these blocks is a pair of independent equivalence relations. In other words, two equivalence relations commute when they are isomorphic to disjoint sums of independent equivalence relations on disjoint sets.

Mme. Dubreil found in her 1939 thesis an elegant characterization of commuting equivalence relations. Two equivalence relations on the same set commute whenever they commute in the sense of composition of relations, hence the name.

The lattice of subspaces of a vector space is an example of a lattice that is naturally isomorphic to a lattice of commuting equivalence relations on the underlying vector space viewed as a mere set. Indeed, if W is a subspace of a vector space V, one defines an equivalence relation on the set of vectors in V by setting $x \equiv_W y$ whenever $x - y \in W$. Meet and join of subspaces are isomorphic to meet and join of the corresponding equivalence relations in the lattice of all equivalence relations on the set V. The lattice of subspaces of a vector space V is isomorphic to a sublattice of the lattice of all equivalence relations on the set V, in which any two equivalence relations commute.

Similar mappings into lattices of commuting equivalence relations exist for the lattice of all ideals of a ring and the lattice of all submodules of a module. Mark Haiman has proposed the term "linear lattice" for lattices of commuting equivalence relations.

Schützenberger found an identity satisfied in certain modular lattices that is equivalent to Desargues's theorem. Not long afterwards, Bjarni Jónsson proved that every linear lattice satisfies Schützenberger's identity. At that time the problem arose of characterizing linear lattices by identities. This brings us to two notable theorems Garrett proved in universal algebra.

The first of Birkhoff's theorems characterizes categories of algebraic systems which can be defined by identities. These are precisely those categories of algebraic systems that are closed under the three operations of products, subalgebras, and homomorphic images. For example, groups and rings can be characterized by identities, but fields cannot, because the product of two fields is not a field. There are algebraic systems which are known to be definable by identities because they have been shown to satisfy the three Birkhoff conditions but for which the actual identities are not known.

The second of Birkhoff's theorems states that a category of algebraic systems is endowed with "free algebras" if and only if it is closed under products and subalgebras.

The category of linear lattices is closed under products and sublattices, so that the free linear lattice on any set of generators exists. A thorough study of free linear lattices, revealing their rich structure, was carried out by Gelfand and Ponomarev in a remarkable series of papers. Their results are so stated as to apply both to modular and to linear lattices. The free linear lattice in n generators is intimately related to the ring of invariants of a set of n subspaces in general position in projective space. Gelfand has conjectured that the free linear lattice in four generators is decidable. Recently an explicit set of generators for the ring

of invariants of a set of four subspaces in projective space has been given by Howe and Huang; Gelfand's conjecture is the lattice theoretic analog and is thus probably true.

It is not known whether linear lattices may be characterized by identities. Haiman has proved that linear lattices satisfy most of the classical theorems of projective geometry, such as various generalizations of Desargues's theorem, and he proved that not even these generalized Desarguian conditions suffice to characterize linear lattices.

The deepest results to date on linear lattices are due to Haiman, who in his thesis developed a proof theory for linear lattices. What does such a proof theory consist of? It is an iterative algorithm performed on a lattice inequality that splits the inequality into subinequalities by a tree-like procedure and eventually establishes that the inequality is true in all linear lattices, or else it automatically provides a counterexample. A proof theoretic algorithm is at least as significant as a decision procedure, since a decision procedure is merely an assurance that the proof theoretic algorithm will eventually stop.

Haiman's proof theory for linear lattices brings to fruition the program that was set forth in the celebrated paper "The logic of quantum mechanics", by Birkhoff and von Neumann. This paper argues that modular lattices provide a new logic suited to quantum mechanics. The authors did not know that the modular lattices of quantum mechanics are linear lattices. In light of Haiman's proof theory, we may now confidently assert that Birkhoff and von Neumann's logic of quantum mechanics is indeed the long-awaited new "logic" where meet and join are endowed with a logical meaning that is a direct descendant of "and" and "or" of propositional logic.

Lattice Theory and Probability

One of the dramas of present-day mathematics is the advent of noncommutative probability. Lattice theoretically, this drama is a game played with three lattices: the lattice of equivalence relations, Boolean algebras, and various linear lattices that are threatening to replace the first two.

Classical probability is a game of two lattices defined on a sample space: the Boolean σ-algebra of events and the lattice of Boolean σ-subalgebras.

A σ-subalgebra of a sample space is a generalized equivalence relation on the sample points. In a sample space the Boolean σ-algebra of events and the lattice of σ-subalgebras are dual notions, but whereas the Boolean σ-algebra of events has a simple structure, the same cannot be said of the lattice of σ-subalgebras. For example, we understand fairly well measures on a Boolean σ-algebra, but the analogous notion for the lattice of σ-subalgebras—namely, entropy—is poorly understood.

Stochastic independence of two Boolean σ-subalgebras is a strengthening of the notion of independence of equivalence relations. Commuting equivalence relations also have a stochastic analog, which is best expressed in terms of random variables. We say that two σ-subalgebras, Σ_1 and Σ_2, commute when any two random variables X_1 and X_2 defining the σ-subalgebras Σ_1 and Σ_2 are conditionally independent. Catherine Yan has studied the probabilistic analog of a lattice of commuting equivalence relations: namely, lattices of nonatomic σ-subalgebras, any two of which are stochastically commuting. There are stochastic processes where all associated σ-subalgebras are commuting in Yan's sense, for example, Gaussian processes.

In a strenuous tour de force, Catherine Yan has developed a proof theory for lattices of nonatomic commuting σ-subalgebras. Her theory casts new light on probability. It is also a vindication of Dorothy Maharam's pioneering work in the classification of Boolean σ-algebras.

The portrait of noncommutative probability is at present far from complete. Von Neumann worked hard at a probabilistic setting for quantum mechanics. His search for a quantum analog of a sample space led him to the discovery of continuous geometries. These geometries are similar to projective spaces, except that the dimension function takes all real values between zero and one. Von Neumann characterized continuous geometries as modular lattices and showed that noncommutative rings can be associated with continuous geometries which share properties of rings of random variables, in particular that there is the analog of a probability distribution.

Sadly the applications of continuous geometries have hardly been explored; allow me to stick my neck out and mention one possible such application. It is probable that some of the attractive q-identities that are now being proved by representation theoretic methods can be given a "bijective" interpretation in continuous geometries over finite fields. I have checked this conjecture only for the simplest q-identities.

The triumph of von Neumann's ideas on quantum probability is his hyperfinite factor, which unlike Hilbert space has a modular lattice of closed subspaces. For a long time I have wondered why quantum mechanics is not done in the hyperfinite factor rather than in Hilbert space. Philosophically, probability in a hyperfinite factor is more attractive than ordinary probability, since the duality between events and σ-subalgebras is replaced by a single modular lattice that plays the role of both. On several occasions I have asked experts in quantum mechanics why the hyperfinite factor has been quietly left aside, and invariably I received evasive answers. Most likely, physicists and mathematicians needed some fifty years of train-

ing to grow accustomed to noncommutative probability, and only now are the tables beginning to turn after the brilliant contributions to noncommutative geometry and noncommutative probability by Alain Connes and Dan Virgil Voiculescu.

Other Directions

It is heartening to watch every nook and cranny of lattice theory coming back to the fore after a long period of neglect. One recent instance: MacNeille, a student of Garrett's, developed a theory of completion by cuts of partially ordered sets, analogous to Dedekind's construction of the real numbers. His work was viewed as a dead end until last year, when Lascoux and Schützenberger, in their last joint paper, showed that MacNeille's completion neatly explains the heretofore mysterious Bruhat orders of representation theory.

Two new structures that generalize the concept of a lattice should be mentioned in closing. First, Tits buildings. It is unfortunate that presentations of buildings avoid the lattice theoretic examples, which would display the continuity of thought that leads from lattices to buildings.

Second, Δ-matroids, due to Kung, and developed by Dress, Wentzel, and several others. Garrett Birkhoff realized that Whitney's matroids could be cast in the language of geometric lattices, which Garrett first defined in a paper that appeared right after Whitney's paper in the same issue of the *American Journal*. Roughly, Δ-matroids are to Pfaffians as matroids are to determinants. Δ-matroids call for a generalization of lattices that remains to be explored.

These developments, and several others that I have not mentioned, are a belated validation of Garrett Birkhoff's vision, which we learned in three editions of his *Lattice Theory*, and they betoken Professor Gelfand's oft-repeated prediction that lattice theory will play a leading role in the mathematics of the twenty-first century.

Garrett Birkhoff and Applied Mathematics

David M. Young

Introduction

Garrett Birkhoff contributed to many areas of mathematics during his long and distinguished career. He is, of course, very well known for his work in algebra and in lattice theory. However, in this article we will focus on his work in applied mathematics, including the numerical solution of elliptic partial differential equations, reactor calculations and nuclear power, and spline approximations. We will also give a very brief discussion of his work on fluid dynamics. Additional information on Birkhoff's work in applied mathematics can be found in many of the publications listed below; see especially [11].

The author gratefully acknowledges the contributions of Richard Varga and Carl de Boor. Varga contributed the section entitled "Reactor Calculations and Nuclear Power", and de Boor contributed the section entitled "Spline Approximations".

The Numerical Solution of Elliptic Partial Differential Equations

In this section we describe two aspects of Birkhoff's work on the numerical solution of elliptic partial differential equations (PDE), his role in the automation of "relaxation methods", and his work on the dissemination of information on the numerical selection of elliptic PDE. Additional work of Birkhoff in this area is described in the section entitled "Reactor Calculations and Nuclear Power".

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The Automation of Relaxation Methods

With the advent of high-speed computers in the 1940s Birkhoff became very interested in their possible use for obtaining numerical solutions to problems involving elliptic PDE. Many such problems could be "reduced", by the use of finite difference methods, to the solution of a (usually) large system of linear algebraic equations where the matrix was very sparse. However, because of the relatively low speeds and the very limited memory sizes of computers which were then available, the direct solution of such systems was usually out of the question.

On the other hand, many such large linear systems were actually being solved by R. V. Southwell and his associates in England using relaxation methods and without using computers; see [39]. Relaxation methods involve first choosing an initial guess for the unknown solution, u, at each grid point and then computing at each point the "residual", i.e., a number which measures the amount by which the linear equation for that point fails to be satisfied. One can eliminate, or "relax", the residual at a given grid point by suitably modifying the value of u at that point. (If one "overcorrects" or "overrelaxes", then the sign of the residual is changed.) Of course the residuals at nearby grid points are also changed when the value of u at a particular grid point is changed. By repeated use of relaxation a skilled person could soon achieve a situation where all of the residuals were very small and where the values of u at the grid points provided a satisfactory solution to the problem.

In the late 1940s when I asked Birkhoff for a thesis topic, he suggested that I work on the

"automation" of relaxation methods. Actually there was already a systematic iteration procedure available, namely, the "Liebmann method" [34] (which is a special case of the Gauss-Seidel method). However, the Liebmann method is often exceedingly slow. Another method that was available at the time was Richardson's method [36]. This method involves the use of a number of parameters. However, at the time it was not obvious how the parameters should be chosen. (It was discovered later that by a suitable choice of the parameters, which could be found using Chebyshev polynomials, one could obtain very rapid convergence; see, e.g., [38] and [43].)

Largely as a result of the stimulus, encouragement, and many useful suggestions provided by Birkhoff, I was able to develop a method which is now called the "successive overrelaxation" (SOR) method and which is described in [41, 42]. (The SOR method was developed independently by Frankel [31], who called it the "extrapolated Liebmann" method.) The SOR method provides an order-of-magnitude improvement in convergence as compared to the Gauss-Seidel method for many linear systems corresponding to the numerical solution of elliptic PDE. Thus, for a class of problems corresponding to the Dirichlet problem the number of iterations required for convergence with the SOR method is proportional to h^{-1}, where h is the grid size, as compared with h^{-2} as required with the Gauss-Seidel method.

The SOR method, with generalizations, modifications, and extensions (see, e.g., Varga [40]), was used extensively for engineering and scientific computations for many years. Eventually it was superseded by other methods, such as preconditioned conjugate gradient methods and methods based on the use of Chebyshev polynomials.

Further discussion of Birkhoff's role in the automation of relaxation methods can be found in [11].

Dissemination of Information on the Numerical Solution of Elliptic PDE

Birkhoff was very active in the dissemination of information on the numerical solution of elliptic PDE. This activity included the preparation of a book with Robert Lynch (see [16]) and playing a leading role in the arranging of two conferences on "Elliptic Problem Solvers". The first of these conferences was held in Santa Fe in 1980 and led to a publication; see [37]. The second conference was held in Monterey in 1982 and also led to a publication; see [20].

The book with Lynch provides an excellent survey of many topics, including formulations of typical elliptic problems and classical analysis, difference approximations, direct and iterative methods, variational methods, finite element methods, integral equation methods, and a description of the ELLPACK software package. The book contains a wealth of information and is recommended reading for anyone interested in working in this area.

The two conferences provided, among other things, forums for discussions about the ELLPACK software package that was being developed at Purdue University by John Rice and his associates. Contributions to ELLPACK were made by a number of other institutions. For example, several iterative programs were contributed by The University of Texas.

David Kincaid and David Young, who directed the development at The University of Texas of the ITPACK software package for solving large sparse linear systems by iterative methods, regard Birkhoff as the "godfather" of the project. For several years he had been patiently but seriously suggesting that such a package be developed. The implementation of his idea was delayed in part by uncertainty as to how to choose the iteration parameters, such as omega for the SOR method, and how to decide when to terminate the iteration process. Eventually, as described in the book by Hageman and Young [32] and in the paper by Kincaid et al. [33], these and other obstacles were largely overcome and the ITPACK software package was completed.

Reactor Calculations and Nuclear Power

Garrett Birkhoff was intimately associated with reactor computations which played an essential role in the design of nuclear power reactors. This arose primarily from his role as a consultant to the Bettis Atomic Power Laboratory from 1955 through the early 1960s.

As a brief background, analytical models of nuclear reactors were brand new in the early 1950s, unlike the case of analytical fluid dynamics, which had enjoyed two hundred years of development. Fortuitously, high-powered digital computers were also making their appearance in the early 1950s. Because building full-scale nuclear reactors was both expensive and very time consuming, it was prudent and farsighted then to look to digital computers to numerically solve the associated nuclear reactor models. Even more fortuitous was the simultaneous emergence in 1950 of David M. Young's thesis [41], which contained an analytic treatment of the SOR iterative method for numerically solving second-order elliptic boundary problems.

In that exciting period when nuclear reactors were first being considered for naval ships, Bettis hired in 1954 five new Ph.D.s—Harvey Amster, Elis Gelbard, and Stanley Stein in physics, and Jerome Spanier and Richard Varga in mathematics—all of whom made contributions to various aspects of nuclear reactor theory. There is no doubt that detailed discussions with the energetic consultant, Garrett Birkhoff, helped solidify many of their emerging ideas. Garrett loved the challenge

of working in new research areas, and his enthusiasm was infectious!

But Garrett's contributions to reactor theory and reactor computations were much more than just the random discussions of a consultant with Bettis people. Three solid contributions of his stand out. Early on he saw the relevance of nonnegative matrices (or, more generally, operators which leave a cone invariant) to nuclear reactor theory, and this can be seen in his publications [3] and [21]. In the latter paper the now well-known terms *essentially nonnegative* and *essentially positive* matrices, as well as *supercritical*, *critical*, and *subcritical* multiplicative processes, were first introduced. Second, while SOR-type iterative methods were being used for solving reactor problems at Bettis, alternating-direction (implicit), or ADI, iterative methods were similarly used for solving reactor problems at the Knolls Atomic Power Laboratory. The superiority of ADI iterative methods over the SOR method had been shown by Peaceman and Rachford [35] and by Douglas and Rachford [30], both for special Laplace-type problems in a rectangle. Garrett observed, in a classroom lecture at Harvard University, that the *commuting nature* of certain matrices may not hold in regions other than a rectangle, a property implicitly used in [30] and in [35]. This observation was the impetus for two research papers, [22] and [28], where many positive and negative results for such ADI schemes were presented.

Garrett was also very much interested in *semi-discrete* approximations of time-dependent problems, such as the heat-conduction equation; here "semi-discrete" means that time remains a continuous variable while other variables, usually the space variables, are discretized. This was researched in his paper [28], where Padé approximations to the function $\exp(z)$ were connected with time-stepping schemes for parabolic-like partial differential equations.

In no uncertain terms, Garrett Birkhoff, through his own research and his collaboration with others, left an indelible mark on nuclear reactor theory.

Spline Approximation

Birkhoff materially influenced the early development of spline theory and practice through his consulting work for General Motors Research. This work started in 1959 when General Motors decided that perhaps widespread use of nuclear energy was not just around the corner and needed some other useful problems for some of the members of its Nuclear Engineering Department to work on. One of the problems posed was the mathematical representation of automobile surfaces in order to exploit the recently developed numerically controlled milling machines for the cutting of dies needed for the stamping of outer and inner panels. The idea was to determine the free parameters in a suitably flexible mathematical model so as to fit closely to measurements taken from the finished physical model of the car. There was also the hope that eventually the design process itself could be carried out entirely on computers.

Birkhoff was quick to recommend the use of cubic splines (i.e., piecewise cubic polynomial functions with two continuous derivatives) for the representation of smooth curves. He was familiar with their use in naval design through his contact with the David Taylor Model Basin, and he also knew of their use at Boeing through a report written by MacLaren. Furthermore, in joint work with Henry Garabedian (see [14]) he developed what we would now call a four-mode, twelve-parameter C^1 macro finite element consisting of eight harmonic polynomial pieces, as a bivariate generalization of cubic spline interpolation, capable of interpolating a C^1 surface to a given rectangular mesh of cubic splines. This method eventually led de Boor to the now standard method of bicubic spline interpolation.

Subsequently, W. J. Gordon of General Motors Research developed the technique of spline blending for fitting smooth surfaces to an arbitrary (rectangular) smooth mesh of curves. This method too has become standard. Some mathematical aspects of blending are taken up in [15].

Birkhoff observed that the cubic spline is a good approximation to the draftsman's (physical) spline only when the latter is nearly flat. He contributed to the mathematical understanding of a more accurate model of the latter; see [26]. His insight into mechanics also made it obvious to him that a cubic spline which vanishes at all its modes must necessarily have exponential growth in at least one direction. The resulting paper [12] on the error in cubic spline interpolation was the first one to demonstrate and make use of the exponential decay of the fundamental functions of spline interpolation for "reasonable" breakpoint sequences.

The survey paper [13] provides a very good record for the many and wide-ranging suggestions concerning interpolation and approximation to univariate and bivariate data which Birkhoff made in those early days.

Somewhat later, in [4], a paper on local spline approximation by moments, Birkhoff proposed what is probably the first spline quasi-interpolant, i.e., a method of approximation that is local, stable, and aims only at reproducing all polynomials of a certain degree (rather than at matching function values).

Birkhoff's method is now treated as a special case of the de Boor-Fix quasi-interpolant. Already the above-mentioned survey contains detailed ideas about the use of splines in the numerical solution of integral and differential equations. The case of eigenvalue calculations for second-order

ordinary differential equations via the Rayleigh-Ritz method is worked out in detail in [27], while the use of tensor-product splines in the numerical solution of partial differential equations is examined in [29] and in other work by Schultz. Since rectangular meshes cannot handle all practically important situations, Birkhoff also investigated splines on triangular meshes in [8, 1, 17]. The theme of multivariate interpolation was taken up one more time, but this time by Birkhoff the algebraist in [9].

Numerical Fluid Dynamics

In this section a very brief discussion of Birkhoff's work in numerical fluid dynamics will be given. For additional information the reader should see his two books, which are cited below, as well as his survey article [10].

Birkhoff worked extensively in numerical fluid dynamics, especially from the middle 1940s to the late 1950s. He was greatly influenced by the work of John von Neumann in fluid dynamics and in the then-emerging field of high-speed computing.

In 1981 Birkhoff was invited to give the John von Neumann lecture at the SIAM meeting in Troy, New York. This lecture led to the publication of a very informative survey article in numerical fluid dynamics; see [10].

It seems truly unfortunate that Birkhoff will not be around to witness the many advances in numerical fluid dynamics which will undoubtedly take place in the next twenty-five to fifty years and which in many cases will benefit from his ideas.

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The Mathematics of F. J. Almgren Jr.

Brian White

Frederick Justin Almgren Jr., one of the world's leading geometric analysts and a pioneer in the geometric calculus of variations, began his graduate work at Brown in 1958. It was a very exciting place and time for geometric measure theory. Wendell Fleming had just arrived and begun his collaboration with Herbert Federer, leading to their seminal paper "Normal and Integral Currents" in 1960 [19]. Among the major results in "Normal and Integral Currents" was a compactness theorem which implied existence of k-dimensional rectifiable area minimizing varieties with prescribed boundaries in $\mathbf{R}^n$. (Similar existence theorems were proved independently by Reifenberg and, in case $n = k + 1$, by De Giorgi.) Shortly afterward, Fleming (using earlier work of Reifenberg) proved that if $k = 2$ and $n = 3$, then the varieties are in fact smooth surfaces. Meanwhile De Giorgi (and subsequently, by a different argument, Reifenberg) did work implying that the varieties were smooth almost everywhere when $n = k + 1$, the case of hypersurfaces.

Fred came to Brown with an unusual background. He had just spent three years as a Navy pilot, and before that his undergraduate degree at Princeton had been not in mathematics but in engineering. In fact, as an undergraduate he took only three math courses: two semesters of honors calculus and one semester of differential equations and infinite series. Later he would jokingly accuse various mathematicians at Brown of calling him "the most ignorant person" that they had ever met.

"It was clear that he had great raw talent and good intuition," says Federer, "but indeed he knew very little mathematics then. There were even basic things in group theory, for example, that he had never heard of. When he asked me to be his advisor, I suggested the problem I did because he didn't know enough analysis for most problems in geometric measure theory."

Federer suggested a problem that was as much topological as measure theoretic. Four years earlier Dold and Thom had shown that there was a natural isomorphism between the homology groups of a compact manifold M and the homotopy groups of their associated symmetric product spaces. Federer realized that this could be interpreted as a statement about the homotopy groups of the space of 0-dimensional integral cycles of M. He conjectured a generalization to k-dimensional cycles, namely, that the mth homotopy group of the space of integral k-cycles in M is naturally isomorphic to the $(m+k)$th homology group of M. Almgren's thesis, published in the first volume of the journal *Topology* [2], proved that this was indeed the case.

Oddly enough, its publication caused trouble. Almgren was supposed to sign the copyright of his thesis over to Brown University, but could not since he had already signed it over to *Topology*. To the dean that meant Almgren could not graduate.

Brian White, the eighth of Fred Almgren's doctoral students, received his Ph.D. in 1982. After a two-year postdoctoral fellowship at the Courant Institute in New York he went to Stanford University, where he is a professor of mathematics. His e-mail address is white@math.stanford.edu.

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Federer actually had to go before the graduate council to have the dean overruled.

After his Ph.D., Almgren took a position at Princeton University. There he remained for the rest of his life, even taking most of his leaves of absence at the Princeton Institute for Advanced Study, though he attended conferences and made summer visits to institutes throughout the world.

After Almgren finished his thesis Federer suggested that he develop a Morse theory for minimal varieties, analogous to the well-developed theory of closed geodesics. In particular, although the Federer-Fleming paper proved existence of area-minimizing varieties (integral currents) in homology classes of compact Riemannian manifolds, there were no theorems asserting the existence of unstable minimal varieties.

Almgren's *Topology* result was a step in that direction, but it was not sufficient. Although the integral currents introduced by Federer and Fleming had proved to be ideally suited to the problem of minimizing area, they were not so suitable for problems in which the solutions are unstable critical points of the area functional. This is, in part, because the area functional is not continuous, but merely lower-semicontinuous on the space of integral currents. To prove the existence of a minimum, lower-semicontinuity suffices. But if one wishes to prove existence of a critical point by a mountain pass lemma, having only lower semicontinuity poses difficulties.

To handle these difficulties, Almgren turned to the class of surfaces that he called integral varifolds.[1] The area functional is continuous (with respect to weak convergence) on the space of integral varifolds, and he was able to carry out a Morse theory with them. In particular, he proved that every compact m-manifold contains stationary integral varifolds of each dimension less than m. He also proved a compactness theorem for integral varifolds. (The Banach-Alaoglu theorem trivially implies a compactness theorem for all varifolds, but the compactness for integral varifolds is quite subtle.) He also proved a striking isoperimetric inequality for stationary integral varifolds. All this was done in Almgren's 1965 *Theory of Varifolds*, mimeographed lecture notes that amazingly were never published. The work, extended and streamlined by Allard, was—with Almgren's encouragement—eventually published together with Allard's celebrated regularity theorem for integral stationary varifolds in [1].

[1] *Essentially the same class of surfaces had been introduced in 1951 by L. C. Young under the name "generalized surfaces" [30]. That term is perhaps confusing since there are many other generalizations of the familiar notion of surface: integral currents, integral flat chains, normal currents, real flat chains, flat chains mod p, and so on. Indeed, Young himself had first used the term "generalized surface" in a somewhat different context [29].*

So far the tremendous advances that had been made in the higher-dimensional calculus of variations had been limited to the area functional. In his 1968 paper [4] Almgren introduced the class of parametric elliptic functionals and (extending the techniques pioneered by De Giorgi) proved the fundamental regularity theorem: if a minimizing surface is weakly close to a multiplicity one disk, then it is smooth near the center of the disk. This implies that minimizing surfaces are smooth almost everywhere (if multiplicity is not counted) or on an open dense set (if multiplicity is counted).

Robert Hardt proved the analog of Almgren's theorem for boundary points [21]. Many years later, Bombieri [12] and Schoen and Simon [24] gave different proofs of Almgren's theorem, replacing some of Almgren's barehanded geometric constructions by more standard PDE techniques. However, the later proofs are limited to oriented surfaces, whereas Almgren's is not. Almgren's regularity theorem is used in almost all subsequent work on parametric elliptic functionals.

Soap-Film-Like Surfaces

Almgren's next major work on regularity was his 1975 monograph, *Existence and regularity almost everywhere of solutions to elliptic variational problems with constraints* [5]. There were two major new features.

The first was that it developed a regularity theory for sets rather than currents. The theory of integral currents, as well as the classical theory of Douglas and Rado, can be regarded as providing solutions to Plateau's problem. But neither theory very accurately models soap films and soap bubbles, which were what Plateau actually studied. For example, the classical Douglas-Rado solutions are sometimes immersed, which real soap films never are. Conversely, soap films display types of singularities that are present neither in the Douglas-Rado minimal surfaces nor in mass-minimizing integral currents. (Reifenberg's theory modeled soap films rather well, but Almgren wanted to handle soap bubbles as well as films and arbitrary elliptic functionals, not just the area functional.) The difficulty with currents, as Almgren saw it, was that they had structure that the physical surfaces did not. "In this paper," he wrote, "we do not wish to assume the existence of a boundary operator...because in many of the geometric, physical, and biological phenomena to which the results and methods [of this paper] are applicable there seems to be no natural notion of such a boundary operator."

The lack of a boundary operator meant that comparison surfaces could no longer be constructed by cut-and-paste operations. Instead, all comparison surfaces had to be obtained by (not necessarily one-to-one) Lipschitz deformations of the original surface. This limitation meant that

proofs were rather cumbersome compared to those in Almgren's earlier work on elliptic regularity.

The second major new feature of the paper is the extremely useful idea of surfaces that "almost" minimize a functional. Given an elliptic functional F, in addition to the basic problem of finding a surface that minimizes F, there are many closely related problems of interest: minimize F among surfaces enclosing a specified volume, or among surfaces in a Riemannian manifold (rather than in $\mathbf{R}^N$), or among surfaces that avoid a specified smooth obstacle, etc. Almgren realized that a solution surface S to any one of these problems must be what he called "(F, ϵ, δ)-minimizing". Roughly speaking, the portion of S in a small ball has F-energy close to the smallest possible F-energy (ignoring volume constraints, obstacles, etc.); the smaller the ball, the closer the F-energy to the minimum possible.

Consider, for example, a circle and the length functional: a small arc of the circle comes close to minimizing length in that the ratio of its arc-length to the chord is only slightly greater than one, and indeed the ratio tends to one as the length tends to 0.

It turns out that the fundamental regularity theorem (a minimizing surface weakly near a multiplicity one disk is regular near the center of the disk) for minimizing surfaces is also true and only slightly more difficult to prove for (F, ϵ, δ)-minimizing surfaces. (Here regular means $C^{1,\alpha}$ for a suitable $\alpha > 0$.) Thus Almgren simultaneously handled the various problems mentioned above.

A special case of the results in Almgren's monograph is the existence and almost-everywhere regularity of surfaces in $\mathbf{R}^3$ that accurately model physical soap films and soap bubble clusters. Jean Taylor wrote a thesis [25] leading to her celebrated 1976 theorem [26] that Almgren's soap-bubble-like surfaces do indeed have exactly the structure described by Plateau: they consist of smooth surfaces which meet in threes along smooth curves, which in turn meet in fours at isolated points. Almgren and Taylor described their work in a beautiful *Scientific American* article [9] on the physics and mathematics of soap films.

Surfaces of Higher Codimension

In the early 1970s very little was known about regularity of mass-minimizing surfaces of codimension greater than one. The singular set of such an m-dimensional surface was known to be closed and nowhere dense, but it was not known to have m-dimensional measure 0. Around 1974 Almgren started on what would become his most massive project, culminating ten years later in a three-volume, 1,700-page proof that the singular set not only has m-dimensional measure 0 but in fact has dimension at most $(m-2)$ [6]. This dimension is optimal, since by an earlier result of Federer there are many examples in which the dimension of the singular set is exactly $(m-2)$. Sheldon Chang, Almgren's eleventh Ph.D. student, proved in his 1986 thesis that for the case $m = 2$ the singular set is not only 0-dimensional (which some cantor sets are) but is locally finite away from the boundary [15].

The reader may wonder why Almgren's theorem is so much more complicated than all the regularity results that preceded it. Perhaps the most fundamental difference is the following. For the various surfaces (e.g., mass-minimizing hypersurfaces, size-minimizing surfaces, mass-minimizing surfaces mod 2) in which almost everywhere regularity was already known, one can determine whether a point is a regular point just by examining its tangent cone: the point is regular if and only if it has a plane as a tangent cone.

For mass-minimizing surfaces of higher codimension, this is no longer true. Suppose, for example, that a two-dimensional mass-minimizing surface has as a tanget cone (at a certain point) a plane with multiplicity 2. The point could be a regular point, namely, part of a smooth multiplicity 2 surface, or it could be a singular branch point (such as the origin in the surface $\{(z^2, z^3) : z \in \mathbf{C}\} \subset \mathbf{C}^2 \cong \mathbf{R}^4$).

Thus the problem is multiplicity. If a tangent cone is a plane with multiplicity one, the standard regularity theory applies. In codimension 1, multiplicity is not a problem: an integral current weakly close to a multiplicity k disk can be decomposed into layers (from top to bottom), each of which is close to the same disk with multiplicity 1. But in codimension greater than 1, such decomposition is impossible because there is no appropriate analog of "top" and "bottom".

To get an idea of how subtle Almgren's theorem is, imagine an m-dimensional mass-minimizing surface consisting of two distinct smooth pieces which intersect and are tangent to each other along a set S. Almgren's theorem asserts in this case that the set S has dimension $\leq (m-2)$, and thus it can be regarded as a delicate unique continuation theorem. Now imagine that the two pieces are actually joined by infinitely many little handles near S. The surface can no longer be locally represented by graphs of functions solving a PDE, but the same conclusion about S has to be reached.

The enormity of Almgren's paper has deterred all but a few people from reading very much of it. Nevertheless, some ideas from it have begun to have an impact. For a description of some of those ideas, see [28]. See [16] for a short overview of the proof.

The Isoperimetric Inequality

Almgren discovered several beautiful theorems relating to the classical isoperimetric inequality. The classical inequality states that if S is a closed

k-dimensional surface in $\mathbf{R}^{k+1}$ and if M is the region bounded by S, then

$$\mathcal{H}^{k+1}(M) \le c_k \mathcal{H}^k(S)^{1+\frac{1}{k}} \tag{1}$$

with the constant c_k chosen so that equality holds if S is a sphere. (Here $\mathcal{H}^k$ denotes k-dimensional Hausdorff measure: length if $k = 1$, area if $k = 2$, and so on.)

In their 1960 paper "Normal and Integral Currents" [19] Federer and Fleming proved a beautiful generalization to k-dimensional surfaces in $\mathbf{R}^n$. Of course, if $n > k+1$, there will be many $(k+1)$-dimensional surfaces bounded by S. Federer and Fleming proved that for any S there exists a surface M bounded by S for which essentially the same inequality still holds, though their proof did not give the best constant c_k. Of course, one may as well take M to be the least area surface with boundary S. Thus their isoperimetric inequality can be stated as follows: if M is a $(k+1)$-dimensional mass-minimizing integral current in $\mathbf{R}^n$ with boundary S, then

$$\text{mass}\,(M) \le c_{k,n}(\,\text{mass}\,(S))^{1+\frac{1}{k}}. \tag{2}$$

Almgren's first discovery along these lines was his beautiful 1965 proof ([3], [1], §7) that (2) is true (possibly with a worse constant) not only for minimizing surfaces M but also for surfaces that are merely stationary for the area functional. (To say that M is stationary means that it satisfies the first-derivative test for minima: if we deform M, then the initial derivative of area is 0.) In particular, it applies to any smooth surface M whose mean curvature is 0 at every point.

The value of the best constants in these isoperimetric inequalities remained open for sixteen years after the Federer-Fleming paper was published. Then in 1986 Almgren published a beautiful proof [7] that the best constant for the Federer-Fleming inequality (2) is the same as for the classical isoperimetric inequality. Thus among all $(k+1)$-dimensional mass-minimizing integral currents of a given mass, a ball in $\mathbf{R}^{k+1}$ of the appropriate radius has the smallest possible boundary mass.

One ingredient of Almgren's proof is the following fact (which is quite interesting in its own right, even for smooth surfaces): if S is any closed k-dimensional surface with mean curvature everywhere bounded above by k, then the area of S is greater than or equal to the area of the unit k-sphere $\partial\mathbf{B}^{k+1}$, with equality if and only if S is isometric to $\partial\mathbf{B}^{k+1}$.

Almgren's proof of this fact is typical of his geometric ingenuity and ability to look at problems from an unusual point of view. First he takes the convex hull C of S. Then he thickens it a little to get a convex body C' with a well-defined unit normal at every boundary point. Let R be the set of points x in $\partial C'$ such that the point in C nearest to x belongs to S. Of course, the image of $\partial C'$ under the Gauss map is the unit sphere $\partial\mathbf{B}^n$. Now Almgren proves that the image of $\partial C' \setminus R$ has area 0, and he bounds the area of the image of R (by a straightforward calculation of the jacobian determinants) in terms of the area of S and the given bound on mean curvature of S. Putting these together gives the inequality.

(See [27] for a more detailed expository account of Almgren's proof.)

Almgren's optimal isoperimetric inequalities paper applies only to minimizing surfaces. Whether his inequality for stationary (but not necessarily minimizing) surfaces is true with the same constant is still not known (though there are some results in this direction: [17, 18, 22, 23]).

Curvature Flows

In recent years Almgren was very interested in dynamic problems in which surfaces move through space with velocities related to their curvatures. His first major contribution to this field was not a paper but a graduate student: in 1975, Ken Brakke wrote a remarkable thesis on mean-curvature flow for varifolds [13]. However, the thesis was ahead of its time and had little impact for many years. After Richard Hamilton's stunning success with the Ricci curvature flow in 1982 [20], Gerhardt Huisken, Mike Gage, Matt Grayson, and Hamilton himself began obtaining striking theorems about mean curvature flow using methods of classical PDE and differential geometry rather than geometric measure theory. The field became a large and active one, as it continues to be. After a few years researchers in the field became aware of Brakke's thesis and were amazed by the wealth of insights it contained. Meanwhile, Brakke had also become interested in numerical work, and today he is even more widely known for his extremely powerful Surface Evolver software for simulating geometric flows [14].

Smooth surfaces evolving under curvature flows typically become singular at a finite time, after which it is not clear even how to define the flow with classical PDE and differential geometry. Thus, people have proposed various notions of weak or generalized solutions to geometric evolution equations.

These notions allow one to prove existence of solutions for all time. Typically it is relatively easy to prove that the generalized solutions agree with the classical ones as long as the surfaces are smooth. It is rather difficult to prove partial regularity results for solutions after singularities form. (Indeed, I believe that Brakke's regularity theorem is the only such result known. That is, the various partial regularity theorems all use Brakke's.)

Almgren and his collaborators Jean Taylor and Lihe Wang wanted a model that would apply to many kinds of geometric evolutions occurring in nature. Brakke's mean curvature flow models mo-

tion of grain interfaces in annealing metals, but mean-curvature flows in general are relevant only when the physical surface energies are isotropic. Almgren, Taylor, and Wang also wanted to model crystal growth, in which the surfaces energies are highly nonisotropic; indeed, for crystals the surface energy density typically depends in a nondifferentiable way on the unit normal.

They proposed such a model in [10]. The idea was to replace the parabolic problem by a series of minimization problems at discrete time steps. The flow is then the limit (as the time step size goes to 0) of the minimization problem. More precisely, at each time one chooses a surface that minimizes the sum of two quantities: the surface energy and a term that measures how far the surface is from where it was at the previous time step.

The main theorem of [10] asserts that a region bounded by the evolving surface is a Holder-continuous function of time. The authors also prove that for smooth initial surfaces and smooth elliptic surface energy density functions their flow agrees with the classical one until singularities appear.

In [11] Almgren and Wang incorporated temperature into the model so that one could, for example, model melting or freezing ice. Thus, in addition to a moving region (the "ice") there is a temperature function. Both in the region and in its complement, the temperature should satisfy a heat equation. Whereas mathematicians studying this problem routinely use the same heat equation in both regions, Almgren characteristically does not, since (as he points out elsewhere [8]) the heat capacity of water is twice that of ice. Furthermore, within the crystal the model allows heat to flow more easily in some directions than in others. Naively one might define the ice region to be the set of points at which the temperature is below freezing, but this neglects (among other things) the "Gibbs-Thomson effect", that is, the dependence of the local freezing temperature (along an interface) on curvature (of that interface). As Almgren explains, "Small crystals with high curvatures melt even though the temperature of the surrounding liquid is slightly below the freezing temperature given in handbooks." [8]

Almgren and Wang [11] define a kind of evolution that includes these many physical effects, they prove existence for all time, and they prove (among other results) that temperature depends Holder-continuously on time.

When illness struck in the summer of 1996, Almgren was busy with a number of projects. One of his main goals was to prove regularity theorems for the Almgren-Taylor and Almgren-Taylor-Wang curvature flows.

Other Works

Almgren wrote a great many other papers, including important work with Schoen and Simon on elliptic regularity, with Allard on uniqueness of tangent cones, with Lieb on liquid crystals and on spherical symmetrization of functions, and with Thurston on the "convex hull genus" of space curves. See [28] for descriptions of some of this work and for fuller accounts of some of the work described here.

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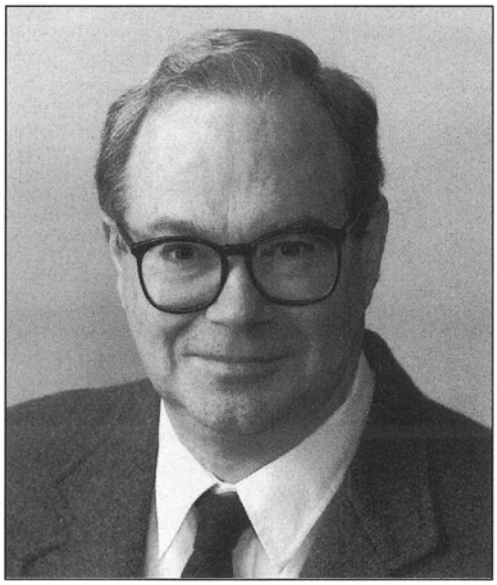
Anthony Knapp Appointed *Notices* Editor



Anthony W. Knapp of the State University of New York, Stony Brook, will begin a three-year term as editor of the *Notices*, starting January 1, 1998. A prominent researcher in representation theory of semisimple Lie groups, Knapp is also well known for his mathematical expositions. This year he won the AMS Steele Prize for mathematical exposition for his book *Representation Theory of Semisimple Groups (An overview based on examples)* (Princeton University Press, 1986).

Knapp will succeed Hugo Rossi of the University of Utah, who was editor from January 1995 until August 1997, when he took the position of deputy director at the Mathematical Sciences Research Institute in Berkeley. *Notices* Editorial Board member Andy Magid of the University of Oklahoma has been serving as acting editor until Knapp's term begins.

As an undergraduate at Dartmouth College, Knapp was part of a mathematical milieu where many people were at work on books. While a graduate student at Princeton University, he collaborated with Dartmouth mathematicians John G. Kemeny and J. Laurie Snell on the book *Denumerable Markov Chains*, which was based on an undergraduate course Knapp had taken. The book appeared in 1966, the year after Knapp received his Ph.D. from Princeton University, under the direction of Salomon Bochner. Knapp was a Moore Instructor at the Massachusetts Institute of Technology (1965–67) before joining the faculty at Cornell University. Starting in 1986, he began to spend time at SUNY Stony Brook and moved there permanently in 1990. He presented an invited address at the International Congress of Mathematicians in Vancouver in 1974. In 1982–83 he held a John Simon Guggenheim Memorial Fellowship.

In 1968 Knapp began a fifteen-year collaboration with Elias Stein of Princeton, during which they made the theory of intertwining operators into a powerful tool for constructing unitary representations by deformation arguments. Around 1975, with Gregg Zuckerman, Knapp completed the classification of "tempered" unitary representations, which appear in Harish-Chandra's Plancherel formula. In the 1980s came results in complementary series representations, some in joint work with Birgit Speh and with M. W. Baldoni-Silva. Knapp has also worked on cohomological induction constructions of representations with L. Barchini, David Vogan, and Roger Zeirau and has used cohomological induction to describe exotic unitary representations. The book by Knapp and Vogan, *Cohomological Induction and Unitary Representations* (Princeton University Press, 1995), received an award from the Association of American Publishers.

The book for which Knapp received the Steele Prize brings readers from the level of a second-year graduate student up to current research. The citation for the prize calls it "a beautifully written book which starts from scratch but takes the reader far into a highly developed subject." His other expository works include *Elliptic Curves* (Mathematical Notes, Princeton University Press, 1992), which received especially wide attention because it appeared close to the time of Andrew Wiles's announcement of his proof of Fermat's Last Theorem, in which elliptic curves play a central role. Knapp's most recent book is the basic graduate text *Lie Groups beyond an Introduction* (Birkhäuser, 1996).

Over the years Knapp's interest in exposition has been fueled in part by contacts with some of the masters of the art, such as Sigurdur Helgason and Elias Stein, both fellow Steele Prize winners. But it was also fueled by the belief that expository writing is important to the development of the field. "Mathematics advances not just by research alone," Knapp notes. "There is a process of distillation that is necessary." The work of the most prominent mathematicians is usually accessible, chiefly through collected works, "but apart from that, unless mathematics gets into some other form—a book form or expository article form—my sense is that it tends to get lost," he remarks. "So exposition is a way of collecting, from the vast amount of research done, the mathematics that survives.... Collectively, mathematicians have this responsibility."

His wife, Susan Knapp, will serve as editorial assistant for the *Notices*. This arrangement has its clear advantages, she notes: "We can talk about the *Notices* at breakfast." Her background in mathematics—she has a bachelor's degree in the subject—will be a useful resource. She has had experience working with mathematics publications, having served as an editorial assistant for the *SIAM Journal on Computing*. She also worked for a brief stint as a secretary for another AMS publication, *Journal of the AMS*.

Anthony Knapp wrote a two-part article for the *Notices* entitled "Group Representations and Harmonic Analysis from Euler to Langlands" (April 1996, pages 410–415, and May 1996, pages 537–549). As editor he is interested, as Hugo Rossi was, "in articles that cut across fields and show connections and possible connections among areas of mathematics." Knapp would like the articles to be akin to excellent colloquia that *Notices* readers can "attend" each month. "I'm constantly on the lookout for possibilities for good mathematics articles," Knapp says. "I'm interested in hearing from people that they heard someone give a wonderful talk that might be converted into a good *Notices* article. I'll do my best to pursue those and persuade people to write them up."

Those with ideas for articles are encouraged to contact Knapp by e-mail at `notices@math.sunysb.edu` or by regular mail at this address: Anthony W. Knapp, Editor, *Notices* of the AMS, P.O. Box 333, East Setauket, NY 11733.

— *Allyn Jackson*

Mathematics: An Interview with AMS President Arthur Jaffe

The following interview was conducted by *Notices* Senior Writer Allyn Jackson.

Notices: *You have been very active in national issues since you were elected president of the AMS. What do you see as ways that the AMS president can help the mathematics community?*

Jaffe: I have been fortunate to be elected at a time when several opportunities arose right away to do things that affect the way the world thinks about our profession. There is a paradox: we are living in a golden age of mathematics research, yet our infrastructure is in danger of total collapse. So at the moment I am focusing on two special issues. The first concerns public support of science, and mathematics in particular. The second revolves around public awareness. These two focal points are intimately connected. In the long run, success with the former relies on the latter.

Notices: *In fact, your national activities started in late 1995, before you formally began your term, when you became involved in the effort to restore the mathematics graduate program at the University of Rochester.*[1]

Jaffe: Yes. Everything I have been doing today at the national level is based on principles I learned from Rochester. One major thing I learned was the importance, value, and necessity of collaborating with our colleagues in other disciplines. At the same time we must preserve our view of mathematics. If anybody is going to make the case for mathematics, it has to begin with us. But we require help from others.

I firmly believe that progress toward our major goals can be made only when the public has a positive attitude toward science as a whole. We have to see mathematics as part of the whole, and that is why I have put so much effort into working for science. As mathematicians we do many things differently, and we contribute in different ways to society, but the goals of our community overlap with those of other sciences. And the general public will not single us out—except when some unusual problem, like Fermat's, both can be explained and does get solved.

Returning to the subject of the University of Rochester, let me emphasize a couple of points about the university's attempt to downgrade the mathematics department. First, the mathematicians expressed surprise at the decision, while some people from other disciplines saw it coming. It is very important that we talk to our colleagues outside our immediate circle and learn what people are thinking about matters of importance.

Second, the general public often has standard misconceptions about the value of mathematics and stereotypes of mathematicians. The initial reactions of the Rochester administration reinforced these, and I believe unfairly to a large extent. Let me give one example: at every university I know there is an extraordinary effort to teach mathematics well and to strive constantly to improve. Still, at these same universities mathematics teaching tends to be criticized. Judging from teaching evaluations, mathematics teaching at Rochester appeared to be as good as or better than that in

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[1] *See "Whatever Happened to Rochester?" in this issue of the* Notices, *page 1463.*

most of the other science departments. The level of criticism was not justified by the facts.

I believe that one of the main problems at Rochester was that mathematicians were "out of the loop". Fortunately, Rochester mathematicians are now "in the loop". In fact, when I met with President Thomas Jackson of the University of Rochester last April, he commented that mathematics might now be the best-connected department in the university. That is quite a statement to make. But now he knows Rochester mathematicians, and he appreciates them.

Notices: *Do you think that his reactions are connected to the broader question of public views of mathematics?*

Jaffe: Yes. But even more generally I would say that we are going through a period in which the national perception of science and of scientists is very negative. For fifteen to twenty years the press has focused on how developments in science adversely affect the environment, on how science is elitist, on how scientists sometimes falsify or misinterpret data, and in general on how science represents not truth, but merely a parochial viewpoint, as valid as any other. These attitudes affect mathematics too, if only indirectly, because we get lumped in with the rest of science. We need to try to turn these attitudes around. We need to focus attention on the multitudinous positive aspects of science. This is no easy task, but I believe that a positive public perception of science and of mathematics is the key to our future.

Furthermore, mathematics is the least understood and most difficult to explain of all the sciences. Most people think that mathematics is handed down on a stone tablet and do not think it is possible, much less fundamentally important, to discover new mathematics. Despite these difficulties, we have to do our best to communicate and to explain our subject to those outside our discipline.

Notices: *What is the AMS doing to promote public awareness of mathematics?*

Jaffe: At the moment we are taking small but important steps. After our very successful (and, I believe, first-time) mathematical briefing in the Rayburn Office Building on Capitol Hill,[2] we are planning another briefing on mathematics next spring, probably in the first week in March. In a different venue, I've just become co-chair with Paul Anderson of the Public Awareness Forum of the Council of Scientific Society Presidents. Here the role of mathematics will be folded into the question of the awareness of science in general. I believe it is important that mathematicians take a visible part in the efforts to bring science to the public. On the Web we have instituted an information page oriented toward nonmathematicians called "What's New in Mathematics", under the auspices of the Working Group on Public Awareness of Mathematics, begun within the Committee on the Profession by Steve Weintraub.

Notices: *You have been especially active in science policy affairs in Washington. Can you talk about what the AMS has been doing in this arena?*

Jaffe: First of all, we have worked hard on unifying the leadership of a number of professional scientific organizations to work toward common goals. As I mentioned, unless there is an environment sympathetic to science as a whole, it is very difficult to have an environment sympathetic to mathematics. One common long-range goal that was easy to agree upon is the importance of positive public perception of science. Of course we would like every person in the government to understand the importance to our country of maintaining our position of scientific leadership. And this means the support of science across the board.

Much of our federal budget is spent on the present or makes up for deficiencies in the past. Science is different. It is an investment in the future of our country. The future outweighs the past, and we cannot emphasize this point too often. We should continue until our public accepts this fact, as the public does in many other countries (especially in Europe and in the Pacific Rim).

The AMS began working together with the American Physical Society, the American Chemical Society, and also with some biologists from the Federation of American Societies in Experimental Biology. Of course we have also been partners in these efforts with the other mathematics societies: the Association for Women in Mathematics, the Mathematical Association of America, and the Society for Industrial and Applied Mathematics.

By this spring our informal coalition had expanded to include forty-six presidents of scientific societies, who endorsed a statement in support of strong funding for science.[3] The statement points out the importance to the country of federal investment in scientific research and also the interdependence of scientific disciplines. It calls for increases for 1998 in the range of 7 percent in the research budgets of agencies that fund science. It was mailed to every member of the House and of the Senate and was given quite a lot of attention in the press, with supporting stories and editorials appearing in the *New York Times*, the *Washington Post*, *U.S. News and World Report*, and the *Wall Street Journal*, among other publications. In addition, I was part of a small group of presidents that paid visits to a number of key legislators and their staffs in order to emphasize our views and

[2] *See "AMS Congressional Briefing: Mathematical Transcriptions of the Real World",* Notices, *May 1997, pages 586–588.*

[3] *See "Coalition Presses Congress for Increases for Research,"* Notices, *May 1997, page 585.*

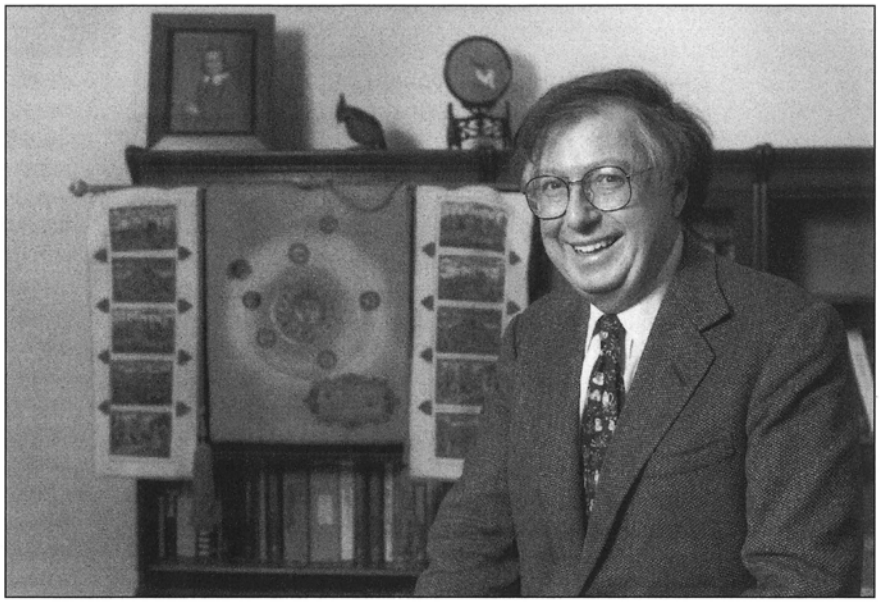
to offer assistance with their implementation. At the same time, a group of about ten Washington representatives of science organizations—including Sam Rankin of the AMS Washington Office— began to meet regularly to plan special projects.

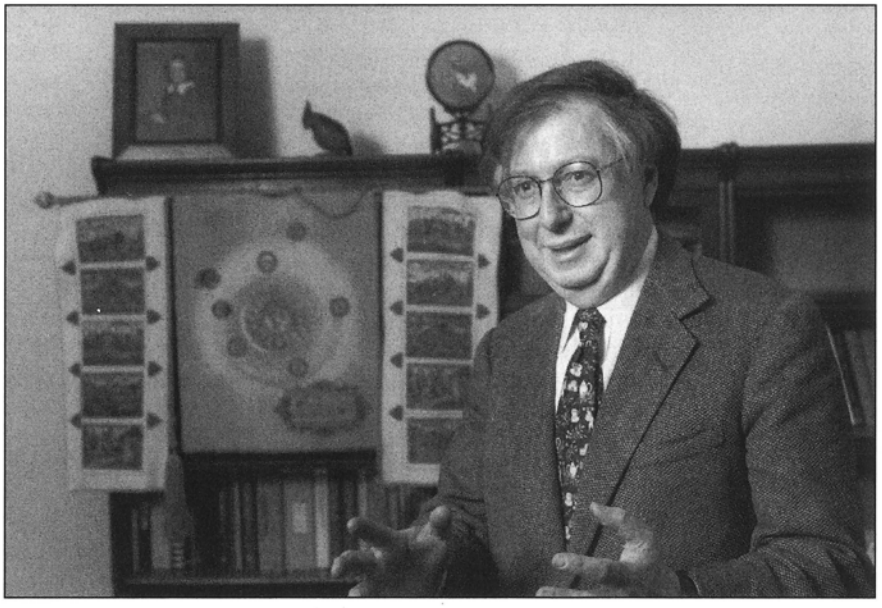
It has been wonderful to see how rapidly opinions changed.

Notices: *What exactly did you observe?*

Jaffe: For example, the day after the press conference in which we presented the statement, we held the briefing about mathematics on Capitol Hill that I mentioned earlier. In his introduction the chair of the House Science Committee, Congressman James Sensenbrenner, gave quite a negative prognosis for the support of science in the 1998 budget. Just two weeks later he changed his opinion and proposed a 3 percent increase in the science budgets under the auspices of his committee. And then, a few weeks after that, his committee actually voted an authorization bill with a 7.2 percent increase! The Appropriations Committee cut this back to 6.8 percent, but it was still more than double the increase that the president had requested and far beyond any prediction at the beginning of the year. Later, the Senate authorization bill was similar, but the appropriations bill cut the increase back to 3.3 percent (an unusual reversal of roles in the Senate and House). During August we did a good deal of work to encourage mathematicians and others to speak to the twelve senators on the conference committee in their local districts and to urge their support of the House version of the bill. In September the final figures will be decided in Senate/House conference.

Whenever we go to Washington, we hear the same story: Scientists are not very visible. And as mathematicians, we're invisible! However, I think that's changing, and an appreciation is building for the fact that the sciences are interdependent—you can't really study, say, medical imaging without using physics, chemistry, mathematics. Furthermore, it is impossible for the federal government to predict which areas of basic science will yield the most important and revolutionary advances. I believe that the best method to ensure success in mathematics is to encourage bright students to pursue mathematics as a career. We then need to support them, both as students and as active mathematicians, for as long as they are successful.





Our natural allies come not only from universities, but also from industry, business, and the financial community, for the future prosperity of our country depends on our scientific strength. A large problem is that science needs more powerful advocates in Congress, persons who put science on the top of their agenda. But few people in government have scientific training, and many do not understand the way that scientific discovery comes about. We have worked with and are grateful to James Sensenbrenner, the current chair, and to George Brown, longtime former chair of the House committee, and to Vernon Ehlers, a distinguished vice chair. There are some active persons in the Senate, including two with whom we have had recent contact, Senators William Frist and Joseph Lieberman. Senator Phil Gramm has put forward a bill, S124, which advocates doubling the nondefense science budget over ten years.

Notices: *What is the next step in these efforts?*

Jaffe: We have met with Senators Gramm and Lieberman and have worked over the year with their staffs to encourage bipartisan support for science. We hope that these two senators will introduce a new joint bill this fall to replace S124.

We are planning a second statement of the ad hoc coalition of presidents of scientific societies and umbrella organizations this fall. Our aim, rather than focusing on a one-year plan, is to formulate a long-range goal for our country concerning the necessity to increase our investment in basic scientific research. We have increased the size of our coalition from forty-six this spring to over ninety presidents currently on board, and we hope that over one hundred will sign by the time of our announcement.

We are building bridges with various leaders in industry and in business, and we hope that they will coalesce into powerful outside support for our position. We are also working in parallel with certain universities and with the Science Coalition, which is a Washington-based organization of universities, professional societies (including the AMS), and a few individuals. Through the AMS Washington Office and JPBM (the Joint Policy Board on Mathematics) we also are active within the Coalition for the National Science Foundation.

Don Lewis, the director of the Division of Mathematical Sciences at the NSF, has provided a strong voice for mathematics. Don plans to retire this academic year, and a big problem for the community will be how to fill his shoes. The person in that position sets the tone for the visibility of mathematics within the Foundation, as well as ensures that our research funds are well spent.

Much of what I have talked about concerns activities in Washington. However, ultimately the long-term success of science must be based on support from the public, and this means throughout the country. Mathematicians should know who their local representatives are and try to meet them. The members of Congress should know that they can call on a constituent in case they need some advice of a technical nature. It is generally much easier and more relaxed to establish a relationship in a person's local district than in Washington.

Notices: *What about the longer term?*

Jaffe: Most important of all, we want to see all these individual actions grow into a "grass roots" movement. Scientists and mathematicians need to take the message to our students, to our schools, to our communities, as well as to our local representatives. Only through the efforts of many people locally can we hope to reach the numbers and the variety of persons needed in order to have a long-term effect. Once the message is sufficiently widespread, it will be taken up by the media.

We are trying to develop models for how this can be done. For example, on October 15 the AMS held a town meeting at its headquarters in Providence. State government officials and local scientists and mathematicians came together to discuss the importance of science.

The AMS Washington Office is working on ways to spawn these kinds of efforts around the country. An ideal setting would be to bring together at a university a group consisting of, say, a couple of mathematicians, a chemist, a physicist, a biologist. The group can invite a local delegation to the university and describe what is going on in different areas of science and explain why it is good for the community. While a few such events have already been held, I hope that in the future mathematicians will play a central role.

I would like to see the AMS and the scientific community set in motion a new passion for science. If we are successful in sparking a grass roots movement, then I believe it can be sustained over the long term.

At press time, the House and Senate conferees had agreed on a final version for the 1998 VA, HUD, and Independent Agencies Appropriations Bill, including an increase in funding for the National Science Foundation of nearly 5 percent above the 1997 level, and nearly 2 percent more than the agency requested.

Whatever Happened to Rochester? Two Years Later, Mathematics Is Getting Accolades

Two years ago the mathematics department at the University of Rochester made national headlines as it battled a move by the university administration to eliminate the department's graduate program. After the crisis was resolved in March 1996 and the administration reversed its decision, the Rochester mathematicians made efforts to improve undergraduate instruction and establish stronger ties to other disciplines. Now, a year and a half later, a remarkable turnaround is in evidence, with the mathematics department enjoying the strong support of the administration and drawing praise—and even prizes—for its work. Says William Green, professor of religion and dean of the college, "It's got to be one of the great success stories of higher education."

Emblem of Departmental Woes

The crisis at the University of Rochester has become emblematic of many of the problems facing mathematics departments in this era of shrinking higher education budgets. It was in November 1995 that the university announced the "Rochester Renaissance Plan", which described a host of measures designed to improve the university's financial position and its attractiveness to undergraduates. The plan called for a reduction of 10% in the number of professors and the elimination of four graduate programs (chemical engineering, comparative literature, linguistics, and mathematics). Mathematics was one of the departments hardest hit, with a reduction in faculty slated for close to 50%.

Shortly after the plan was announced, the AMS dispatched a small group to Rochester to offer assistance in helping the department and the administration resolve their differences. When these meetings did not prove fruitful, a number of AMS representatives—including Salah Baouendi, member of the AMS Committee on the Profession, and Arthur Jaffe, who was then AMS president-elect—orchestrated a campaign to get people outside Rochester to write in support of the mathematics department. The campaign was quite successful, drawing a total of over one hundred letters, many of them from prominent scholars outside of mathematics, including a number of Nobel laureates.

All along the biggest sticking point at Rochester was the elimination of the mathematics graduate program, which the mathematics faculty believed would drain the lifeblood from its research effort and eventually undermine the intellectual tone of the university. When, after nineteen weeks of internal negotiation and pressure from the letter writers, the administration agreed to reinstate the graduate program, the landscape suddenly changed. "I think that at that moment everybody realized that we were all on the same team," says Douglas Ravenel, who became chair of the mathematics department. The department was able to breathe a sigh of relief and address the very real problems the administration had pointed out, and the administration now had an interest in strengthening the mathematics department.

With Ravenel as chair, the mathematics department has been working hard to improve its undergraduate teaching and to reach out to other departments. Because Ravenel is one of the most highly regarded researchers in the department, the fact that he took an active interest in the department's fate was important in bringing about the turnaround. "This is a group of leaders, strong

mathematicians who stepped up" to the challenge, says Thomas LeBlanc, professor of computer science and dean of the faculty. "They are intellectual leaders, not political leaders." That the change came so quickly is quite remarkable. "When you tell people this happened in a year and a half, it seems like we're trying to put a happy face on a bad situation," LeBlanc remarks. "But that's not the case."

Improvements in Teaching

The mathematics department started making improvements in the area that had drawn the most complaints: lower-level teaching. One of the most visible manifestations is WeBWorK, an Internet tool developed by Michael Gage and Arnold Pizer. (Ironically, WeBWorK was under development even before the crisis broke at Rochester.) Earlier this year Gage received a regional prize from the Mathematical Association of America for his role in developing WeBWorK, and he has also received an on-campus teaching award.

WeBWorK supplies students with homework problems in such a way that they all have the same problems, but each has slightly different numbers. Therefore, the correct answers are different for each student. When the student keys an answer into WeBWorK, he or she is told immediately whether or not the answer is right. No hints are given, but with the immediate feedback the students become quite persistent: Eventually, 80 percent of them get all of the answers right. In addition, when a student does come to the professor with questions, he or she has usually thought about the problem quite a bit. "So the direct communication between student and professor is much more specific, much more focused, than student questions are in a traditional course," Ravenel explains.

WeBWorK was introduced in a new course called "Calculus with Foundations", which is aimed at precalculus students. The department found that these students, who tend not to be highly motivated in mathematics, responded well to WeBWorK. "They say that the immediate feedback is a huge asset," says Ravenel, noting that the students also seemed to work a lot harder at the course. This fall the department is expanding the use of WeBWorK into its slower-paced calculus course, which has an enrollment of about 170 students.

The reasons for developing "Calculus with Foundations" provide a good example of the problems the department faced. At Rochester—as on many campuses nationwide—freshmen have been arriving with steadily declining mathematical backgrounds. "There was a widening gap between what incoming freshmen knew about mathematics and what other departments expected them to know as sophomores, and we were expected to fill this ever-widening gap," says Ravenel. With precalculus the situation was even worse, because other departments would steer their students from the course because it offered so few credits. Predictably, these students would flounder in calculus. "Calculus with Foundations" addresses these problems by filling in holes in the students' background while introducing them to ideas from calculus and offering them more credits.

Another new course developed by the department is "Calculus for Understanding". It is tougher than the regular calculus course for science and engineering majors but less theoretical than honors calculus. The hallmark of the new course is the use of two-hour workshops—in which students collaborate on the homework, with a teaching assistant roaming around the room to provide help—rather than traditional recitation sections. The new course is one of a group of "Quest" courses on the Rochester campus, which are designed for highly motivated freshman students and which provide a setting where students work in groups on problems and get a taste of what real research is like. Enrollments in the mathematics department's Quest courses far exceed those of any other department. The department's success with precalculus and calculus courses has resulted in articles in the Rochester alumni magazine as well as in the local newspaper, the *Rochester Democrat and Chronicle*, which on September 27 ran a story entitled "UR Tries to Cure Calculus Fear".

One factor that has buoyed the fortunes of the mathematics department is that the Renaissance Plan's aim to improve the academic preparation of the student body has paid off: the average SAT score for this and last year's incoming classes is just shy of 1300, the highest it has been in twenty years. The mathematics department is seeing the change firsthand, says Ravenel. "We see more people enrolled in these very challenging courses, and this is very encouraging." Thirty-three students made it through honors calculus in the fall semester of 1996, "a huge enrollment," according to Ravenel. What is perhaps even more striking is the half dozen freshmen who enrolled in and succeeded at sophomore-level honors calculus. "Nothing like this has ever happened before," Ravenel remarks, noting that in the past at most one or two freshmen might enroll in that course. And generally the courses in the mathematics department just seem to be popular. Ravenel says nobody knows why last semester a dozen economics graduate students showed up for a graduate course in measure theory. Although the economics department at Rochester has a mathematical bent, having so many economics students in such a theoretical mathematics course is unusual.

At the time the Renaissance Plan was announced many departments had complaints about the teaching in the mathematics department, and relations with engineering were especially strained. The en-

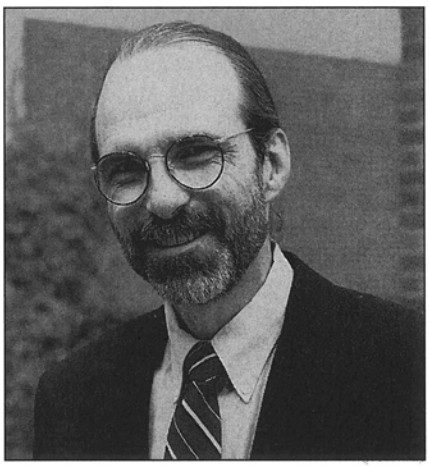
gineers' frustration was compounded by the fact that one of their own faculty, Al Clark, has a doctorate in applied mathematics and is an excellent mathematics teacher. To the dismay of the mathematics department, the engineering school began offering its own versions of some upper-level mathematics courses. Two initiatives have calmed these troubled waters. First, discussions between mathematics and other departments led to the development in the mathematics department of a new differential equations course that better addressed what other departments said their students need. And second, the mathematics department extended a joint appointment to Clark. (A joint appointment between mathematics and physics is also in the works.)

The mathematics department has not only reached out to other departments to address teaching concerns but has also made scholarly connections. There is now a joint mathematics-physics colloquium attended by members of both departments. In addition, an applied mathematics seminar was started last year that brings in speakers from a variety of other departments to talk about the use of mathematics in their own subjects. "There is a lot of mathematics being done outside the mathematics department," says Ravenel, "and this is a very good way to get people together." There have been talks on DNA computing and chemical reactions—and even one that used flag manifolds to help explain the dance language of honeybees. When the speaker suggested a connection between this dance and quantum mechanics, "the physicists went ballistic," Ravenel reports. The speaker "set a new standard for intellectual provocation," he says, and the discussion went on for about half an hour after the talk had ended. (The work of the speaker, mathematician Barbara Shipman, is described in the article "Quantum Honeybees", *Discover* magazine, November 1997.)

One dark cloud looming over the Rochester mathematics department is the administration's insistence that the number of mathematics faculty be reduced to 15. Mathematics faculty member Michael Cranston says that the reduction would make it "impossible" for the department to meet its teaching responsibilities. Since the time the Renaissance Plan was announced the department has lost three faculty: one moved to the University of Iowa when the turmoil erupted, and two others have accepted early retirement packages. With one of the retirees working half-time, the faculty now numbers 18 1/2 full-time members. In addition, the graduate program is currently limited to twenty students, down from a steady-state of the low thirties before the Renaissance Plan. "The size restrictions on the faculty and the graduate program put constraints on our ability to cover the teaching that needs to be done," Cranston says.

Advice for Other Departments

The turnaround in the mathematics department at Rochester can provide lessons for other institutions. For example, "communication with other departments is vital," Ravenel observes. "Mathematicians have a tendency to be politically aloof and not to get involved in the politics of their institutions and not to interact with other departments. This makes us very vulnerable. I think that when you meet with other departments one-on-one and discuss issues related to mathematics, it can be very beneficial." His department has met with almost every other department that has a mathematics requirement to discuss what the other departments want their students to know about mathematics. As a result of these meetings, says Ravenel, "I think there's a feeling around the university that the math department is very approachable and responsive to the needs of other departments."



Chair of the Rochester Department of Mathematics, Douglas Ravenel.

These meetings also revealed some misconceptions on the part of other departments. For example, many believed that mathematics courses were taught too abstractly or too theoretically. "On the other hand, they admit that mathematical maturity is a very valuable commodity and it's something that they want all their students to have," Ravenel notes. Bringing such contradictions to light helps the two sides understand better the problems that need to be addressed. Another misconception, says Ravenel, is that professors in other departments tend to believe that calculus is taught in the same way as when they were in college. "They are oblivious to the changes that have been made in the way that calculus has been taught in the last twenty years," he notes. "The more you can communicate with them about these things, the better off you'll be."

In addition to discussing mathematics instruction, it is also important to forge scholarly connections to other departments through such activities as joint seminars. Asked which was more important, Ravenel says, "if you do it right, these things can reinforce each other." In particular, he believes that having lively interactions with other departments makes the mathematics major more appealing to undergraduates. "Every math department needs to have an attractive major so that they can get more students, and that will improve the health of the department," he notes. In this way

the scholarly and teaching missions are drawn closer together.

Ingredients in the Resolution

According to Paul Slattery, chair of the Rochester physics department, the key ingredient in the solution of the crisis at Rochester was the internal response of the mathematics department. Another important factor, he notes, was the support of physics. "Physicists nationwide had rallied to the support of the math department in significant numbers," says Slattery, "and physicists at Rochester were certainly no exception. Some wrote semipublic letters and some chose to proceed more discreetly, but all fully understood the obvious fact that we would not long continue to be a top quartile department in association with a completely dysfunctional math department." The support of the physics department for strengthening ties to mathematics, through joint appointments and other mechanisms, increased the receptiveness of the administration to reversing its decision.

How important were the letters from well known scholars and Nobel laureates outside Rochester, who took the administration to task for its demotion of the mathematics department? Views on this question vary. Certainly many in the mathematics department believe the letter-writing campaign was critical. "It made it impossible for the administration to ignore, and also for other departments to ignore," says Cranston. That many of the letters came from outside mathematics made them especially influential. It was not just the AMS functioning as "a guild protecting its own members," he notes.

Others see the letters as less important. In fact, Slattery points out that the very intensity of the protest made it especially difficult for the administration to consider reversing itself, "lest it appear to be irresolute in the face of outside criticism." Dean LeBlanc says the letters "raised the temperature" but were not a critical factor. The idea that the administration changed its mind under the pressure of opinion outside Rochester is "wrong," he says, "because without the leadership in the math department coming forward, the letter-writing campaign would not have had an effect." LeBlanc worries that the mathematics community might see Rochester entirely as a political battle, with the lesson being that mathematics must be vigilant and defend itself against its enemies. Instead, he says, mathematicians should recognize that there are real problems in higher education that they need to work on. If they become "part of the solution to those problems, it will be good for mathematics."

Asked about the letter campaign, Dean Green replies that change came not as a reaction to pressure but "through quiet, intelligent negotiation and diplomacy." He credits Rochester president Thomas Jackson with having the courage to reverse a decision to which he had made a substantial commitment. Jackson could have stuck to his decision, for he had the support of the Rochester Board of Trustees (in fact, he took some heat afterwards from supporters of departments in which the decision to eliminate the graduate programs was not reversed). For its part the mathematics department could have retreated into itself and become "bitter and self-righteous," says Green. "But they turned around, looked at the problems, and saw what they needed to do. There was real leadership from the department and from the president."

Many of the letter writers from outside Rochester focused on the central role of mathematics in the scholarly and academic world. In this the letter writers were correct, Green believes, but mathematicians must take this centrality seriously. "The message to mathematicians is that, because your subject is essential to so much, you cannot afford to be anything but powerfully engaged in thinking through the future of your own institutions," he says. "Not all fields have that obligation, but mathematics really does." The centrality of mathematics "does not give you entitlements; it gives you responsibilities."

—Allyn Jackson

Nature's Numbers

J. E. Cremona

Nature's Numbers
I. Stewart
Basic Books, Harper Collins Publishers, Inc.
$20.00 hardcover
164 pages

Mathematicians are frequently called upon to write and talk about their work to a general audience in order to convince those who pay our salaries and (if we are lucky) support our research activity that the research we do is worthwhile and interesting. Indeed, the editorial column in these *Notices* has itself urged just this on more than one occasion. Most of us find this task such a daunting challenge that we put it aside for a rainy day, only to find that there are always more pressing things to be done, whether it is writing up a new piece of research or preparing a new course. There is a small but significant number of mathematicians, however, who succeed in this task and produce a (seemingly) constant stream of entertaining (and informative) books about mathematics for a "general audience". Ian Stewart is one of these, and one of the most successful.

Despite being a professional mathematician, and therefore by definition not one of the intended audience, I enjoy reading these "popular" mathematical books just as I enjoy reading many popularizations of science. In the case of mathematics books, however, I always find myself wondering who my fellow readers actually are. Are they, like me, other mathematicians wanting a relaxed good read? Are they the same people who read Stewart's "Mathematical Recreations" column in *Scientific American* each month? Are they mathematics graduates in nonmathematical careers who like to keep their mathematical hand in? Or people who always wanted to be able to understand mathematics better but left it behind at an earlier age?

Nature's Numbers is the sixth in a series of fairly short books called The Science Masters, in which leading scientists communicate their ideas to general readers. As far as I know (from the list of current and planned future contributors on the back cover) Stewart is the only mathematician currently on the list. Having read two or three of the books in the series, I would say that the format is very successful. The books are short enough to be read in one or two sittings and are very accessible to their intended audience. At least that is true of the other books in the series; it is rather dangerous for a mathematician to judge what is or is not accessible to nonmathematicians.

The starting point for *Nature's Numbers* is that there are many patterns to be found in nature, including numerical patterns (such as Fibonacci numbers in sunflowers) and shape patterns (such as in snowflakes). The first chapter already seeks to define what we actually mean by "a pattern", coming to the conclusion that we see a pattern in something that has symmetry, but not too much symmetry — that is, broken symmetry. We do not see a pattern in the still surface of a pond, as there is too much symmetry. If we then toss the traditional pebble into the pond, however, the perfect symmetry is broken: we lose all but the symmetries which fix the point where the pebble strikes the surface in the resulting pattern of concentric circles. This theme of broken symmetry is a recurring one in the book, particularly in Chapter 6. The

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idea that symmetries are operations that may be combined together, rather than static properties of a shape, is brought out. Nature has symmetries at every scale, from elementary particles and atoms right up to galaxies. The role of mathematics is to describe symmetry-breaking processes in order to explain in a unified way the fact that the patterns we see in sand dunes and zebras' stripes are caused by processes which, while physically different, are mathematically very similar.

In the early chapters of the book there is an excellent attempt to answer the questions What is mathematics for? and What is mathematics about?. For the former, the answers given include solving puzzles in nature (such as why planets move in the way that they do), describing changing quantities via calculus, modeling change (such as the evolution of the eye), and the prediction and control of physical systems. The useful point is made that there is often a very long time lag between the original, "pure" mathematical work and the eventual application, so that purely goal-directed research is often inappropriate in mathematics. I hope that the grant-awarding bodies read as far as this (page 29)!

Under the heading "What Mathematics Is About" Stewart emphasizes that it is not just about numbers, but also about operations (also known as functions or transformations), about the logical relationships between facts, and about proof. He gives a good example of the process of finding a proof. There is also an interesting section on the "thingification of processes" as a basic mathematical process. I have previously read about this (using the more standard word "reification", which Stewart says sounds pretentious) only in articles on mathematics education; here it is made clear what a universal abstraction process this is, not just in mathematics.

There is not space here to describe the contents of each of the book's nine chapters in detail: the pace is fast, and hence a lot of ground is covered quickly. I must confess that when I started to read it, I was expecting more of a bias towards nonlinear dynamics and chaos, but this does not appear (except briefly) until the last two or three chapters. Prospective readers who have not been prepared to tackle a whole book on these topics (such as Stewart's own *Does God Play Dice?*) could do a lot worse than to read Chapters 8 and 9 of this book for an entertaining and readable account. In the last chapter, entitled "Drops, Dynamics and Daisies", there are three examples of "simplicity emerging from complexity": the formation of water droplets, population dynamics, and Fibonacci numbers cropping up in the formation of daisy petals. I found it particularly surprising to learn that it was not until 1993 that the latter phenomenon was given a satisfactory dynamical explanation. In each of the three examples the case is made that nonlinear dynamics provides a better insight and explanation into what happens than earlier attempts, which were either purely descriptive or overly formula-bound.

The epilogue to the book is entitled "Morphomatics". It appears to be a kind of manifesto for a new mathematical theory of that name, or even for a new kind of mathematics that will complement rather than replace current scientific thinking. This new theory does not currently exist, but Stewart sees its creation as a necessary way forward in the use of mathematics to understand the natural world. Not all mathematicians will necessarily agree with this manifesto, but it should certainly stimulate an interesting debate. It is a little puzzling, however, for such a manifesto to appear in the epilogue of a book that is not aimed at mathematicians!

Finally, there are several dozen references for further reading, divided up by chapter. These are mostly articles and books published within the last ten years, but include a few earlier items such as the classic *On Growth and Form* by D'Arcy Thompson (originally published in 1917, and still in print). I would like to add one title: *Patterns in Nature* by Peter S. Stevens (Little, Brown & Co., 1974) is a beautifully illustrated account covering some of the same ground.

This book claims it will equip its readers with a mathematician's eyes and hence change the way they see the world. In this aim it stands a good chance of succeeding—provided that they are not already mathematicians, of course.

Mathematics Research Libraries at the End of the Twentieth Century

N. D. Anderson, K. Dilcher, and J. Rovnyak

Libraries are special resources in mathematics, and their health is a matter of concern not only to librarians but also to mathematicians. Spiraling journal costs, budget problems, space problems, and the increasing role of electronic media continue to require decisions that affect every aspect of the operation.

In the late 1980s the AMS became interested in collecting data on mathematics research libraries to replace anecdotal information. The overall purpose is to assist librarians and mathematicians to build and maintain the best possible mathematics research libraries in academic institutions. The first AMS survey of mathematics research libraries was conducted in the fall of 1990 (*Notices of the AMS*, December 1991, 1258–1262). As in 1990 the goal of the 1996 survey was to document the state of the system.

The 1996 survey was run in the fall of 1996 and extended into February 1997. As in 1990 the questionnaire was sent to all institutions granting the doctorate in mathematics in the U.S. and Canada. The questionnaire was designed to be filled out by the librarian in charge of the mathematics library, which is defined as the main mathematics collection used by the mathematics faculty and graduate students, whether this collection is housed in a general library or some other structure such as a science library or branch library. In some institutions there is more than one collection that is important to mathematicians, and rather than combine data it was requested that these collections should be reported separately. The focus, however, is on the main collection in each institution.

The questionnaire was sent to 25 institutions in AMS Group I public, 23 in Group I private, 56 in Group II, 72 in Group III, and to 29 Canadian doctoral-granting departments. The U.S. peer groups are determined by "scholarly quality of program faculty," as reported in the 1995 publication *Research-Doctorate Programs in the United States: Continuity and Change.* Group I is composed of 48 departments with scores in the 3.00–5.00 range and is further divided into public and private institutions. Group II is composed of 56 departments with scores in the 2.00–2.99 range. Group III contains the remaining U.S. departments with doctoral programs and includes a number of departments that were not part of the 1995 ranking. The response rates were:

Group I public: 23 libraries in 22 institutions; 22/25 or 88% of institutions responded (1990, 85% for all of Group I)

Group I private: 22 libraries in 21 institutions; 21/23 or 91% of institutions responded (1990, 85% for all of Group I)

Group II: 37 libraries in 35 institutions; 35/56 or 63% of institutions responded (1990, 74%)

Group III: 48 libraries in 48 institutions; 48/72 or 67% of institutions responded (1990, 66%)

Canadian: 26 libraries in 25 institutions; 25/29 or 86% of institutions responded (1990, 48%)

In all, this amounts to responses from 156 libraries in 151 institutions, that is, 151/205 or 74% of all

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1996 AMS-IMS-MAA Library Survey

The Canadian Mathematical Society participated in the 1996 survey. The questionnaire was written by the AMS Library Committee. Current (*) and participating retired (†) librarian members are: Nancy D. Anderson*(co-chair), Carol Hutchins*, Dorothy McGarry*, Mary Ann Southern†, Martha Tucker*, John W. Weigel II†. Mathematician members are: George E. Andrews†, Bruce Berndt* (co-chair), Felix Browder†, Lawrence S. Husch*, James Rovnyak†, James J. Tattersall*, Hung-Hsi Wu*. Karl Dilcher served as the Canadian liaison.

A copy of the full report on the 1996 AMS-IMS-MAA library survey may be obtained from the Web site: `http://wsrv.clas.virginia.edu/~jlr5m/survey/survey.html`.

institutions. For comparison, the 1990 overall response rate was 138 libraries in 134 institutions, that is, 134/193 or 69% of all institutions.

Some factors should be kept in mind in interpreting results. As in 1990 the survey assumes a local definition of mathematics: in some cases this includes related subjects such as statistics. Data also include 6 departmental reading rooms (1 in Group I public, 2 in Group II, 2 in Group III, and 1 in Canada). An effort was made to get more responses from reading rooms, but we regret that the numbers are too small to report them as a separate group. Reading rooms nevertheless play a very important role in many departments.

The size of the mathematics literature is also a factor in interpretation of results. Compared to the humanities, the mathematics literature is relatively compact and monolithic. Its size and diversity nevertheless come as a surprise to many people.

- In 1996 *Mathematical Reviews* selected articles from 1,629 journals (in 1990, about 1,400), and of these it indexed cover-to-cover about 600 (in 1990, about 400).
- In 1997 there are about 29 purely electronic journals in mathematics or closely related areas. Of these, 22 are indexed cover-to-cover. About 123 journals are offered in both paper and electronic format, and this number appears to be rising rapidly.

The authors thank B. TePaske-King and P. Shanks of *Mathematical Reviews* for supplying these figures.

Some of the ground covered in the 1990 survey was not duplicated in 1996. In 1990 there were questions probing characteristics that make a good library. These are the same today. The ideal mathematics library has a deep and broad collection including older and historical materials and complete runs of journals. Mathematicians prize ease of access, ability to browse, and a pleasant environment. Professionalism in the staff and good service are also frequently named by mathematicians as important characteristics of a good library.

In the 1996 survey we have been especially interested in comparisons with 1990. Direct comparisons are complicated by the fact that the Group I population has been enlarged from 39 in 1990 to 48 in 1996. Group I is also newly divided into two subgroups, Group I public and Group I private. In some cases Group I public and Group I private were combined for the purpose of comparison with 1990.

These conclusions stand out.

- Significant numbers of journals are being cancelled (Table 1), and some added. Since the questionnaire did not ask the respondents to note if domestic titles were replacing foreign ones or if titles were replaced with those of equal value, we cannot state the extent to which this trend is deleterious. However, a major reshaping of journal collections is under way, from broadly based collections to those which more closely reflect the specific research interests of various departments. Market forces and inflation are driving cancellations. This is shown most strikingly in Group I public universities and Canadian universities: the former with a net change of -22, due to a decrease in state funding, and the latter with a net change of -46, partly due to the decline of the Canadian dollar. Subscriptions of paper journals in 1996 are down about a quarter from 1990. These data are consistent with data published by Chrzastowski and Schmidt (*Library Acquisitions: Practice and Theory*, 1997), which show an overall drop of 18% in domestic science serial holdings in a national aggregate serial collection between 1992 and 1994.
- Serials budgets are up sharply, but they cannot compensate for price increases. The median for Group I rose 58% from 1990 to 1996. Group II rose 32%, Group III rose 20%, and the Canadians rose only 11% in U.S. dollars. Canadian serials budgets increased 30% in Canadian dollars, but a strong decrease in exchange rates for Canadian currency negated much of the budget increase. Spiraling journal costs have hit smaller libraries especially hard, and a growing gap between budgets of large and small libraries may be a byproduct of the journal cost crisis.
- Demand for electronic journals is modest thus far. There is interest in receiving journals in both paper and electronic format. The numbers for purely electronic journals obtained by subscription, or free but cataloged, are very small. At the same time, 60% of all libraries provide access to free electronic preprints, journals, and other mathematical resources such as e-MATH (Table 2, column (H)).
- The Web-based MathSciNet is popular: after only a little more than a year, already 69% of all libraries report that they have subscribed.
- The median for total number of volumes is up 15%. In terms of numbers reporting space problems, this issue seems to take second place to budget shortfalls. The problem is very

serious for those who have it. Space problems affect about 29% of all libraries: 20% have less than a quarter of their books in other locations, 9% a quarter or more. In a subject that has so much emphasis on browsing and the older literature, a badly split collection threatens productivity and quality of scholarship.

- There is an increase in the number of mathematics libraries that are part of a general library or a science and engineering library. The increase appears across all groups. In Group I this is due to at least one change from a departmental library to a science library, but another effect is the change of population by the 25% enlargement of Group I from 1990. We also note erosion of the numbers of mathematics libraries located in the same building as the mathematics faculty. There remains, however, a strong correlation of location in the same building with the top-ranked departments: the figure drops from 73% in Group I to 17% in Group III.
- Oversight by a professional librarian remains strong in 1996 as in 1990. There is an increase from 77% to 91% in Group I. Group III also shows an increase, while Group II is down slightly. The decrease from 75% to 65% in the Canadian group must be read in light of the fact that the 1996 population of the Canadian group is significantly larger than in 1990.

Table 1 shows the net change in number of journals from reported cancellations and additions. The median for the Canadian group is particularly striking when total holdings are taken into account. In Group I about twice as many show a negative net change as positive. Group III stands out in a table not included here for the very small number of additions to replace cancellations; whereas the other groups are reshaping their collections, Group III appears to be mainly reducing.

Table 1

Net change in number of journals:
number added minus number cancelled
(numbers in parentheses show response rates)

	Group I public (20/23)	Group I private (18/22)	Group II (25/37)	Group III (39/48)	Canadian (21/26)	Total (123/156)
80 to 89	1					1
70 to 79						0
60 to 69	1					1
50 to 59						0
40 to 49						0
30 to 39		1				1
20 to 29	1				1	2
10 to 19				1		1
0 to 9	1	8	3	6		18
−1 to −9	2	2	6	10	2	22
−10 to −19	4	4	4	9	1	22
−20 to −29	1	1	3	4	1	10
−30 to −39	1		1	2	5	9
−40 to −49	4		6		1	11
−50 to −59	1			1		2
−60 to −69		1		4	3	8
−70 to −79			1		2	3
−80 to −89	2			1		3
−90 to −99			1		3	4
≤ −100	1	1		1	2	5
Median	−22	0	−18	−10	−46	−16

The next table shows electronic products available in the library:

A. MathSciNet (Web version on the Internet)
B. MathSci online (component of online catalog, through site-load or consortium arrangement)
C. MathSci on CD-ROM
D. Science Citation Index online
E. Science Citation Index CD-ROM
F. CompactMath (online version of *Zentralblatt für Mathematik*)
G. Campus network including some of the above products
H. Access to other electronic sources in mathematics (such as preprints, electronic journals, e-MATH)

Table 2

Electronic products

	A	B	C	D	E	F	G	H
Group I public	19	4	14	5	11	1	5	18
Group I private	20	3	11	4	11	2	4	19
Group II	25	4	14	5	15	3	4	23
Group III	23	3	11	15	14		2	23
Canadian	21	3	8	1	9		3	10
Total	108	17	58	30	60	6	18	93

Over all groups, 69% report use of (A) MathSciNet (Web version) as compared to 37% for (C) the CD-ROM version; 11% have (B) the online version through a site-load or consortium. Only 3% subscribe to (F) CompactMath.

Group III and Canadian institutions are most affected by lack of electronic access; an exception is that the larger libraries in Group III are more likely to have products like (D) and (E).

Comparisons with 1990 are not so easy to make, because the electronic scene has been in such a state of change.

- Already in 1990 most libraries had their catalogs online; asking this question in 1996 did not seem worthwhile, as the practice now is essentially universal.
- Availability of electronic media from faculty offices was an issue in 1990. We conjecture that the nonresponse to our questions in this area means that this is not an issue in 1996; that is, access is widely available to faculty who desire it.
- MathSciNet did not exist in 1990. In 1990 only 28% reported some version of MathSci available in-house in the library; 62% had MathSci available via a vendor. Today having some version of MathSci is on its way to becoming universal in Group I and the Canadian institutions, but Groups II and III lag in this area.

The full report on the survey includes many additional tables and should be consulted for detailed information.

Note: A version of this report is also being published in the November 1997 *CMS Notes*.

MAA Prizes Presented in Atlanta

At the MAA Mathfest in Atlanta in August 1997 the Mathematical Association of America presented a number of prizes.

The Carl B. Allendoerfer Award was established in 1976 to honor articles of expository excellence in the *Mathematics Magazine*. In 1997 the award went to COLM MULCAHY of Spelman College for his article "Plotting and Scheming with Wavelets", *Mathematics Magazine*, December 1996; and to LIN TAN of West Chester University for his article "The Group of Rational Points on the Unit Circle", *Mathematics Magazine*, June 1996.

The Trevor Evans Award, established in 1992, recognizes authors of exceptional articles that are accessible to undergraduates and published in *Math Horizons*. The 1997 award went to WILLIAM DUNHAM of Muhlenberg College for his article "1996—A Triple Anniversary", *Math Horizons*, September 1996; and to DAN KALMAN of American University for his article "A Perfectly Odd Encounter in a Reno Cafe", *Math Horizons*, April 1996.

The Lester R. Ford Award was established in 1964 to honor articles of expository excellence published in *The American Mathematical Monthly*. The 1997 award went to four authors: ROBERT G. BARTLE of Eastern Michigan University for his article "Return to the Riemann Integral", *The Monthly*, October 1996; A. F. BEARDON of Cambridge University for his article "Sums of Powers of Integers", *The Monthly*, March 1996; and JOHN BRILLHART of the University of Arizona and PATRICK MORTON of Wellesley College for their paper "A Case Study in Mathematical Research: The Golay-Rudin-Shapiro Sequence", *The Monthly*, December 1996.

The Merten M. Hasse Award is intended to encourage young mathematicians to take up the challenge of exposition and communication. Presented in alternate years, the prize recognizes a noteworthy expository paper appearing in an MAA publication where at least one of the authors is less than forty years old at the time of the paper's acceptance. The 1997 Hasse award was presented to JONATHAN KING of the University of Florida for his paper "Three Problems in Search of a Measure", *The American Mathematical Monthly*, August-September 1994.

The George Pólya Award, established in 1976, honors articles of expository excellence in *The College Mathematics Journal*. This year the award went to CHRIS CHRISTENSEN of Northern Kentucky University for his article, "Newton's Method for Resolving Affected Equations", *College Mathematics Journal*, November 1996; and to LEON HARKELROAD of Poughkeepsie, New York, for his article "How Mathematicians Know What Computers Can't Do", *College Mathematics Journal*, January 1996.

— *Allyn Jackson*

Forum

On Issues of Immigration and Employment For Mathematicians

Cora Sadosky

The major political and economic changes that shook the world during the last decade led to population displacements. The simultaneous globalization of the economy produced complex effects on unemployment resulting in confusion, exasperation, and despair. Such a reaction is being felt in the U.S. mathematical community, which has faced an unexpected and sustained scarcity of jobs. Issues pertaining to immigration have come before the Society a number of times in the past few years. In view of this I accepted an invitation from the editors of the *Notices* to write on this subject.

Mathematics (Universal Science) in the U.S. (an Immigrant Nation)

Mathematics is the universal science *par excellence*, with no language or national barriers. This constitutes one of its great traditions. The validity of the same theorems in Chicago, Jerusalem, Beijing, Cape Town, Paris, Rio, Cairo, or Tokyo is one of the few things still beyond doubt—ours is an international enterprise.

"Throughout its history, the United States has been a nation of immigrants" reads the first sentence of "The New Americans", the monumental new report produced by the National Research Council on "Economic, Demographic and Fiscal Effects of Immigration" [9]. It concludes that "immigration produces substantial economic benefits to the U.S. as a whole," yet recalls that "the current debate over... immigration is not new; it stretches back even to colonial times. There are concerns about the effects of immigration on the economic prospects of native-born residents." On scientific immigration there is little, and all is praise.

In fact, there is not one significant aspect of American life that has not gained through immigration, from music to modern art and architecture, to sports, to medicine, and—paramount to all—to science. "The emergence of American research mathematics coincides with the founding of Johns Hopkins University and the hiring of the British Algebraist J. J. Sylvester in 1876" [5], while modern medicine began when the new Johns Hopkins School of Medicine brought Sir William Osler from Oxford.

Many of the immigrant scientists arrived already famous, as did Albert Einstein and Emmy Noether, and became the teachers to many of the more senior AMS members. But many others—refugees from Nazism also among them—developed brilliant careers here, building in the process renowned schools in U.S. institutions. The contribution of immigrants to the formation and consolidation of the American mathematical community is well known (see, e.g., [2] and [5]).

In the mathematics departments of many U.S. universities a substantial percentage of professors—in particular, of mathematicians—are foreign born. This would be unthinkable in Europe! It is a sign of how more socially open this country is with respect to the rest of the world. We should be collectively proud of the U.S. openness, which underlines an extraordinary social dynamism. The enlightened acceptance foreigners receive at our universities ought to be promoted as an example to follow.

Shortage of Professional Employment for Mathematicians

All this being widely acknowledged, there is a shortage of mathematical jobs in the United States of unprecedented proportions. Although

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many causes coalesce to produce this problem, some voices are turning to a not-so-new approach: curtail immigration to protect jobs for U.S. nationals.

The problem of finding employment for graduating and recently graduated mathematicians is real and severe. Much has been said about how responsible institutions (like the National Science Foundation or the National Academy of Sciences) have made wrong predictions on the issue in the recent past (see, e.g., [1]).

This appalling situation is not unique to mathematics, but widespread in all academia, worse in the humanities than in the sciences. Many of its causes are common to the problems created by an increasingly global economy, but some are peculiar to the academic environment. Among the latter are declining overall federal funding for basic research, declining states' funding for higher education, and university administrations applying corporate methods to handle the educational boom, which has made colleges and universities into a $180 billion industry, nearly 3 percent of the total U.S. economy (*New York Times*, August 31, 1997).

Under this plight, and finding it plausible that immigration has played a part in the high unemployment figures, a few mathematicians have gone to the public (see, e.g., articles in the *Wall Street Journal*, September 4, 1996, and in the *Boston Globe*, March 17, 1997) and to Congress, urging that the immigration of research scientists and university professors be restricted.

Traditional Scapegoat: The Alien

"2,000,000 chomeurs = 2,000,000 arabes" was Le Pen's slogan for the French National Party last fall. ("Chomeurs" translates as unemployed.) The FNP had to do away with this one xenophobic slogan when it was pointed out in the press as a carbon copy of the anti-Semitic slogan of the Vichy Government during WWII: "200,000 chomeurs = 200,000 juifs". ("Juifs" translates to Jews.) The public found it a bit too much to swallow, even with the high rates of unemployment that exist in France.

But if this happens in France, the cradle of rationalism and once a traditional refuge from persecution, what can one expect from the rest of the world? Elsewhere immigrants are often held responsible for social ills such as epidemics, housing shortages, lower economic standards, and unemployment.

Study after study has failed to substantiate these perceptions, but they still are used to create a scapegoat to explain every evil people suffer from. No need to look for real causes then, much less for solutions.

In the early 1990s at the start of the current job shortage in mathematics the easy explanation was "women are getting all the jobs". Although AMS data provided the basis for an effective early refutation [3, 7], it helped spread stereotypes while diverting attention from the search for solutions.

Now some would make foreigners rather than women the scapegoats. *It is imperative that the xenophobic "foreigners are getting all the jobs" does not become a rallying cry for inaction on the real causes of the problem.*

"Do Baptist Preachers Cause Public Drunkness?"

"I raise this unlikely inquiry because an old and famous tabulation clearly shows a strong positive correlation between the number of preachers and the frequency of arrests for inebriation during the second half of the nineteenth century in America.

"You don't need a Ph.D. in logic to spot the fallacy in my first sentence. Correlation is not causality. The undeniable association of preachers and drunks might mean that hellfire inspires imbibing, but the same correlation could also (and more reasonably) suggest the opposite causal hypothesis that the rise in public drinking promotes the hiring of more preachers. But yet another possibility—almost surely correct in this particular case—holds that preaching and drinking may have no causal relationship, while their simultaneous increase only records a common link to a third, truly determining factor. The steady rise of the American population during the late nineteenth century promoted an increase in thousands of phenomena linked to total numbers, but otherwise unrelated—arrests for drinking and hiring of clergy among them. This tale has long served as the standard textbook example for illustrating the difference between correlation and causality" [4, p. 296].

Surely mathematicians know better than to mistake correlation with causality in their efforts to deal with the current job crisis.

Enrollments Decline and Part-Timers Are the Cheap Solution

Recent data suggest that we ought to be paying more attention to other factors in mathematical unemployment in addition to those stemming from the global economy and from changes in government funding. From 1990 to 1995 enrollment in calculus decreased by over 100,000 students at all four-year institutions according to [6, Table 1]. During the same time period calculus enrollment at two-year community colleges increased by 5,000. Both the net enrollment decrease and the shift between institutions represent a significant number of positions [8]. Assuming full-time faculty normally teach 100 students of calculus per semester, this can add up

to a loss of 1,000 full-time faculty positions. Not a figure to disregard.

Worse, as new enrollments increase again the positions lost will probably not be replaced in kind, but by part-time, low-paying, no-benefits, heavy-teaching, nonpermanent jobs.

The Size of Graduate Programs and Chinese Students Who Stayed

Under the (debatable) assumption that "we are producing too many Ph.D.s," there is talk of the need to downsize graduate output. It is easy to err with such a policy—we have seen how predictions made twelve years ago were flawed. It is also hard to implement, since it is usually somebody else's graduate program that we would agree to cut. Professors need the graduate programs to justify their research as part of their thesis advising, and chairmen need graduate students as teaching assistants to sustain their undergraduate programs.

When the number of graduate students began to decrease in the 1980s, the Chinese were welcomed. But the influx of Chinese students was not purely spontaneous. The visits of prestigious mathematicians to Beijing were followed by the appearance in their institutions of talented and extremely hard-working students, without whom entire programs would have disappeared. And after graduation they went home. Everybody was happy. Then came the massacre at Tienanmen Square, the Chinese students started to remain in the U.S., and they needed jobs. Even now the U.S. graduates from China face an employment problem far worse than any other group of mathematicians in the U.S., so grave that it has created a racist atmosphere damaging even U.S.-born citizens bearing a Chinese name.

A steady flow of foreign students has come to this country since the 1960s when it became clear that the U.S. had the best graduate education in the world. After a postdoctoral period, most foreign graduates yearn to go home. But it is not always easy or possible to do so. The worst-case scenario is when returning may mean the loss of freedom or life. This is but one more reason why the American mathematical community should care about the human rights situation in China and elsewhere.

Perceptions, Competition, and the American Way

This is not the first time that historical events led to an influx of foreign scientists, as did racist persecution and war in the 1930s and 1940s. Yet it has been repeatedly claimed in the press and in [1] that the current increase in scientific immigration transcends the historical events of the last decade, such as the massacre at Tienanmen Square and the demise of the Soviet Union.

However, a recent NSF study shows that this perception is false. In 1993 the number of people in all fields of science and engineering admitted to the U.S. on permanent visas peaked at 23,534. But in 1994 the number of these immigrants admitted had dropped to 17,403, or a decline of 26 percent. "The number of immigrant scientists and engineers entering the United States each year was stable throughout the 1980s, rose in the early 1990s, and then declined dramatically in 1994 back toward 1980s levels. The latest data indicates that what observers thought was a major, long-term rise in skilled immigrants was only a temporary surge"[10].

The increased influx of mathematicians associated with the dissolution of the Soviet Union coincided with the onset of employment problems. Many of the incoming mathematicians were already very accomplished, while most of the rest had training both broad and deep. Some decried this as unfair competition. Why unfair?

Is it the American Way to give preference to less-qualified U.S. citizens? While the true American Way would be to improve the U.S. educational system to train our graduates so as to ensure their competitiveness, is barring competitive foreigners a New American Way of Affirmative Action?

This would be a perverse caricature—one all too common and responsible for much current backlash. Affirmative action is not about *closing* doors for those who are able and well trained in favor of those who are not. It is about *opening* opportunities to *all* those who are able to become well trained and to compete as such.

Let us work to eliminate the stereotype of foreigners as smart but unable to teach simply because they have accents. Both U.S. nationals and immigrants should be judged on their true mathematical and pedagogical talents when they seek opportunities to flourish.

Who Wants to Be a Mathematician? How to Remain One?

"There is considerable evidence that labor market considerations play a strong role in determining educational and career choices for young people" [1]. This seems to be so and is an important factor in the sharply declining number of U.S. nationals that pursue Ph.D.s in mathematics. "To our most talented students, the mere $6,000 difference in starting salary over that for mathematics bachelor's degree holders does not make a strong economic case for years of intensive postbaccalaureate training amidst deteriorating employment conditions" [1]. But

since when are mathematicians selected on their ambition to make money?

Mathematics is hard. The training requires a lifetime of work; it brings usually less money than corporate law, surgery, or really good computer wizardry; and job security is dependent on circumstances and economics. Those who opt out of mathematics on the basis of economics have made the right choice. There is no way we can attract them—much less keep them—with mere economic incentives. Nor should we want to.

If we are talking about how to attract and keep in the profession all those with strong inclination for the unique pleasures of mathematics, that is another question. At the very least they need to be able to make a decent living and to work under conditions conducive to doing mathematics.

Many young mathematicians are trying to develop research careers in difficult circumstances. Research mathematicians in nonresearch environments, including those at nondoctoral institutions, need support. For ages many women have faced these difficulties without help, and some have survived as mathematicians. Their experiences could help others, and their losses should not be repeated. Now some see promising young mathematicians take positions at nonresearch institutions, and they cry foul. Instead, we should help devise support systems to make small-college positions compatible with research.

Conclusion

The employment problem in mathematics exists and is very serious, warping the lives of many people. It is not clear what the future will bring, yet we have to oppose measures that carry a terrible social cost. It is morally imperative to seek rational and democratic solutions—nonexclusionary, embracing all ethnic groups—in keeping with America's tradition of openness.

Banning immigrant mathematicians would, at best, make a few positions available without going to the roots of the problem yet creating others.

The American Mathematical Society has gone on record deploring restrictions in the new immigration law[1], signaling that a significant segment of the community does not see foreign mathematicians as the problem.

Finding ways to support an active research population in the U.S. will become increasingly difficult in an era of globalization of the world economy, where the competition is fierce and international.

As an organized community we have to react positively to the challenge, not by asserting supposed birth rights of the U.S.-born in divisive chauvinist quests, or with anti-immigration innuendo, but with constructive proposals to improve the teaching of mathematics at all levels throughout America and to ensure the possibility of doing research outside the top institutions.

We can and must defend the profession and all of its members, and we will succeed only if we act in concert.

[1] *At its meeting in April 1996, the AMS Council expressed alarm at then-pending federal legislation to restrict visits and immigration by academic scholars [11]. Despite the concerns voiced by the AMS and other groups, the bill was enacted into law in September 1996. At its meeting in January 1997, the AMS Council passed a resolution deploring provisions of the bill [12]. In April 1997 the Council approved, so as to speak in the name of the Society, the first four paragraphs of that resolution [13].*

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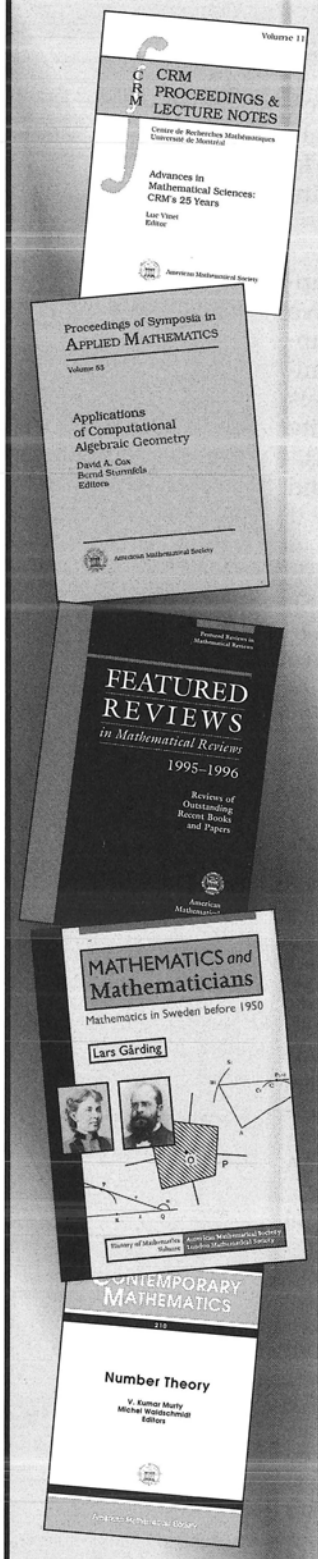

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Advances in Mathematical Sciences: CRM's 25 Years

Luc Vinet, *Centre de Recherches Mathématiques, Université de Montréal, PQ, Canada*, Editor

This volume commemorates the 25th anniversary of the Centre de Recherches Mathématiques (CRM)—a national institute for research in the mathematical sciences in Canada. It includes contributions by eminent scientists who have been closely involved with the CRM. Various topics in pure and applied mathematics, statistics, theoretical physics, and mathematical biology are covered. Original research papers, reviews, as well as historical notes and reminiscences are included in the volume.

CRM Proceedings & Lecture Notes, Volume 11; 1997; 491 pages; Softcover; ISBN 0-8218-0686-6; List $99; Individual member $59; Order code CRMP/11NA

Applications of Computational Algebraic Geometry

David A. Cox, *Amherst College, MA*, and **Bernd Sturmfels**, *University of California, Berkeley*, Editors

This book introduces readers to key ideas and applications of computational algebraic geometry. Beginning with the discovery of Gröbner bases and fueled by the advent of modern computers and the rediscovery of resultants, computational algebraic geometry has grown rapidly in importance. The fact that "crunching equations" is now as easy as "crunching numbers" has had a profound impact in recent years. At the same time, the mathematics used in computational algebraic geometry is unusually elegant and accessible, which makes the subject easy to learn and easy to apply.

This book begins with an introduction to Gröbner bases and resultants, then discusses some of the more recent methods for solving systems of polynomial equations. A sampler of possible applications follows, including computer-aided geometric design, complex information systems, integer programming and algebraic coding theory. The lectures in the book assume no previous acquaintance with the material.

Proceedings of Symposia in Applied Mathematics, Volume 53; 1998; 173 pages; Hardcover; ISBN 0-8218-0750-1; List $35; All AMS members $28; Order code PSAPM/53NA

Featured Reviews in *Mathematical Reviews* 1995–1996

Donald G. Babbitt, *Publisher, American Mathematical Society, Providence, RI*, and **Jane E. Kister**, *Associate Executive Editor, Mathematical Reviews, Ann Arbor, MI*, Editors

This collection of reprinted Featured Reviews published in *Mathematical Reviews* (MR) in 1995 and 1996 makes widely available informed reviews of some of the best mathematics published recently.

All of the papers reviewed here contain interesting new ideas or applications, a deep synthesis of existing ideas, or any combination of these. The volume is intended to lead the user to important new research across all fields covered by MR.

Featured Reviews from Mathematical Reviews; 1998; 380 pages; Softcover; ISBN 0-8218-0771-4; List $39; All AMS members $31; Order code FREV/1NA

Mathematics and Mathematicians

Mathematics in Sweden before 1950

Lars Gårding, *Lund University, Sweden*

This book is about mathematics in Sweden between 1630 and 1950—from S. Klingenstierna to M. Riesz, T. Carleman, and A. Beurling. It tells the story of how continental mathematics came to Sweden, how it was received, and how it inspired new results. The book contains a biography of Gösta Mittag-Leffler, the father of Swedish mathematics, who introduced the Weierstrassian theory of analytic functions and dominated a golden age from 1880 to 1910.

Important results are analyzed and re-proved in modern notation, with explanations of their relations to mathematics at the time. The book treats Bäcklund transformations, Mittag-Leffler's theorem, the Phragmén-Lindelöf theorem and Carleman's contributions to the spectral theorem, quantum mechanics, and the asymptotics of eigenvalues and eigenfunctions. Other important features include sketches of personalities and university life.

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

History of Mathematics, Volume 13; 1997; 268 pages; Hardcover; ISBN 0-8218-0612-2; List $75; Individual member $45; Order code HMATH/13NA

Number Theory

V. Kumar Murty, *University of Toronto, ON, Canada*, and **Michel Waldschmidt**, *Université Pierre et Marie Curie, Paris, France*, Editors

To observe the tenth anniversary of the founding of the Ramanujan Mathematical Society, an international conference on Discrete Mathematics and Number Theory was held in January 1996 in Tiruchirapalli, India. This volume contains proceedings from the number theory component of that conference. Papers are divided into four groups: arithmetic algebraic geometry, automorphic forms, elementary and analytic number theory and transcendental number theory. This work deals with recent progress in current aspects of number theory and covers a wide variety of topics.

Contemporary Mathematics, Volume 210; 1997; 399 pages; Softcover; ISBN 0-8218-0606-8; List $69; Individual member $41; Order code CONM/210NA

Partial Differential Equations

Harold Levine, *Stanford University, CA*

The subject matter partial differential equations (PDEs) has a long history dating from the 18th century and an active contemporary phase. An early phase (with a separate focus on taut string vibrations and heat flow through solid bodies) stimulated developments of great importance for mathematical analysis, such as a wider concept of functions and integration, the existence of trigonometric or Fourier series representations. The direct relevance of PDEs to all manner of mathematical, physical and technical problems continues. This book presents a reasonably broad introductory account of the subject, with due regard for analytical detail, applications and historical matters.

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

AMS/IP Studies in Advanced Mathematics, Volume 6; 1997; 706 pages; Hardcover; ISBN 0-8218-0775-7; List $69; All AMS members $55; Order code AMSIP/6NA

Studies on Composition Operators

Farhad Jafari, *University of Wyoming, Laramie*, **Barbara D. MacCluer**, *University of Virginia, Charlottesville*, **Carl C. Cowen**, *Purdue University, West Lafayette, IN*, and **A. Duane Porter**, *University of Wyoming, Laramie*, Editors

This book reflects the proceedings of the 1996 Rocky Mountain Mathematics Consortium conference on "Composition Operators on Spaces of Analytic Functions" held at the University of Wyoming. Readers will find here a collection of high-quality research and expository articles on composition operators in one and several variables. The book highlights open questions and new advances in the classical areas and promotes topics which are left largely untreated in the existing texts.

Contemporary Mathematics, Volume 213; 1997; 252 pages; Softcover; ISBN 0-8218-0768-4; List $49; Individual member $29; Order code CONM/213NA

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 02206-5904, USA. For credit card orders, fax (401) 455-4046 or call toll free 800-321-4AMS (4267) in the U. S. and Canada, (401) 455-4000 worldwide. Or place your order through the AMS bookstore at http://www.ams.org/bookstore/. Residents of Canada, please include 7% GST.

Mathematics People

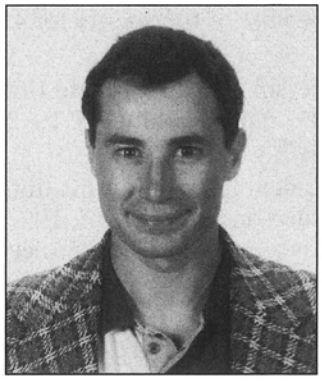
Coxeter Receives Sylvester Medal

H. S. M. COXETER, Professor Emeritus of Mathematics at the University of Toronto, has been awarded the Sylvester Medal of the Royal Society. He received the honor "in recognition of his achievements in geometry, notably projective geometry, non-euclidean geometry and the analysis of spatial shapes and patterns, and for his substantial contributions to practical group theory which pervade much modern mathematics."

— Royal Society

Loïc Merel Receives Blumenthal Prize

The Leonard M. and Eleanor B. Blumenthal Award for the Advancement of Research in Pure Mathematics has been awarded to LOÏC MEREL of Université Denis Diderot, Paris VII. The award was presented at the AMS meeting in Montreal, Canada, on September 27, 1997, where Merel also presented a lecture entitled "Rational Points: The Case of Elliptic Curves".



Merel was born in Carhaix-Plouguer, Brittany, France, on August 13, 1965. In 1986 he became a student at the École Normale Supérieure, where his interest in number theory was kindled. In 1989 he began a thesis on modular symbols under the supervision of Joseph Oesterlé of the Université Pierre et Marie Curie, Paris VI. Merel took inspiration from the work of Y. Manin and B. Mazur from the 1970s. After a year of military service at the École Polytechnique, Merel completed his Ph.D. in 1993. He then took a CNRS position in the team Problèmes Diophantiens at the Université Pierre et Marie Curie. By combining the techniques developed in his thesis with work of other people, Merel proved that the torsion of elliptic curves over number fields is uniformly bounded. On the basis of that result, he obtained his habilitation in 1994. He held a Miller Professorship at the University of California, Berkeley from 1995 to 1997. He is currently a professor at the Université Denis Diderot.

Merel received the Saintour Prize (1994) and the Peccot Prize (1995) of the Collège de France, the Bronze Medal of the CNRS (1995), and the European Mathematical Society Prize at the European Congress of Mathematics in Budapest (1996).

The Leonard M. and Eleanor B. Blumenthal Trust for the Advancement of Mathematics was created for the purpose of assisting the Department of Mathematics of the University of Missouri at Columbia, where Leonard Blumenthal served as professor for many years. Its second purpose is to recognize distinguished achievements in the field of mathematics through the Leonard M. and Eleanor B. Blumenthal Award for the Advancement of Research in Pure Mathematics, which was originally funded from the Eleanor B. Blumenthal Trust (dated September 24, 1984) upon Mrs. Blumenthal's death on July 12, 1987.

The Trust, which is administered by the Financial Management and Trust Services Division of Boone County National Bank in Columbia, Missouri, pays its net income to the recipient of the award each year for four years. The recipient is selected by a committee of five members, each of whom has made notable contributions to mathematics. On the committee are Hendrik Lenstra (chair), University of California, Berkeley; Ronald Coifman, Yale University; Benedict Gross, Harvard University; Thomas C. Spencer, Institute for Advanced Study; and Robert J. Zimmer, University of Chicago.

The recipient accepts the award in person and immediately following the formal presentation of the award gives an address on the research for which the award was given. The recipient also presents his or her current research

in an address to at least one meeting of an academy or mathematical society over the next four years.

— *AMS Announcement*

Nomizu Receives Blaschke Medal

The Wilhelm Blaschke Memorial Foundation of Hamburg has awarded the Blaschke Medal to KATSUMI NOMIZU of Brown University. A Festkolloquium in honor of Nomizu was held in Hamburg in October and featured several lectures on modern developments in affine differential geometry as well as the medal presentation ceremony.

Nomizu was born in Osaka, Japan, and was educated in Japan and the United States. He received his Ph.D. from the University of Chicago in 1953 and worked in Japan and France before going to Brown University in 1960. A prominent differential geometer, Nomizu has lectured widely in the United States and Europe and is the author of over 85 scientific papers and 7 books. His most widely known work is the two-volume *Foundations of Differential Geometry*, which he wrote with S. Kobayashi of the University of California, Berkeley. It became the standard reference text for a generation of differential geometers. A theme running through Nomizu's mathematical career has been affine differential geometry, starting with his Ph.D. thesis and continuing through his most recent mathematical papers. While maintaining his active research career, Nomizu retired from Brown University in 1995 as the Florence Pirce Grant University Professor and Professor of Mathematics.

Wilhelm Blaschke (1885–1962) was a prominent geometer and professor of mathematics at the Universität Hamburg from 1919 through his retirement in 1953. He worked in the area of differential geometry and is known for his geometrical intuition and his use of analytic techniques. His major work, the three volumes of *Vorlesungen über Differentialgeometrie* (1921–1929), was influential in the modern development of the field. Volume 2 of this work is dedicated in particular to the exposition of affine differential geometry. Under his influence the Universität Hamburg became a prominent center for mathematics, and Blaschke attracted there the well-known mathematicians E. Artin, E. Hecke, and H. Hasse.

— *Walter Craig, Chair, Mathematics Department, Brown University*

NRC-Ford Foundation Minority Fellowships

The National Research Council administers the Ford Foundation fellowship program, which awards fellowships to outstanding minority graduate students and postdoctoral researchers. This year the program presented 100 fellowships in mathematics, the sciences, and the humanities. One award was made in mathematics, to JIM A. BRYAN of the University of California, Berkeley.

— *from NRC News Release*

Presidential Awards for Mentoring

Ten individuals and nine institutions have been named winners of the 1997 Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring. This is the second year of the award, administered and funded through the National Science Foundation (NSF). The awards recognize outstanding individual efforts and organizational programs to increase the participation of underrepresented groups in science, mathematics, and engineering at the K–12 through graduate level. Up to ten individuals and ten institutions annually may qualify for the award, which includes a $10,000 grant and a commemorative presidential certificate.

Among the individual awardees were four in the mathematical sciences: CARLOS CASTILLO-CHAVEZ, Cornell University; DAVID FERGUSON, State University of New York, Stony Brook; ROBERT MEGGINSON, University of Michigan; and WILLIAM Y. VELEZ, University of Arizona. Among the institutions receiving the awards is University of Texas, San Antonio, which was honored for the Pre-Freshmen Engineering Program (PREP), directed by mathematician Manuel Berriozabal.

— *from NSF News Release*

Deaths

RODERICK P. C. CALDWELL, associate professor at the University of Rhode Island, died on September 8, 1997. Born on March 18, 1915, he was a member of the Society for 43 years.

LOUIS HERMAN, associate professor at Kansas State University, died on August 19, 1997. Born on June 25, 1942, he was a member of the Society for 31 years.

ANDREY MALISHEVSKI, senior resident fellow at the Institute of Control Sciences, Moscow, died on September 4, 1997. Born on March 17, 1943, he was a member of the Society for 2 years.

MASAMI OKADA, professor at Tohoku University, Japan, died on August 11, 1997. Born on February 11, 1951, he was a member of the Society for 13 years.

CHARLES L. RIGGS, of Lubbock, Texas, died on November 30, 1996. Born on August 13, 1923, he was a member of the Society for 47 years.

Mathematics Opportunities

News from DIMACS

DIMACS, the Center for Discrete Mathematics and Theoretical Computer Sciences, will hold its 1998–1999 Special Year on Large Scale Discrete Optimization.

This special year is motivated by developments in the past ten years. There have been three simultaneous advances: at the algorithmic level, with new and interesting algorithms for solving large scale discrete problems both exactly and approximately; at the implementation level, providing codes and systems for solving such problems; and at the practical level, with interests in the fast solution of real world problems. Examples of such applications include airline crew scheduling, chemical process design, and telecommunication network design. The goal in this year is to unite these groups. The confluence of exciting recent work on approximation and other algorithms and greatly improved software/hardware for optimization makes large scale discrete optimization a practical, useful approach to solving problems of practical interest.

The special year organizers hope to provide forums to increase research contacts between groups not frequently in contact—for example, practitioners and academics, operations research and computer science researchers, theoretically oriented researchers (in areas such as interior point IP methods, combinatorial geometry approaches, approximation methods, and group formulations) and computationally oriented researchers, including those interested in AI techniques such as constraint programming.

A variety of workshop and mini-workshop topics are under consideration. A pre-special-year workshop on Large Scale Discrete Optimization organized by R. Ravi and Vijay Vazirani is already planned for May 27–29, 1998. Among the topics under consideration are large scale discrete optimization in engineering, in production and scheduling, in transportation, in robotics and vision, and in data mining, as well as algorithms for large scale discrete optimization, semidefinite programming, and constraint programming. In addition, there will be at least one Computational Challenge, addressing one or more problems in large scale discrete optimization. Those with suggestions for workshops or who are interested in aiding the organization of workshops should contact the organizing committee.

Applications for research and graduate student visits to the center are invited. Some funds are available for travel and local support. Two postdoctoral positions will be offered in this area.

Organizers for the special year are: Endre Boros (Rutgers/DIMACS) (local chair), William Pulleyblank (IBM), Michael Trick (Carnegie Mellon) (general chair), Bob Vanderbei (Princeton/DIMACS), and Vijay Vazirani (Georgia Tech). Researchers interested in early discussions about visiting are encouraged to contact the organizing committee by sending e-mail to `dimacs98@mat.gsia.cmu.edu`. Information about workshops and other activities will be made available on the DIMACS Web site at `http://dimacs.rutgers.edu/`. The mailing address is DIMACS Center, Rutgers University, P.O. Box 1179, Piscataway, NJ 08855-1179. The telephone number is 732-445-5928.

—from DIMACS Announcement

ICM-98 Grants for Mature Mathematicians from Developing Countries

The International Congress of Mathematicians will be held August 17–27, 1998, in Berlin, Germany. The Organizing Committee of ICM-98 has set up programs whereby young mathematicians from developing countries and mathematicians from Eastern Europe can attend ICM-98. The Organizing Committee has received a number of requests for support for mature mathematicians (age 35 or older) from developing countries who are not eligible for support under the other ICM-98 grant programs. To meet this need, the ICM-98 Committee for Support of Mathematicians from Developing Countries (CSMDC) was established.

This committee will consider applications from mature mathematicians (older than 35 years of age at the occasion of the Congress) with residence in developing countries for grants to attend ICM-98. The funds for financial support are very limited. To secure the participation of as many persons as possible, only local costs in Berlin (registration, board and lodging) will be supported. Travel grants can only be provided in exceptional cases.

The deadline for the submission of applications is **January 1, 1998**. All applications will be reviewed and all applicants will be informed about the result immediately after May 1, 1998.

For further information and application forms, visit the ICM-98 Web site at `http://elib.zib.de/ICM98/`.There is a mirror site at the AMS at `http://www.emis.ams.org/mirror/ICM98/`. One may also write to: Freie Universität Berlin, Fachbereich Mathematik und Informatik, ICM-CSMDC, Arnimallee 2-6, 14195 Berlin, Germany. E-mail requests may be directed to Gerhard Berendt, `berendt@math.fu-berlin.de`, or to Eberhard Letzner, `letzner@math.fu-berlin.de`.

— from ICM-98 Announcement

NRC-Ford Foundation Postdoctoral Fellowships for Minorities

The National Research Council (NRC) administers the Ford Foundation Postdoctoral Fellowships for Minorities. This program enables teacher-scholars to engage in postdoctoral research and scholarship in an environment free from the interference of their normal professional duties and helps them to achieve greater recognition in their respective fields and to develop the professional associations that will make them more effective and productive in academic employment.

To be eligible, applicants must be U.S. citizens or nationals who are members of one of the following ethnic minority groups: Alaskan Natives (Eskimo or Aleut), Black/African Americans, Mexican Americans/Chicanas/Chicanos, Native American Indians, Native Pacific Islanders (Polynesian or Micronesian), or Puerto Ricans. Applicants are required to have earned the Ph.D. or Sc.D. degree by March 10, 1998, from a U.S. educational institution and may not have held the degree for more than seven years as of the deadline date.

Approximately 25 one-year postdoctoral fellowships are given each year. The total amount of the fellowship is $35,000, which includes a $25,000 stipend. The deadline to apply is **January 5, 1998**, and awards will be announced in early April 1998.

For further information, consult the NRC Web site `http://www2.nas.edu/fo/` or contact: Fellowship Office, National Research Council, 2101 Constitution Avenue, NW, Washington, DC 20418; telephone 202-334-2860.

— from NRC Announcement

Society of Women Engineers

The Society of Women Engineers is seeking applicants for 56 scholarships in amounts varying from $1,000 to $5,000 and totaling more than $75,000. Scholarships are available for reentry, undergraduate, and graduate students. While none of the scholarships is for mathematics students, mathematics faculty may wish to refer mathematically inclined computer science and engineering students to this program. The deadline to apply is **February 1, 1998**.

For further information, contact: Society of Women Engineers, 120 Wall Street, 11th Floor, New York, NY 10005-3902; telephone 212-509-9577; fax 212-509-0224; e-mail `hq@swe.org`.

— Allyn Jackson

For Your Information

BMS Workshop Report Available

The Board on Mathematical Sciences (BMS) of the National Research Council (NRC) has issued the report *Preserving Strength While Meeting Challenges.* The product of a workshop held in May 1996, the 83-page report contains papers on a range of issues facing the mathematical sciences community.

The last section of the report contains a summary of the proceedings of the workshop. "The summary was prepared by the BMS and reviewed by the NRC in accordance with the usual NRC report reviewing procedures," writes workshop chair Avner Friedman in the report's preface. "The BMS believes that the views expressed at the workshop should be seen by the mathematical sciences community at large." What follows is from the "Closing Observations" section of the summary.

Closing Observations

• To preserve the discipline's strengths while meeting challenges posed by a changed environment, the U.S. mathematical sciences community's major national responsibilities include:

1. Promoting research and discovery in all areas of the mathematical sciences so that the U.S. will continue to maintain preeminence in these powerful, innovative endeavors;
2. Supporting the use of mathematical results and acumen in order to increase the capabilities of the various scientific and engineering disciplines and to help advance science and technology in the United States; and
3. Providing top-quality education and skills in the mathematical sciences at all levels and for all members of the student population to ensure that the United States will continue to have a scientifically and technically trained work force and an informed citizenry.

• Fulfilling these responsibilities is doubly challenging in the current changed environment. The end of the cold war has increased the national emphasis on economic competitiveness and pressing social concerns, health care issues, and environmental needs. One consequence of this shift in national priorities is that a strong scientific base, as an end in itself, is not as high a priority as it was. Another change affecting the environment for science, and for the mathematical sciences, involves the national resolve to balance the federal budget and to cut government spending.

• There are several implications of these changes. In the near future there may be less public money (in constant dollars) for support of universities and of scientific research. Also, the scientific community may have to justify much of its research as contributing to societal goals. For example, quality education, especially K–12 education, for all segments of society remains high on the national agenda and is a goal to which the scientific community is expected to contribute. What support—both political and financial—there now is for the mathematical sciences may well diminish if the community's responsibilities are not met. On the other hand, efforts to meet those responsibilities can provide opportunities for additional resources.

• Action might be taken by different cohorts within the mathematical sciences community on various fronts. For example, it is clear that much of the educated public, including the scientifically educated public, is unaware of new discoveries in the mathematical sciences and their importance. The general public also is not made aware of the fundamental contributions of the mathematical sciences to many advances in science and technology. In the general technical community, there is a sense that the mathematical sciences community could do more to accelerate

the impact of mathematical sciences research on science, technology, and society in general.

• The mathematical sciences community has not been very successful in the important area of attracting underrepresented minority groups, and the disproportionately small number of women at many levels in the mathematical sciences is self-evident. By identifying broader career opportunities in the mathematical sciences, some of the obstacles to attracting these groups to the mathematical sciences might be overcome.

• A further area where mathematical sciences involvement could be increased is in the education of all undergraduates. It is important for mathematical sciences departments to strengthen their scientific and educational ties with the university community at large. It is also important that the full mathematical sciences community enhance its scientific and educational ties with the general scientific and technological community. The pervasiveness of the mathematical sciences in those diverse areas makes this both a responsibility and an opportunity.

• In light of the present environment for science and the direction that continuing change in that environment will likely take, how the mathematical sciences community now acts could be crucial to its future strength and health and so deserves urgent attention. The mathematical sciences community now faces serious challenges in a changing and demanding environment that warrant quick and effective responses. The health of the mathematical sciences community and how well it fulfills its national responsibilities depend on its ability to resolve these issues.

• Clearly a successful resolution of these issues requires the active participation of mathematical sciences departments, the professional societies, and the community as a whole.

For Information

For further information on this and other BMS reports, consult the BMS Web site at `http://www2.nas.edu/bms/`. Or contact: Board on Mathematical Sciences, National Research Council, 2101 Constitution Avenue, NW, Washington, DC 20418; telephone 202-334-2421; e-mail: `bms@nas.edu`.

— Allyn Jackson

B. N. Prasad Centenary Commemoration

The Committee for Publications of the Allahabad Mathematical Society invites contributions to special commemorative volumes of the *Indian Journal of Mathematics* and the *Bulletin of the Allahabad Mathematical Society*. These volumes will commemorate the 100th anniversary of the birth of B. N. PRASAD (1899–1966), founder of the Society. The material will appear in volume 41 (1999) of the *Journal* and volume 14 (1999) of the *Bulletin*.

Contributions for the commemorative volumes should reach the editors preferably by August 1998; those received after December 1998 may have to be shifted to a later volume. For further information, contact Pramila Srivastava, Chair, Committee for Publications, Allahabad Mathematical Society, 10, C.S.P. Singh Marg, Allahabad 211 001, India; e-mail: `pramila@almas.almas.wiprobt.ems.vsnl.net.in`.

— Pramila Srivastava

Members Dues Information

The Internal Revenue Code requires that not-for-profit organizations advise their members of the amount of their dues which is tax deductible as a charitable contribution. The determination of this amount must reduce the dues payment by the "fair value" of the benefits received as a member. When journals or magazines are privileges of membership, the "fair value" of membership rights includes the price that nonmembers would have to pay for the journals or magazines. Other benefits of membership are less easily quantified, and include such items as the availability of discounts on publications and meeting registration fees.

Staff of the Society have studied these issues and consulted with other professionals, and have concluded that no portion of a member's dues to the AMS is tax deductible as a charitable contribution. However, a member's dues payment to the AMS may be tax deductible under other provisions of the Internal Revenue Code, such as those addressing professional expenses. Members should consult with their personal tax advisors.

—AMS Fiscal Department

Statistics Teachers Group

In the summer of 1991 a group now known as the Isolated Statisticians met for the first time at the Joint Statistics Meetings. These individuals were largely from departments in which they were the only statistician. They found they had no one with whom to exchange ideas about picking a statistics textbook, trying a new teaching technique for statistics, or incorporating technology into their statistics courses. Starting with 15 participants in 1991, the informal "Isostat" meeting has become a yearly event. The group has held its own national meeting in 1995 and eleven regional workshops in 1996 and 1997 and also has an e-mail network of 150 people.

The group will meet for an informal discussion on Friday, January 9, from 7–9 p.m. at the Joint Mathematics Meetings in Baltimore. For further information, contact: Dexter Whittinghill, Department of Mathematics, Rowan University, Glassboro, NJ 08028; e-mail `whittinghill@rowan.edu`.

— Dexter Whittinghill, Rowan University

From the AMS

Honorary Members of the AMS

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

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

James C. Abbott
Clarence M. Ablow
H. L. Alder
Franz L. Alt
German Ancochea
R. Lucile Anderson
Richard D. Anderson
Theodore W. Anderson
Thomas B. Andrews Jr.
Tom M. Apostol
Richard F. Arens
Bradford H. Arnold
Winifred A. Asprey
Silvio Aurora
Christine W. Ayoub
Edward G. Baker
George A. Baker Sr.
Richard W. Ball
Donald H. Ballou
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Paul T. Bateman
Helen P. Beard
Marjorie Heckel Beaty
Frank S. Beckman
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Philip O. Bell
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Ebon E. Betz
Z. William Birnbaum
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William A. Blankinship
Joseph Blum
William M. Boothby
Truman A. Botts
Julia W. Bower
Harold E. Bowie
Evelyn Hull Boyle
Wray G. Brady
Joel L. Brenner
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F. Eugene Clark
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Mary Dean Clement
Haskell Cohen
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Michael Golomb
Mario O. Gonzalez
Richard A. Good
A. W. Goodman
Walter H. Gottschalk
John W. Green
Bernard Greenspan
Thomas N. E. Greville
Norman G. Gunderson
Margaret Gurney
Theodore Hailperin
Deborah Tepper Haimo
Paul R. Halmos
Carl Hammer
George H. Handelman
Frank Harary
R. I. Hardin
Walter J. Harrington
I. Henson Harris
Philip Hartman
A. Raymond Harvey
George E. Hay
Charles A. Hayes
Maurice H. Heins
Alex Heller
Erik Hemmingsen
Leon A. Henkin
Anna S. Henriques
John G. Herriot
Ivan R. Hershner Jr.
Fritz Herzog
Edwin Hewitt
F. B. Hildebrand
Abraham P. Hillman
W. M. Hirsch
Elizabeth S. Hirschfelder
Gerhard P. Hochschild
William C. Hoffman
Alfred Horn
Bernard E. Howard
Chuan C. Hsiung
Raymond Huck
Gerald B. Huff
M. Gweneth Humphreys
Louise S. Hunter
Solomon Hurwitz
Harry D. Huskey
Eugene Isaacson
Robert F. Jackson
William H. Jaco
Florence D. Jacobson
Nathan Jacobson
William J. Jaffe
Robert C. James
James A. Jenkins
Ralph N. Johanson
L. Wayne Johnson
F. Burton Jones
Phillip S. Jones
Bjarni Jonsson
Shizuo Kakutani
Gerhard K. Kalisch
Edward L. Kaplan
Samuel Kaplan
Wilfred Kaplan
Irving Kaplansky
Paul J. Kelly
Edward S. Kennedy
Harry S. Kieval
Wilfred M. Kincaid
David B. Kirk
Victor Klee
Horace Komm
H. S. Konijn
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Carl F. Kossack
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Joseph Landin
Ray G. Langebartel
J. Halcombe Laning
Everett H. Larguier
Violet H. Larney
Peter D. Lax
William J. LeVeque
William G. Leavitt
George F. Leger
Joseph Lehner
Richard A. Leibler
Roy B. Leipnik
Bela A. Lengyel
Benjamin Lepson
Howard Levene
Howard Levi
Jack Levine
Robert J. Levit
D. J. Lewis
Sister Mary Teresine Lewis
F. W. Light Jr.
Miriam A. Lipschutz-Yevick
H. David Lipsich
J. N. B. Livingood
Lee Lorch
Jack Lorell
Warren S. Loud
Edith H. Luchins
Saunders MacLane
G. W. Mackey
Moray S. Macphail
William G. Madow
Lucille Maier
Henry B. Mann
W. Robert Mann
Ralph Mansfield
Margaret O. Marchand
R. J. Marcou
May H. Maria
J. C. Mark
M. H. Martin
William T. Martin
Pesi R. Masani
William S. Massey
John R. Mayor
Vincent O. McBrien
Clyde T. McCormick
Dorothy McCoy
N. H. McCoy
Janet McDonald
Audrey W. McMillan
Brockway McMillan
Albert E. Meder Jr.
Paul Meier
N. S. Mendelsohn
David M. Merriell
Bruce E. Meserve
Burnett C. Meyer
Herman Meyer
Paul T. Mielke
D. D. Miller
Donald S. Miller
Kenneth S. Miller
William H. Mills
Hugh J. Miser
Josephine M. Mitchell
Edwin E. Moise
Marvin G. Moore
Charles W. Moran

Morris Morduchow
Kathryn A. Morgan
Chester Ray Morris
Donald R. Morrison
David C. Morrow
Thirza A. Mossman
George Daniel Mostow
Benjamin N. Moyls
Francis J. Murray
David Nelson
Cecil J. Nesbitt
Bernhard H. Neumann
Albert Newhouse
August Newlander Jr.
Morris Newman
Louis Nirenberg
Ivan Niven
Andrewa R. Noble
Edward A. Nordhaus
Albert B. Novikoff
Anne F. O'Neill
P. S. Olmstead
A. C. Olshen
Paul Olum
Alexander Oppenheim
Daniel Orloff
T. G. Ostrom
Lowell J. Paige
Theodore P. Palmer
Herbert C. Parrish
Mauricio M. Peixoto
Anthony J. Penico
Paul M. Pepper
Sam Perlis
George W. Petrie III
Albert Pfluger
Ralph S. Phillips
Edmund Pinney
George Piranian
Everett Pitcher
Emily C. Pixley
Theresa L. Podmele
Harry Polachek
Donald H. Potts
Walter Prenowitz
G. Baley Price
Robert C. Prim III
Murray H. Protter
W. T. Puckett Jr.
Alfred L. Putnam
Calvin R. Putnam
Grace S. Quinn
George N. Raney
Robert A. Rankin
Anatol Rapoport
Lawrence L. Rauch
Maxwell O. Reade
Ottis W. Rechard
Raymond M. Redheffer
Mina S. Rees
Paul K. Rees
Haim Reingold
Robert R. Reynolds
Charles E. Rickart
Karlem Riess
Malcolm S. Robertson
Robin Robinson
Gene F. Rose
Israel H. Rose
Robert A. Rosenbaum
J. H. Rosenbloom
Maxwell A. Rosenlicht
Arnold E. Ross
Fritz Rothberger
Herman Rubin
William Salkind
Charles Saltzer
Herbert E. Salzer
Hans Samelson
Pierre Samuel
Ward C. Sangren
Jane Cronin Scanlon
Henry M. Schaerf
Alice T. Schafer
Richard D. Schafer
Samuel Schechter
Max M. Schiffer
Albert Schild
Lowell Schoenfeld
K. C. Schraut
Jewell E. Schubert
Augusta L. Schurrer
Benjamin L. Schwartz
Jacob T. Schwartz
Irving E. Segal
Bernard Sherman
Harold Shniad
Marlow C. Sholander
Darrell R. Shreve
Annette Sinclair
Frank Smithies
Ernst Snapper
J. Laurie Snell
John J. Sopka
Edward J. Specht
Abraham Spitzbart
William H. Spragens Jr.
George Springer
David W. Starr
F. H. Steen
Irene A. Stegun
Robert Steinberg
Clarence F. Stephens
Arthur H. Stone
William J. Strange
Dirk J. Struik
Eric A. Sturley
Sister M. Helen Sullivan
Fred Supnick
P. P. Sutton
Taffee T. Tanimoto
Abraham H. Taub
Angus E. Taylor
Clayton J. Thomas
George B. Thomas Jr.
D. L. Thomsen Jr.
Charles J. Thorne
Robert M. Thrall
Wolfgang J. Thron
William R. Transue
Bryant Tuckerman
Atwell R. Turquette
E. F. Tyler
W. Roy Utz Jr.
F. A. Valentine
A. H. Van Tuyl
Elbridge P. Vance
Bernard Vinograde
Arthur G. Walker
Azelle B. Waltcher
Eleanor B. Walters
Daniel Waterman
Martin T. Wechsler
John V. Wehausen
Everett T. Welmers
James G. Wendel
William Wernick
D. W. Western
Marion D. Wetzel
Charles H. Wheeler III
Myron E. White
George W. Whitehead
Kathleen B. Whitehead
Philip M. Whitman
D. Ransom Whitney
Arthur S. Wightman
L. R. Wilcox
J. Ernest Wilkins Jr.
Robert L. Wilson
G. Milton Wing
Eva P. Winter
Yung-Chow Wong
Rhoda M. Wood
Max A. Woodbury
John W. Wrench Jr.
Leo M. Wulf
Marie A. Wurster
Fumio Yagi
Bertram Yood
Gail S. Young
Laurence C. Young
Paul M. Young
Eduardo H. Zarantonello
Daniel Zelinsky
Joseph L. Zemmer Jr.
Joseph A. Zilber
Delbert E. Zilmer
J. W. Zimmer
Hyman J. Zimmerberg

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/profession/employ.html`), 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.

Academic Employment in Mathematics

AMS Standard Cover Sheet

Last Name _____

First Name _____

Middle Names _____

Address *through June 1998* **Home Phone**

_____ _____

_____ **e-mail Address**

_____ _____

Current Institutional Affiliation **Work Phone**

_____ _____

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 _____ Dates _____

Indicate the position for which you are applying and position posting code, if applicable

_____

If unsuccessful for this position, would you like to be considered for a temporary position?

☐ Yes ☐ No If yes, please check the appropriate boxes.

☐ Postdoctoral Position ☐ 2+ Year Position ☐ 1 Year Position

List the names, affiliations, and e-mail addresses *of up to four individuals who will provide letters of recommendation if asked. Mark the box provided for each individual whom you have already asked to send a letter.*

☐ _____

☐ _____

☐ _____

☐ _____

This form is provided courtesy of the American Mathematical Society.

This cover sheet is provided as an aid to departments in processing job applications. It should be included with your application material.

Please print or type. Do not send this form to the AMS.

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

Statistics on Women Mathematicians Compiled by the AMS

At its August 1985 meeting, the Council of the AMS approved a motion to regularly assemble and report in the *Notices* information on the relative numbers of men versus women in at least the following categories: membership in the AMS, invited hour addresses at AMS meetings, speakers at special sessions at AMS meetings, percentage of women speakers in AMS Special Sessions by gender of organizers, and members of editorial boards of AMS journals.

It was subsequently decided that this information would be gathered by determining the sex of the individuals in the above categories based on name identification and that additional information on the number of Ph.D.s granted to women would also be collected using the AMS-IMS-MAA Annual Survey. Since name identification was used, the information for some categories necessitated the use of three classifications:

Male: names that were obviously male;

Female: names that were obviously female;

Unknown: names that could not be identified as clearly male or female (e.g., only initials given, non-gender-specific names, etc.)

The following is the twelfth reporting of this information. Updated reports will appear annually in the *Notices*.

Invited Hour Address Speakers at AMS Meetings (1987–1996)

Male:	396	85%
Female:	63	14%
Unknown:	4	1%
Total checked:	463	

Speakers at Special Sessions at AMS Meetings (1992–1996)

Male:	7,030	81%
Female:	1,081	12%
Unknown:	647	7%
Total checked:	8,758	

Percentage of Women Speakers in AMS Special Sessions by Gender of Organizers (1996)

Special Sessions with at Least One Woman Organizer

Total number of speakers:	411	
Male:	306	75%
Female:	75	18%
Unknown:	30	7%

Special Sessions with No Women Organizers

Total number of speakers	1,420	
Male:	1,146	81%
Female:	184	13%
Unknown:	90	6%

Members of the AMS Residing in the U.S.

Male:	13, 609	70%
Female:	3,519	18%
Unknown:	2,237	12%
Total checked:	19,365	

Trustees and Council Members

	1996		1995		1994		1993	
Total:	48		48		49		51	
Male:	36	75%	34	71%	35	71%	39	76%
Female:	12	25%	14	29%	14	29%	12	24%

Members of Editorial Boards of AMS Journals

	1996		1995		1994		1993		1992		1991		1990		1989		1988		1987	
Total:	198		194		176		177		178		169		183		194		161		133	
Male:	177	89%	175	90%	161	91%	159	90%	163	92%	156	92%	171	93%	182	94%	148	92%	125	94%
Female:	21	11%	19	10%	15	9%	18	10%	15	8%	13	8%	12	7%	11	6%	13	8%	8	6%

Ph.D.s Granted to U.S. Citizens

	1996		1995		1994		1993		1992		1991		1990		1989		1988		1987	
Total:	493		567		469		526		430		461		401		411		363		362	
Male:	377	76%	426	75%	345	74%	381	72%	327	76%	349	76%	312	78%	313	76%	287	79%	289	80%
Female:	116	24%	141	25%	124	26%	145	28%	103	24%	112	24%	89	22%	98	24%	76	21%	73	20%

Reference

*The **Reference** section of the* Notices *is intended to provide the reader with frequently sought information in an easily accessible manner. New information is printed as it becomes available and is referenced after the first printing. As soon as information is updated or otherwise changed, it will be noted in this section.*

Upcoming Deadlines

January 1, 1998: Deadline for submission of applications for grants for mathematicians from Eastern Europe to attend ICM98. Information and application forms are available at the ICM98 Web site, `http://elib.zib.de/ICM98/`.

January 15, April 15, August 15, 1998: Deadlines for applications for NRC Associateship Programs. Information available at the Web site `http://rap.nas.edu/`.

February 11, 1998: Deadline for first round of proposals for NSF Grants for Vertically Integrated Research and Education (VIGRE). (Deadline for second round is September 1, 1998.) See NSF DMS Web site, `http://www.nsf.gov/mps/dms/`.

National Science Board

The National Science Board (NSB) serves as a national science policy advisor to the president and the Congress and as the governing body for the National Science Foundation. The term of service on the NSB is six years.

The following lists the names, titles, and affiliations of current NSB members.

John A. Armstrong, IBM Vice President for Science and Technology (retired).

F. Albert Cotton, Distinguished Professor of Chemistry, Texas A & M University.

Mary K. Gaillard, Professor of Physics, University of California, Berkeley.

Sanford D. Greenberg, Chairman and CEO, TEI Industries, Inc.

M. R. C. Greenwood, Chancellor, University of California, Santa Cruz.

Charles E. Hess, Director of International Programs, University of California, Davis.

John E. Hopcroft, Joseph Silbert Dean of Engineering, Cornell University.

Stanley V. Jaskolski, Vice President, Eaton Corporation.

Eamon M. Kelly, President, Tulane University.

Neal F. Lane, Director, National Science Foundation (ex officio).

Jane Lubchenco, Wayne and Gladys Valley Professor of Marine Biology and Distinguished Professor of Zoology, Oregon State University, Corvallis.

Shirley M. Malcom, Head, Directorate for Education and Human Resources Programs, American Association for the Advancement of Science.

Eve L. Menger, Director, Characterization Science and Services, Corning, Inc.

Claudia I. Mitchell-Kernan, Vice Chancellor, Academic Affairs, and Dean, Graduate Division, University of California, Los Angeles.

Diana Natalicio, President, University of Texas at El Paso (vice chair).

James L. Powell, President and Director, Los Angeles County Museum of Natural History.

Frank H. T. Rhodes, President Emeritus, Cornell University.

Ian M. Ross, President Emeritus, AT&T Bell Laboratories, Holmdel, New Jersey.

Vera C. Rubin, Staff Member, Department of Terrestrial Magnetism, Carnegie Institution of Washington, DC.

Robert M. Solow, Institute Professor Emeritus of Economics, Massachusetts Institute of Technology.

Bob H. Suzuki, President, California State Polytechnic University, Pomona.

Richard Tapia, Professor, Department of Computational and Applied Mathematics, Rice University.

Warren M. Washington, Senior Scientist and Head, Climate Change Research Section, National Center for Atmospheric Research.

John A. White Jr., Chancellor, University of Arkansas, Fayetteville.

Richard N. Zare, Professor of Chemistry, Stanford University (chair).

Where to Find It

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

Mathematics Calendar

December 1997

December **International Symposium on Mathematical Physics in Memory of S. Chandrasekhar**, Calcutta, India. (Mar. 1997, p. 380)

1-6 **Neural Information Processing Systems-Natural and Synthetic**, Marriott Hotel, Denver, Colorado. (Sept. 1997, p. 1024)

*3-4 **Fourth CANT Conference -Number Theory and Cryptography**, University of Sydney, Sydney, Australia.
Aim: The conference aims to provide an overview of recent developments in computational number theory, with an emphasis on areas that are applicable to public-key cryptography.
Information: Further information is available from the conference home page at `http://www.maths.usyd.edu.au:8000/u/richardr/CANT97/announce_call.html`.

3-6 **MATHTOOLS'97 International Workshop "Tools for Mathematical Modelling"**, Saint Petersburg State Technical University, Saint Petersburg, Russia. (Oct. 1997, p. 1155)

4-7 **3rd Joint Meeting of the AMS and the Sociedad Mathematica Mexicana**, Oaxaca, Mexico. (Dec. 1996, p. 1560)

8-9 **Workshop on Quantum Coherence and Information Processing**, Adelaide, South Australia. (Sept. 1997, p. 1024)

8-11 **International Congress on Modelling and Simulation-MODSIM 97**, Hobart, Tasmania, Australia. (Oct. 1997, p. 1156)

8-12 **International Conference on Scientific Computing and Math Modelling**, New Delhi, India. (Oct. 1997, p. 1156)

12-14 **DIMACS Workshop on Randomization Methods in Algorithm Design**, Computer Science Dept., Princeton University, Princeton, New Jersey. (Oct. 1997, p. 1156)

13-17 **8th Meeting of European Women in Mathematics**, Trieste, Italy. (Mar. 1997, p. 380)

13-17 **AMAST'97 Sixth International Conference on Algebraic Methodology and Software Technology**, Macquarie University, Sydney, Australia. (Sept. 1997, p. 1024)

14-16 **CMS Winter 1997 Meeting**, Victoria Conference Centre, Victoria, British Columbia. (Nov. 1997, p. 1361)

26-28 **3rd International Triennial Calcutta Symposium on Probability and Statistics**, Calcutta, India. (Oct. 1996, p. 1206)

27-30 **Applied Analysis and Optimization (on the 70th Birthday of Professor Hoang Tuy)**, Hanoi Institute of Mathematics, Vietnam. (Mar. 1997, p. 380)

28-January 1 **International Symposium on Mathematical Physics in Memory of S. Chandrasekhar with Special Session on Abdus Salam**, Calcutta, India. (Aug. 1997, p. 845)

January 1998

3-6 **Ninth International Conference on Approximation Theory**, Nashville, TN. (June/July 1997, p. 731)

4-6 **Fifth International Symposium on Artificial Intelligence and Mathematics**, Fort Lauderdale, Florida. (Sept. 1997, p. 1025)

6 **Ethnomathematics and the History of Mathematics: Conference in Honor of the 65th Birthday of Ubiratan D'Ambrosio**, Omni Hotel, Baltimore, Maryland. (Oct. 1997, p. 1156)

7-10 **Joint Mathematics Meetings**, Baltimore, Maryland (including the annual meetings of the AMS, AWM, MAA, and NAM). (Dec. 1995, p. 1570)

*9 **Isolated Teachers of Statistics Meeting**, Baltimore, Maryland.
Description: This year at the Joint Mathematics Meetings in Baltimore, there will be an informal meeting of 'isolated teachers

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This section contains announcements of meetings and conferences of interest to some segment of the mathematical public, including ad hoc, local, or regional meetings, and meetings and symposia devoted to specialized topics, as well as announcements of regularly scheduled meetings of national or international mathematical organizations. A complete list of meetings of the Society can be found on the last page of each issue.

An announcement will be published in the *Notices* if it contains a call for papers and specifies the place, date, subject (when applicable), and the speakers; a second announcement will be published only if there are changes or necessary additional information. Once an announcement has appeared, the event will be briefly noted in every third issue until it has been held and a reference will be given in parentheses to the month, year, and page of the issue in which the complete information appeared. Asterisks (*) mark those announcements containing new or revised information.

In general, announcements of meetings and conferences held in North America carry only the date, title of meeting, place of meeting, names of speakers (or sometimes a general statement on the program), deadlines for abstracts or contributed papers, and source of further information. Meetings held outside the North American area may carry more detailed information. In any case, if there is any application deadline with respect to participation in the meeting, this fact should be noted. All communications on meetings and conferences in the mathematical sciences should be sent to the Editor of the *Notices* in care of the American Mathematical Society in Providence or electronically to `notices@ams.org` or `mathcal@ams.org`.

In order to allow participants to arrange their travel plans, organizers of meetings are urged to submit information for these listings early enough to allow them to appear in more than one issue of the *Notices* prior to the meeting in question. To achieve this, listings should be received in Providence **six months** prior to the scheduled date of the meeting.

The complete listing of the Mathematics Calendar will be published only in the September issue of the *Notices*. The March, June, and December issues will include, along with new announcements, references to any previously announced meetings and conferences occurring within the twelve-month period following the month of those issues. New information about meetings and conferences that will occur later than the twelve-month period will be announced once in full and will not be repeated until the date of the conference or meeting falls within the twelve-month period.

The Mathematics Calendar, as well as Meetings and Conferences of the AMS, is now available electronically through 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 (`telnet e-math.ams.org`; login and password `e-math`) and use the Lynx option from the main menu.)

of statistics' on Friday night, from 7–9 pm, in the Convention Center (room TBA). The ASA/MAA Joint Committee on Undergraduate Statistics is inviting those of you who teach all or most of the statistics in your department. At this first meeting there will be an informal discussion where you can raise (and discuss?) issues that are important or significant to you. The intent is that the meeting will become a yearly exchange of ideas among the isolated teachers of statistics, and possibly the beginning of a network. See the MAA Online Web page for a detailed announcement.
Information: D. Whittinghill, Department of Mathematics, Rowan University, Glassboro, NJ 08028. E-mail: whittinghill@rowan.edu.

11–16 **AMS-SIAM Summer Seminar in Applied Mathematics: Neuroengineering and Dynamical Systems in Neuroscience**, Arizona State University, Tempe, Arizona. (Apr. 1997, p. 534)

12–16 **Introductory Workshop on Model Theory of Fields**, Mathematical Sciences Research Institute, Berkeley, CA. (June/July 1997, p. 731)

12–23 **Emerging Applications of Dynamical Systems**, University of Minnesota, Minneapolis, Minnesota. (Sept. 1997, p. 1025)

13–21 **Reflection Groups and Applications**, International School for Advanced Studies (SISSA), Trieste, Italy. (Oct. 1997, p. 1156)

19–23 **First Pacific Rim Conference on Mathematics**, City University of Hong Kong, Hong Kong. (Apr. 1997, p. 481)

23–24 **A Numerical Analysis Conference in Honor of Olof B. Widlund on the Occasion of his 60th Birthday**, Courant Institute of Mathematical Sciences, New York University, New York City, NY. (Nov. 1997, p. 1361)

February 1998

2–4 **33 Years of Gröbner Bases**, Risc-Linz, Hagenberg, Austria. (Apr. 1997, p. 481)

5–6 **Emerging Applications of Dynamical Systems**, University of Minnesota, Minneapolis, Minnesota. (Sept. 1997, p. 1026)

9–13 **Emerging Applications of Dynamical Systems**, University of Minnesota, Minneapolis, Minnesota. (Sept. 1997, p. 1026)

9–13 **Seventh International Conference on Hyperbolic Problems Theory, Numerics, Applications**, ETH Zürich, Switzerland. (Oct. 1997, p. 1156)

11–13 **XI International Symposium On Mathematical Methods Applied To The Sciences (SIMMAC)**, Santa Clara, Costa Rica. (Nov. 1997, p. 1362)

11–14 **Xth National Conference of Finsler and Lagrange Spaces and Applications**, Craiova, Romania. (Nov. 1997, p. 1362)

*18–20 **Seventeenth IASTED International Conference on Modelling, Identification and Control**, Grindelwald, Switzerland.
Topics: Modelling, identification, control, systems, technology, applications.
Organizers: The International Association of Science and Technology for Development (IASTED); e-mail: iasted@cadvision.com; Web site: http://www.iasted.com.

*20–21 **Fourteenth Conference on Applied Mathematics**, University of Central Oklahoma, Edmond, Oklahoma.
Program: An interdisciplinary conference on mathematics with applications, this year's CAM will feature Nobel laureate H. Hauptman (Director of the Hauptman-Woodward Medical Research Foundation), who will speak on "A Minimal Principle in the Phase Probe of X-Ray Crystallography." Also featured will be P. O'Dell (Baylor Univ., Dept. of Mathematics), who will give a talk on "Solving Matrix Equations Using Generalized Inverses of Matrices." A MATLAB workshop will be available for participants.
Call for Papers: Abstracts should be postmarked by December 16, 1997, and mailed to the address below. There will be a special session on Differential Equations and Dynamical Systems.
Information: Conference on Applied Mathematics, College of Mathematics and Science, University of Central Oklahoma, 100 N. University, Edmond, OK 73034; tel: 405-341-2980, ext. 5381; fax: 405-330-3824; e-mail: cam@aix1.ucok.edu.

*20–22 **8th Annual Conference of the Jammu Mathematical Society: Seminar on Recent Trends in Geometry, Operator Theory and Complex Dyamnics**, University of Jammu, Jammu, India.
Call for Papers: Mathematicians interested in participating in the conference should contact R. K. Singh, Dept. of Mathematics, Univ. of Jammu, Jammu-4, India and send title of their articles/talks.

*27–28 **The 14th annual Southeastern Analysis Meeting (SEAM 14)**, The University of Alabama, Tuscaloosa, Alabama.
Main Speakers: M. Ashbaugh (Univ. of Missouri); R. V. Kadison (Univ. of Pennsylvania); R. Rochberg (Washington Univ.); J. Wermer (Brown Univ.).
Organizers: R. Brown, A. Hopenwasser, R. Moore, T. Trent, J. Wang, Z. Wu; e-mail: cconf@euler.math.ua.edu.

March 1998

*9–13 **Twenty-ninth Southeastern International Conference on Combinatorics, Graph Theory and Computing**, Florida Atlantic University, Boca Raton, Florida.

9–14 **Emerging Applications of Dynamical Systems**, University of Minnesota, Minneapolis, Minnesota. (Sept. 1997, p. 1026)

12–14 **Spring Topology and Dynamics Conference**, George Mason University, Fairfax, Virginia. (Sept. 1997, p. 1026)

14–15 **Knots, Braids, and Mapping Class Groups: A Conference in Low-Dimensional Topology in Honor of Joan Birman's 70th Birthday**, Columbia University/Barnard College, New York, New York. (Sept. 1997, p. 1026)

16–18 **Conference on Complex Hyperbolic Geometry and Discrete Groups**, Okayama University of Science, Okayama, Japan. (Oct. 1997, p. 1056)

20–21 **AMS Southeastern Sectional Meeting**, University of Louisville, Louisville, Kentucky. (Dec. 1996, p. 1560)
Information: R. Cascella, rgc@ams.org.

23–25 **DIMACS Workshop on Discrete Mathematical Chemistry**, DIMACS Center, Rutgers University, Piscataway, New Jersey. (Sept. 1997, p. 1026)

23–27 **Geometric Stochastic Analysis and Fine Properties of Stochastic Processes**, Mathematical Sciences Research Institute, Berkeley, CA 94720-5070. (Sept. 1997, p. 1026)

23–29 **Japan-U.S. Mathematics Institute Conference and Workshop on Meromorphic Mappings and Intrinsic Metrics in Complex Geometry**, Johns Hopkins University, Baltimore, Maryland. (Nov. 1997, p. 1362)

25–28 **Global Analysis 30 Years Later**, University of Cincinnati, Cincinnati, Ohio. (Nov. 1996, p. 1384)

27–28 **AMS Central Section Meeting**, Kansas State University, Manhattan, KS. (Sept. 1997, p. 1027)
Information: W. Drady, AMS, P.O. Box 6887, Providence, RI 02940; e-mail: wsd@math.ams.org.

30–April 3 **European Joint Conferences on Theory and Practice of Software (ETAPS), Preliminary announcement and call for satellite events**, Lisbon, Portugal. (Nov. 1996, p. 1385)

April 1998

4–5 **AMS Eastern Sectional Meeting**, Temple University, Philadelphia, Pennsylvania. (Dec. 1996, p. 1560)
Information: R. Cascella, rgc@ams.org.

16–18 **Twenty-Second Arkansas Spring Lectures in the Mathematical Sciences**, Fayetteville, Arkansas. (Sept. 1997, p. 1027)

19–22 **Supporting Educational, Faculty & TA Development Within Departments and Disciplines**, Austin, Texas. (Nov. 1997, p. 1362)

20–23 **International Conference on Interval Methods and their Application in Global Optimization (INTERVAL '98)**, Nanjing, China. (Oct. 1997, p. 1156)

*20–24 **Workshop on Probability: Theory and Applications**, Nottingham Trent University, Nottingham, England.

Aim: The aim of the workshop is to encourage interaction between pure and applied probabilists on topics of mutual interest. One day will be devoted to each of the following areas: (1) probability in finance; (2) probability in information science; (3) probability in biology; (4) probability in physics; (5) probabilistic methods and modelling.
Plenary Talks: The following have accepted invitations to give plenary talks: D. Aldous (Berkeley), A. Barbour (Zurich), J. Chayes (Microsoft), M. Davis (Mitsubishi), A. Dorlas (Swansea), T. Gowers (Cambridge), L. Hughston (Merrill Lynch), C. Pfister (Lausanne), S. Tavare (USC) and J. Ziv (Haifa). Other speakers will include B. Derrida (Paris), P. Donnelly (Oxford) and J. Rosenthal (Toronto).
Hotel Accommodation: As hotel accommodation in Nottingham is limited, prospective participants are advised to register their intention to attend by contacting the workshop administrator D. Jones as soon as possible (e-mail: cos3jonesdr@ntu.ac.uk, tel: 0115-9418418, ext. 2249, fax: 0115-9486536). Participants wishing to give short talks should send an e-mail giving the title and a short abstract to pconf@maths.ntu.ac.uk.
Funding: This meeting is partially funded by EPSRC. All non-EPSRC funded participants will be required to pay a workshop fee of 100 pounds (this does not include accommodation and subsistence). Nottingham Trent Univ. will make available 20 workshop fellowships of up to 300 pounds each to cover travel and subsistence for young research-active participants under the age of 30. To apply for one of these, please send a short (one page) cv and an estimate of your travel expenses by e-mail to pconf as above.
Scientific Committee: D. Applebaum (NTU)-main organizer, F. Ball (Nottingham), A. Etheridge (QMW), C. Goldie (Sussex), J. Lewis (Dublin), G. Roberts (Cambridge), D. Williams (Bath).
Information: WWW page: http://euler.ntu.ac.uk/pconf/html/.

25-26 **AMS Western Sectional Meeting**, University of California-Davis, CA. (Apr. 1997, p. 481)
Information: W. Drady, wsd@ams.org.

27-29 **Conference on Real Numbers and Computers**, Pierre et Marie Curie University, Paris, France. (Sept. 1997, p. 1027)

27-May 1 **Emerging Applications of Dynamical Systems**, University of Minnesota, Minneapolis, Minnesota. (Sept. 1997, p. 1028)

29-May 1 **Nonlinear* Problems in Aviation and Aerospace**, Daytona Beach, Florida. (Sept. 1997, p. 1028)

May 1998

*1-3 **Conference on Algebraic Combinatorics and Applications**, Oakland University, Rochester, Michigan.
Speakers: Invited one-hour speakers include: A. Bjorner (Royal Institute of Technology, Stockholm), R. Calderbank (AT&T Research), P. Cameron (Queen Mary College, London), J. Chayes (Microsoft), P. Flajolet (INRIA), R. Graham (AT&T Research), D. Jackson (University of Waterloo), R. Stanley (MIT). There will also be sessions for invited half-hour talks.
Participation: Persons in academia or industry interested in exploring this fertile and evolving area of mathematics and its interactions with and applications to other areas are encouraged to participate. Some support will be available to assist graduate students in attending the conference.
Sponsors: Sponsors include the National Science Foundation, the National Security Agency, Oakland University, the Oakland University Foundation, and others still pending.
Information: Anyone interested in further information should send name, institution, e-mail address, and current estimated probability of attending, to the organizers by e-mail or snail-mail. Conference e-mail address: calca@oakland.edu; World Wide Web home page: http://www.oakland.edu/~calca/.

6-8 **Astrophysics and Algorithms: A DIMACS Workshop on Massive Astronomical Data Sets**, Computer Science Dept., Princeton University, Princeton, New Jersey. (Oct. 1997, p. 1157)

7-9 **Fourth SIAM Conference on Control and Its Applications**, Omni Jacksonville Hotel, Jacksonville, Florida. (Oct. 1997, p. 1157)

11-15 **Emerging Applications of Dynamical Systems**, University of Minnesota, Minneapolis, Minnesota. (Sept. 1997, p. 1028)

11-15 **Workshop in Mathematical Population Dynamics**, Gothenburg Stochastic Centre, Chalmers University of Technology, Gothenburg, Sweden. (Oct. 1997, p. 1157)

18-23 **Third Conference on Function Spaces**, Southern Illinois University at Edwardsville, Edwardsville, Illinois. (Oct. 1997, p. 1157)

*24-31 **International Algebraic Conference (Dedicated to the Memory of A. G. Kurosh)**, Department of Algebra, Faculty of Mechanics and Mathmatics, MoscowState University, Moscow, Russia.
Topics: Group theory, rings and modules, homological algebra, algebraic K-theory, Lie groups and algebras, theory of invariants, algebraic groups, algebraic geometry, algebraic number theory, commutative algebra, general algebraic systems, computer algebra, algorithmic problems.
Organizing Committee: P. M. Cohn, O. H. Kegel, A. I. Kostrikin, M. Suzuki, E. I. Zelmanov, and others.
Deadline for Abstracts: January 1, 1998.
Information: Contact the organizing committee at Dept. of Algebra, Faculty of Mechanics and Mathematics, Moscow State University, 119899, Moscow, Russia; fax: 095-9392090; e-mail: artamon@nw.math.msu.su; http://www.math.msu/users/artamon/kurosh.html.

26-29 **ICDCS'98, the 18th International Conference on Distributed Computing Systems**, Center of Mathematics and Computer Science (CWI), Amsterdam, The Netherlands. (Oct. 1997, p. 1157)

27-29 **Joint DIMACS-CMU-Georgia Tech Workshop on Large Scale Discrete Optimization**, DIMACS Center, Rutgers University, Piscataway, New Jersey. (Oct. 1997, p. 1157)

28-31 **19th Annual Meeting of Canadian Applied Mathematics Society (CAMS/SCMA) and 13th Canadian Symposium on Fluid Dynamics**, Simon Fraser University, Burnaby, British Columbia, Canada. (Sept. 1997, p. 1028)

31-June 6 **Sixth International Spring School "Nonlinear Analysis, Function Spaces and Applications"**, Prague, Czech Republic. (Sept. 1997, p. 1028)

June 1998

June-July **MODELLING '98, 1st IMACS Conference on Mathematical Modelling and Computational Methods in Mechanics and Geodynamics**, Prague, Czech Republic. (Oct. 1997, p. 1157)

*1-4 **IASTED International Conference on Computer Graphics and Imaging**, Halifax, Canada.
Organizer: The International Association of Science and Technology for Development (IASTED); e-mail: iasted@cadvision.com; Web site: http://www.iasted.com.
Scope: Rendering, image processing, modelling, animation, visualization, applications.
Deadline: Submission deadline for abstracts and tutorial proposals - November 15, 1997.

*1-4 **Mathematics and Design 98**, The University of the Basque Country, San Sebastian, Spain.
Deadline: For abstracts: November 15.
Topics: Computer design, mathemaitcal modelling, visualization and system media design, computational geometry, art and mathematics.
Information: http://ww.sc.ehu.es/md98.

1-5 **Emerging Applications of Dynamical Systems**, University of Minnesota, Minneapolis, Minnesota. (Sept. 1997, p. 1028)

1-5 **Fifth International Conference on p-Adic Functional Analysis**, A. Mickiewicz University of Poznań, Poland. (Sept. 1997, p. 1028)

1-5 **Fourth International Conference on Mathematical and Numerical Aspects of Wave Propagation**, Colorado School of Mines, Golden, Colorado. (Oct. 1997, p. 1157)

1-5 **Model Theory, Algebra and Arithmetic**, Mathematical Sciences Research Institute, Berkeley, CA. (Sept. 1997, p. 1028)

3-6 **Seventh Conference of the International Linear Algebra Society, The Hans Schneider Linear Algebra Conference**, University of Wisconsin-Madison, Madison, Wisconsin. (Nov. 1997, p. 1362)

9-11 **1998 International Conference on Dynamic Systems and Differential Equations**, Shanghai Jiao Tong University, Shanghai, The People's Republic of China. (Sept. 1997, p. 1028)

15-20 **Second International Conference on Differential Equations and Applications**, St. Petersburg State Technical University, St. Petersburg, Russia. (Oct. 1997, p. 1157)

17-23 **6th Purdue International Symposium on Statistics**, West Lafayette, Indiana. (Sept. 1997, p. 1028)

21-24 **LICS'98 (The Thirteenth Annual IEEE Symposium on Logic in Computer Science**, Indiana University Conference Center, Indianapolis. (Sept. 1997, p. 1029)

21-26 **Thirteenth U.S. National Congress of Theoretical & Applied Mechanics**, University of Florida, Gainesville, Florida. (Sept. 1997, p. 1029)

22-26 **The Eighth International Conference on Fibonacci Numbers and Their Applications**, Rochester, New York. (Sept. 1997, p. 1029)

22-26 **Third International Conference on Monte Carlo and Quasi-Monte Carlo Methods in Scientific Computing**, The Claremont Colleges, Claremont, California. (Oct. 1997, p. 1158)

22-27 **Third Siberian Congress on Industrial and Applied Mathematics (INPRIM-98) dedicated to the memory of S. L. Sobolev (1908-1989)**, Novosibirsk Akademgorodok, Russia. (Sept. 1997, p. 1029)

*28-July 2 **Pacific Rim Geometry Conference**, Univeristy of British Columbia, Vancouver, British Columbia.
Sponsoring Organization: Pacific Institute of Mathematical Sciences.
Organizing Committee: D. Austin (UBC), J. B. Carrell (UBC), P. Li (UCI), S.-T. Yau (Harvard).
Description of Conference: This will be the fourth meeting of the Pacific Rim Geometry Conference and the first to be held in North America. Previous meetings of the conference have been in Hong Kong, Singapore, and Seoul. The conference will not focus on a particular topic but will disseminate recent important developments in such areas as Riemannina geometry, Gage theory, Seiberg-Witten equations, harmonic maps and minimal surfaces, mirror symmetry and others.
Confirmed Speakers: J. Chen (Vancouver), W. Fulton (Chicago), A. Givental (Berkeley), M. Hwang (Seoul), P. Li (Irvine), R. Schoen (Stanford), C. Taubes (Harvard), G. Tian (MIT), S.-T. Yau (Harvard).
General Comments: There will be two one-hour talks by principal lecturers each morning and one principal lecture after lunch. In addition, there will also be sessions for shorter contributed talks in the afternoon. The organizers hope to avoid having too many talks so that there will be ample time for participants to interact mathematically.
Contributed Talks and Sessions: It is anticipated that there will be sessions in some or all of the following topics: complex differential geometry, gauge theory and four manifolds, harmonic maps and minimal surfaces, quantum cohomology, partial differential equations and Riemannian geometry. Participants who wish to give a contributed talk should please send an abstract by e-mail to `prgc@math.ubc.ca`.
Information: E-mail: `prgc@math.ubc.ca`. Regular mail may be addressed to: Pacific Rim Geometry Conference, Pacific Institute of Mathematical Sciences, Univ. of British Columbia, Vancouver V6T 1Z2, Canada. The conference will have a home page accessible at the PIms WWW site at the URL `http://www.pims.math.ca/`.

*29-July 3 **Second International Conference on Bifurcation Theory and its Numerical Analysis**, Xi'an Jiaotong University, Xi'an, P.R. China.
Purpose: The aim of this conference is to bring together active researchers with different backgrounds to discuss recent and prospective advances in the bifurcation theory and its numerical analysis.
Call for Papers: Prospective authors are invited to submit 500 word abstracts of their papers by Feb. 1, 1998, to: H. Yanren, Research Center for Applied Mathematics, Xi'an Jiaotong Univ., Xi'an, 710049, P. R. China; e-mail: `ktli@xjtu.edu.cn`.

July 1998

*5-9 **1998 New Zealand Mathematics Colloquium**, Victoria University of Wellington, New Zealand.
Information: See the colloquium Web page at: `http://cantor.math.vuw.ac.nz:1998/`.

6-10 **Twenty-Third Australasian Conference on Combinatorial Mathematics and Combinatorial Computing**, The University of Queensland, Brisbane, Australia. (Sept. 1997, p. 1029)

*7-9 **Thirteenth International Conference on Artificial Intelligence in Engineering (AIENG 98)**, Galway, Ireland.
Organized by: Wessex Institute of Technology, UK Univeristy College Calway, Ireland.
Contact: S. Radford, AIENG 98 Conference Secretariat, Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southamptoon SO40 7AA UK; tel: 44-1703-293-223; fax: 44-1703-292-853; e-mail: `sradford@wessex.ac.uk`; URL: `http://www.wessex.ac.uk`.

7-11 (Note: NEW DATE) **The 1st IMACS Conference on Mathematical Modelling and Computational Methods in Mechanics and Geodynamics Modelling '98**, Prague, Czech Republic. (Oct. 1997, p. 1157)

7-17 **Emerging Applications of Dynamical Systems**, University of Minnesota, Minneapolis, Minnesota. (Sept. 1997, p. 1029)

*8-10 **4th International Conference on Lattice Paths Combinatorics and Applications**, University of Vienna, Vienna, Austria
Topics: Lattice paths and boundaries; plane partitions; Young tableaux; q-calculus; orthogonal polynomials; random walk problems; nonparametric statistical inference; discrete distributions and urn models; queueing theory; analysis of algorithms.
Deadlines: Authors are invited to submit abstracts of at most four pages before February 1, 1998. Preferred way of submission is by sending ONE postscript file by email to `boehm@isis.wu-wien.ac.at`. If an author is not able to send a postscript version of her/his extended abstract, four copies of the extended abstract should be mailed to Walter Boehm, Department of Statistics, University of Economics and Business Administration, Augasse 2-6, A-1091 Vienna, Austria. Authors are also requested to indicate how much time they will need to present their talks.
Organizers: W. Boehm, Department of Statistics, Univ. of Economics and Business Administration, Vienna; C. Krattenthaler, Department of Mathematics, Univ. of Vienna.
Information: e-mail: `boehm@isis.wu-wien.ac.at`; `http://www.wu-wien.ac.at/wwwu/institute/stat1/lp/lp.html`.

8-11 **IFAC-LSS '98, Symposium on Large Scale Systems: Theory and Applications**, Patras, Greece. (Oct. 1997, p. 1158)

19-August 2 **7th Workshop on Stochastic Analysis**, Didim, Turkey. (Sept. 1997, p. 1029)

24-25 **Second International Conference on Matrix-Analytic Methods in Stochastic Models**, Winnipeg, Manitoba, Canada. (Sept. 1997, p. 1029)

*27-August 7 **SMS-NATO ASI: Nonlinear Analysis, Differential Equations, and Control**, Université de Montreal, Montreal, Canada.
Program: The main topics to be discussed in this summer school are: nonlinear analysis, differential equations, control theory, nonsmooth analysis, mathematical finance, viscosity solutions, critical point theory, functional analysis.
Speakers: N. Barron, J. Borwein, G. Buttazzo, F. H. Clarke, J.-M. Coron, R. Deville, A. Ioffe, Y. Ledyaev, E. Pardoux, M. Soner, E. Sontag, R. Stern.
Deadline for Application: Before March 13, 1998.
Information: G. David, Dept. Mathematiques and Statistique, Univ. Montreal, CP 6128-Centre-ville, Montreal H3C 3J7, Canada; tel: 514-343-6710; fax: 514-343-5700; `http://www.dms.umontreal.ca/`.

August 1998

August–December **The Fields Institute for Research in Mathematical Sciences Program in Probability and Its Applications**, The Fields Institute, Toronto, Ontario, Canada. (Sept. 1997, p. 1029)

3–7 **Conference on Lattices and Universal Algebra**, JATE Bolyai Institute, Szeged, Hungary. (Oct. 1997, p. 1158)

*3–7 **XI - Brazilian Meeting of Topology**, Departamento de Matematica do Instituto de Geociencias e Ciencias Exatas da UNESP - Rio Claro, Sao Paulo, Brazil.
Organizing Committee: S. Druck (UFF-Rio), A. K. M. Libardi (IGCE-UNESP), O. M. Neto (ICMSC-USP), I. C. Rossini (IGCE-UNESP), M. J. Saia (IGCE-UNESP), J. P. Vieira (IGCE-UNESP).
Scientific Committee: J. P. Brasselet (Luminy), D. L. Goncalves (IME-USP), U. Koshorke (Siegen), O. Saeki (Hiroshima), P. Schwartz (PUC-Rio).
Information: e-mail: `topxi@igce.unesp.br`.

*9–15 **Conference on Geometry and Topology**, University of Aarhus, Aarhus, Denmark.
Emphasis: This is the 5th in a series of topology conferences hosted by Aarhus Univ. the week prior to the ICM, when located in Europe. The tradition started in 1962 with a conference on algebraic topology, but over the years, the emphasis has moved more toward manifold theory and geometry.
Sponsor: Danish Science Council and Univ. of Aarhus.
Organizing Committee: K. Grove, I. Madsen and E. K. Pedersen.
Program: All lectures will take place in the Mathematics Department, where lunch as well as breakfast are also available.
Social Program: Monday, August 10, 5:30 p.m.: Banquet at City Hall; Wednesday, August 12: Dinner and guided tour at the Steno museum (235 DKR); Friday, August 14: Conference dinner. Daily lunch and conference dinner are free for participants.
Accommodations: Help will be provided in finding accommodations. Registration fee: 500DKR (≈ $70).
Information: A second announcement will be sent out in January 1998 with information on hotel reservations and registration. For further information see the home page at `http://www.mi.aau.dk/~tag98/`.

*10–13 **Integral Methods in Science and Engineering '98**, Michigan Technological University, Houghton, Michigan.
Chairs: Conference Chairman: C. Constanda (U.K.); Chairman of the Local Organizing Committee: B. Bertram (USA).
Invited Speakers: G. Beylkin (Univ. of Colorado, Boulder); A. G. Gibson (Univ. of New Mexico); G. R. Ierley (Scripps, Univ. of California, San Diego); S. Kim (Univ. of Wisconsin, Madsion); M. Z. Nashed (Univ. of Delaware); J. C. Nedelec (Ecole Polytechnique, Palaiseu, France); B. D. Sleeman, (Univ. of Leeds, England).
Participation: Participation is open to all scientists and engineers whose work makes use of analytic and numerical methods, integral equations, ordinary and partial differential equations, finite element methods, conservation laws, hybrid approaches, vortex methods, etc. A second announcement will be sent to all prospective participants who indicate their interest to the Chairman of the Local Organizing Committee before November 1, 1997.
Contributed Papers: The authors of contributed papers are requested to submit an abstract containing the topic of the talk, a summary (not exceeding 300 words), and the full institutional address, including telephone and fax numbers and e-mail address.
Deadlines and Fees: Abstract of contributed paper: February 28, 1998; decision on acceptance notified to the author by March 15, 1998. Camera-ready copy for the Proceedings: September 30, 1998; publication of the Proceedings scheduled for early 1999. It is a condition of publication that at least one of the authors of the article has registered as a participant at the conference. Registration before March 31, 1998: US$150; late registration: US$170. The fee (halved for graduate students) includes a copy of the abstracts, a copy of the Proceedings, and daily refreshments. Banquet: August 12, 1998, US$40.
Information: B. Bertram, IMSE98, Department of Mathematical Sciences, Michigan Technological University, Houghton, Michigan; tel: 906-487-2211; fax: 906-487-3133; e-mail: `imse@mtu.edu`; Website access through `http://www.math.mtu.edu`.

10–14 **From Individuals to Populations**, Ceske Budejovice, Czech Republic. (Sept. 1997, p. 1030)

13–17 **Seventh International Colloquium on Numerical Analysis and Computer Science with Applications**, Plovdiv, Bulgaria. (Sept. 1997, p. 1030)

16–21 **1998 IEEE International Symposium on Information Theory**, Massachusetts Institute of Technology, Cambridge, Massachusetts. (Sept. 1997, p. 1030)

18–23 **Ninth International Colloquium on Differential Equations**, Plovdiv, Bulgaria. (Sept. 1997, p. 1030)

18–27 **International Congress of Mathematicians (ICM98)**, Berlin, Germany. (June 1996, p. 702)

*19–21 **20th Anniversary of Boundary Elements Conference (BEM 20)**, University of Central Florida, Orlando, Florida.
Purpose: BEM 20 will bring together researchers in industry and academia who are involved with the use of the method. This conference is internationally recognized as the forum for boundary element research and always attracts a large number of well established practitioners and leading researchers in the field. The meeting also holds a special appeal for young researchers who are actively involved in advances of boundary elements; the meeting provides a unique forum in which they can present and discuss their ideas with their colleagues. Exhibitors wishing to display products, services, hardware, software, or literature relating to the theme of the conference are also welcome.
Call for Papers: Papers are invited on the topics indicated and others falling within the scope of the conference. An abstract of no more than 300 words, clearly stating the purpose, results, and conclusion of the work to be described in the final paper should be submitted to the Conference Secretariat as soon as possible and no later than January 2, 1998. The camera-ready manuscript of the final full-length paper must be received by April 15, 1998. Final acceptance will depend on the full-length paper.
Information: For more information on the conference go to Web page `http://www.wessex.ac.uk/` and click on the conference information link, or contact the conference secretariat, L. Kerr, at Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southampton, UK SO40 7AA; tel: 44-1703-293-223; fax: 44-1703-292-853; e-mail: `liz@wessex.ac.uk`.

*19–23 **4th International Conference on Numerical Methods and Applications**, Sofia, Bulgaria.
Purpose: NMA'98 is the 4th in a row International Conference in the broad field of numerical methods and their applications in mathematical modeling and aims at providing forum for exchange of ideas between scientists who develop and study numerical methods, and researcher who apply them for solving real-life problems.
Topics: Finite differene methods; finite element methods; finite volume methods; boundary element methods; Monte Carlo mehtods; numerical linear algebra; parallel computing; numerical methods for non-linear problems; numerical methods for multiscale problems; multigrid and domain decomposition; computational fluid dynamics; structural mechanics modeling; environmental modeling; engineering applications; minisymposia.
Contributions: Minisymposia (proposals due by November 30, 1997); paper (due by February 15, 1998). Submit two hard copies of the paper (up to 8 pages).
Organizers: The Institute of Mathematics and Informatics, Bulgarian Academy of Sciences, in cooperation with Central Laboratory for Parallel Processing, Bulgarian Academy of Sciences, Faculty of Mathematics and Informatics, University of Sofia, and the Society for Industrial and Applied Mathematics (SIAM).
Confirmed Key and Invited Speakers: O. Axelsson (The Netherlands), J. H. Bramble (USA), B. N. Chetverushkin (Russia), R. E. Ewing (USA), R. P. Fedorenko (Rus-

sia), S. K. Godunov (Russia), M. Griebel (Germany), P. Hemker (The Netherlands), U. Jaekel (Germany), Z. Kamont (Poland), S. P. Kurdyumov (Russia), Yu. A. Kuznetsov (USA/Russia), R. Lazarov (USA/Bulgaria), H. Niederreiter (Austria), L. Perkins (USA), B. Philippe (France), Yu. P. Popov (Russia), I. V. Puzynin (Russia), S. Rjasanow (Germany), A. A. Samarskii (Russia), M. Schaefer (Germany), V. Thomee (Sweden), P. N. Vabishchevich (Russia), H. A. van der Vorst (The Netherlands), M. F. Wheeler (USA), L. Xanthis (UK), Z. Zlatev (Denmark).
Call for Organizing Minisymposia: To organize a minisymposium provide: name and address of the organizer; minisymposium title and abstract; titles and authors of a minimum of four presentations; abstracts of presentations (optional).
Call for Papers: To present a paper, submit by e-mail a LaTeX file. Two hard copies of the paper will also be required by February 15, 1998. The final version of the papers should not exceed 12 pges for key and invited lectures, and 8 pages for contributed talks. Notification of acceptance and mandatory format of the final manuscript will be sent by May 1, 1998.
Conference Proceedings: Proceedings (in a book form) of refereed and presented papers will be published.
Abstracts: Abstracts of a maximum of 1 page are required from all participants wishing to present a talk at the conference. Abstracts have to be send as ASCII files via e-mail. The deadline is February 15, 1998.
Information: Submit papers to: NM&A - O(h4)'98, c/o O. Iliev, Institute of Mathemaitcs and Informatics, Bulgarian Academy of Sciences, Acad. G. Bonchev Str., B1.8, 1113 Sofia, Bulgaria; e-mail: NMA98@MATH.ACAD.BG; URL: http://orca.st.usm.edu/marcin/mp/cfp/sofia.html or http://banmatpc.math.acad.bg/~nma98/.

30-September 5 **Algebraic Number Theory and Diophantine Analysis**, Graz, Austria. (Sept. 1997, p. 1030)

*31-September 4 **Conference on Functional Analysis, Partial Differential Equations and Applications, in honor of V. Mazya**, Rostock, Germany.
Information: WWW: http://www.math.uni-rostock.de/math/events/FunctionalAnalysis/.

31-September 6 **International Conference on Mathematics and Applications Dedicated to the 90th Anniversary of L. S. Pontryagin**, Steklov Mathematical Institute and Moscow State (Lomonosov) University, Moscow, Russia. (Sept. 1997, p. 1030)

September 1998

1-9 **Fourth International Workshop on Complex Structures and Vector Fields**, St. Constantine resort (near Varna), Bulgaria. (Sept. 1997, p. 1031)

12-13 **Central Sectional Meeting**, DePaul University, Chicago, IL. (Sept. 1997, p. 1031)

*16-18 **Seventh International Conference on Hydraulic Engineering Software (HYDROSOFT 98)**, Centro di in Como, Italy.
Contact: L. Kerr, HYDROSOFT 98 conference secretariat, Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southampton SO40 7AA UK; tel: 44-1703-293-223; fax: 44-1703-292-853; e-mail: liz@wessex.ac.uk; Web: http://www.wessex.ac.uk.

24-26 **HERCMA'98, 4th Hellenic European Conference on Computer Mathematics and Its Applications**, Athens, Greece. (Oct. 1997, p. 1158)

*28-30 **International Conference on Ordinal and Symbolic Data Analysis (OSDA98)**, University of Massachusetts, Lincoln Campus Center, Amherst, Massachusetts.
Theme: The theme of the conference is motivated by the fact that ordinal and symbolic data occur quite frequently, but theoretical tools for handling ordinal and symbolic data are not sufficiently developed. The physical layout of the facilities, as well as the design of the program, will encourage active discussions and frequent exchanges of information during the conference.
Organizers: E. Diday (Paris), M. F. Janowitz (Amherst), R. Wille (Darmstadt).
Support: The conference will be supported in part by the University of Massachusetts. Despite this, attendance at the conference will involve a nominal registration fee. Courses on conceptual data analysis and on conceptual knowledge processing will be offered immediately before the conference at the University of Massachusetts.
Deadline: The deadline for applications and abstracts is July 1, 1998. If possible the abstract should be submitted in LaTeX, and should not consist of more than a single page. A template for the abstracts is available on request.
Information: Inquiries, applications, and abstracts should be sent to: M. F. Janowitz, Dept. of Mathematics and Statistics, Univ. of Massachusetts, Lederle Graduate Research Tower, Box 34515, Amherst, MA 01003-4515, or preferably by e-mail to: OSDA98@math.umass.edu.

28-October 4 **International Conference "Dynamical Systems: Stability, Control, Optimization (DSSCO'98)"**, Minsk, Belarus. (Oct. 1997, p. 1158)

October 1998

9-10 **AMS Southeastern Sectional Meeting**, Wake Forest University, Winston-Salem, North Carolina. (Sept. 1997, p. 1031)

24-25 **AMS Eastern Sectional Meeting**, Pennsylvania State University, State College, PA. (Sept. 1997, p. 1031)
Information: R. Cascella, rgc@ams.org.

*25-28 **Fractal 98, Complexity and Fractals in the Sciences**, Valletta, Malta.
Information: Further details on http://www.kingston.ac.uk/fractal/.

November 1998

14-15 **AMS Western Sectional Meeting**, University of Arizona, Tucson, AZ. (Sept. 1997, p. 1031)
Information: W. Drady, wsd@ams.org.

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.

February 1999

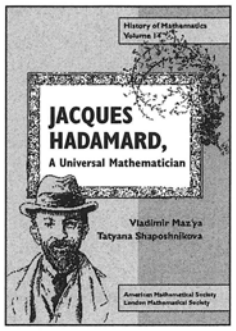
*7-11 **35th Australasian Applied Mathematics Conference**, Mollymook Golf Club, Ulladulla, New South Wales.
Purpose: This conference, traditionally held at a summer holiday resort, covers a broad spectrum of applied mathematics, strongly encouraging lectures on concrete applications. Areas include engineering and industrial mathematics, fluid and solid mechanics, mathematical modelling, numerical mathematics, operations research, financial mathematics, and solution methods for partial differential equations.
Organizers: P. Broadbridge, M. Edwards, J. Hill, M. Lee, X. Lu, B. Macaskill, T. Marchant, S. Zhu.
Information: Secretary, ANZIAM'99, School of Mathematics and Applied Statistics, University of Wollongong, NSW 2522, Australia; fax: 61-2-42214845; e-mail: Tim_Marchant@uow.edu.au.

July 1999

*5-9 **The Fourth International Congress on Industrial and Applied Mathematics**, Edinburgh, Scotland.
Program: The congress will focus worldwide attention on the importance of mathematical and computational methods in the solution of real world problems. The program consists of invited and contributed lectures, minisymposia, poster presentations, and an exhibition.
Topics: Presentations are welcomed in all areas of applied and computational mathematics, computer science, applied probability and statistics, scientific computing and applications of mathematics to industrial, financial, medical, environmental, and other related fields.
Information: Details of the conference are available by accessing the conference Web page: http://www.maths.ed.ac.uk/conferences/iciam99/, or by writing/telephoning/faxing/e-mailing ICIAM '99 Congress Secretariat, c/o Meeting Makers, 50 George Street, Glasgow G1 1QE, UK; tel: +44 0 141 553 1930; e-mail: geninfo.iciam@meetingmakers.co.uk; fax: +44 0 141 552 0511.

New Publications Offered by the AMS

General and Interdisciplinary



Jacques Hadamard, A Universal Mathematician

Vladimir Maz´ya and **Tatyana Shaposhnikova**, *Linköping University, Sweden*

This book presents a fascinating story of the long life and great accomplishments of Jacques Hadamard (1865–1963), who was once called "the living legend of mathematics". As one of the last universal mathematicians, Hadamard's contributions to mathematics are landmarks in various fields. His life is linked with world history of the 20th century in a dramatic way. This work provides an inspiring view of the development of various branches of mathematics during the 19th and 20th centuries.

Part I of the book portrays Hadamard's family, childhood and student years, scientific triumphs, and his personal life and trials during the first two world wars. The story is told of his involvement in the Dreyfus affair and his subsequent fight for justice and human rights. Also recounted are Hadamard's worldwide travels, his famous seminar, his passion for botany, his home orchestra, where he played the violin with Einstein, and his interest in the psychology of mathematical creativity.

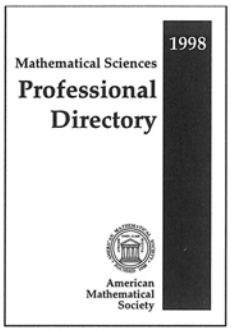
Hadamard's life is described in a readable and inviting way. The authors humorously weave throughout his jokes and the myths about him. They also movingly recount the tragic side of his life. Stories about his relatives and friends, and old letters and documents create an authentic and colorful picture. The book contains over 300 photographs and illustrations.

Part II of the book includes a lucid overview of Hadamard's enormous work, spanning over six decades. The authors do an excellent job of connecting his results to current concerns. While the book is accessible to beginners, it also provides rich information of interest to experts.

Contents: *Part I. Hadamard's Life:* Prologue; The beginning; The turn of the century; Mature years; After the Great War; Le Maître; In the thirties; World War II; After eighty; *Part II, Hadamard's Mathematics:* Analytic function theory; Number theory; Analytical mechanics and geometry; Calculus of variations and functionals; Miscellaneous topics; Elasticity and hydrodynamics; Partial differential equations; Hadamard's last works; Epilogue; Principal dates in Hadamard's life; A Hadamard collection; Bibliography of Jacques Hadamard; Publications about Jacques Hadamard and his work; General bibliography; Archival material; Index.

History of Mathematics, Volume 14

February 1998, approximately 507 pages, Hardcover, ISBN 0-8218-0841-9, LC 97-36357, 1991 *Mathematics Subject Classification*: 01-02, 01A70, 01A99; 11-03, 26-03, 30-03, 35-03, 46-03, 53-03, 73-03, 76-03, **Individual member $47**, List $79, Institutional member $63, Order code HMATH/14N

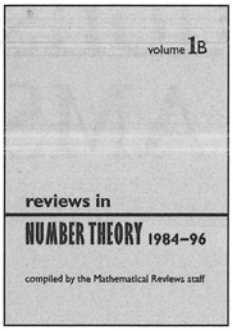


Mathematical Sciences Professional Directory

This annual directory provides a handy reference to various organizations in the mathematical sciences community. Listed in the directory are: officers and committee members of over thirty professional mathematical organizations (terms of office and other pertinent information are also provided in some cases); key mathematical sciences personnel of selected government agencies; academic departments in the mathematical sciences; mathematical units in nonacademic organizations; and alphabetic listings of colleges and universities. Current addresses, telephone numbers, and electronic addresses for individuals are listed in the directory when provided.

March 1998, approximately 224 pages, Softcover, ISBN 0-8218-0934-2, List $50, Institutional member $40, Order code PRODIR/98N

Number Theory



Reviews in Number Theory 1984–96

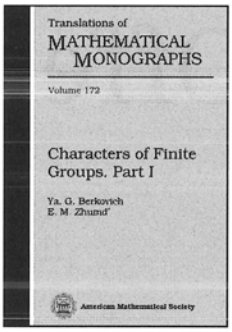
These six volumes include approximately 20,000 reviews of items in number theory that appeared in *Mathematical Reviews* (MR) between 1984 and 1996. This is the third such set of volumes in number theory: The first was edited by W. J. LeVeque and included reviews from 1940–1972; the second was edited by R. K. Guy and appeared in 1984.

With the publication of the new review volumes, readers now have available reviews in number theory covering more than half a century.

Contents: *Volume 1B:* Elementary number theory; Sequences and sets; Polynomials and matrices; *Volume 2B:* Diophantine equations; Forms and linear algebraic groups; Discontinuous groups and automorphic forms; Arithmetic algebraic geometry (Diophantine geometry); *Volume 3B:* Geometry of numbers; Diophantine approximation, transcendental number theory; Probabilistic theory: distribution modulo 1; metric theory of algorithms; *Volume 4B:* Exponential sums and character sums; Zeta and L-functions: analytic theory; Multiplicative number theory; Additive number theory; partitions; Other arithmetic-analytic topics; *Volume 5B:* Algebraic number theory: global fields; Algebraic number theory: local and p-adic fields; Finite fields and commutative rings (number-theoretic aspects); Connections with logic; Computational number theory; *Volume 6B:* Preface; Chapter Z General; Classification scheme; Subject word index; Author index; Key index; MR number list; Cyrillic table.

February 1998, 405 pages (Volume 1B), 1055 pages (Volume 2B), 452 pages (Volume 3B), 606 pages (Volume 4B), 764 pages (Volume 5B), 1012 pages (Volume 6B), 4294 pages (Set), Softcover, ISBN 0-8218-0931-8 (Volume 1B), ISBN 0-8218-0932-6 (Volume 2B), ISBN 0-8218-0933-4 (Volume 3B), ISBN 0-8218-0935-0 (Volume 4B), ISBN 0-8218-0936-9 (Volume 5B), ISBN 0-8218-0937-7 (Volume 6B), ISBN 0-8218-0848-6 (Set), LC 97-38703, 1991 *Mathematics Subject Classification*: 11-XX, ***Volume 1B*: Individual member $25**, List $42, Institutional member $34, ***Volume 2B*: Individual member $64**, List $107, Institutional member $86, ***Volume 3B*: Individual member $25**, List $42, Institutional member $34, ***Volume 4B*: Individual member $37**, List $62, Institutional member $50, ***Volume 5B*: Individual member $47**, List $78, Institutional member $62, ***Volume 6B*: Individual member $61**, List $102, Institutional member $82, ***Set*: Individual member $195**, List $325, Institutional member $260, Order code REVNUM/96/1N (Volume 1B), REVNUM/96/2N (Volume 2B), REVNUM/96/3N (Volume 3B), REVNUM/96/4N (Volume 4B), REVNUM/96/5N (Volume 5B), REVNUM/96/6N (Volume 6B), REVNUM/96N (Set)

Algebra and Algebraic Geometry



Characters of Finite Groups. Part I

Ya. G. Berkovich, *University of Haifa, Israel*, and **E. M. Zhmud′**, *Kharkov University, Ukraine*

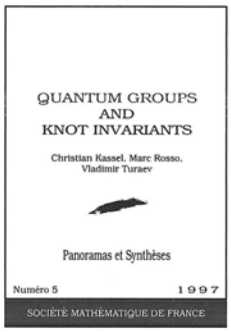
This book discusses character theory and its applications to finite groups. The work places the subject within the reach of people with a relatively modest mathematical background. The necessary background exceeds the standard algebra course with respect only to finite groups.

Starting with basic notions and theorems in character theory, the authors present a variety of results on the properties of complex-valued characters and applications 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 and applications of monomial groups. The presentation is detailed, and many proofs of known results are new. Most of the results in the book are presented in monograph form for the first time. Numerous exercises offer additional information on the topics and help readers to understand the main concepts and results.

Contents: Basic concepts; Characters; On arithmetical properties of characters; Products of characters; Induced characters and representations; Projective representations; Clifford theory; Brauer's induction theorems; Faithful representations; Existence of normal subgroups; On sums of degrees of irreducible characters; Groups of relatively small height; The Brauer-Suzuki theorem; Appendices; Notes on the bibliography; Bibliography; Author index; Subject index.

Translations of Mathematical Monographs, Volume 172

December 1997, 382 pages, Hardcover, ISBN 0-8218-4606-X, LC 97-39813, 1991 *Mathematics Subject Classification*: 20C15, **Individual member $77**, List $129, Institutional member $103, Order code MMONO/172N



Quantum Groups and Knot Invariants

Christian Kassel, Marc Rosso, and **Valadimir Turaev**, *CNRS, Strasbourg, France*

This book provides a concise introduction to quantum groups, braided monoidal categories and quantum invariants of knots and of three-dimensional manifolds. The exposition emphasizes the newly discovered deep relationships between these areas.

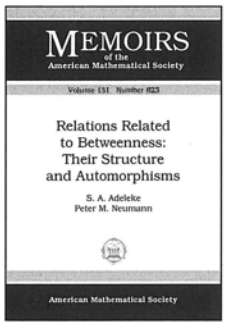
This text will also be of interest to those working in geometry and topology.

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 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: The Yang-Baxter equation and braid group representations; Hopf algebras and monoidal categories; Drinfeld's quantum double; The quantized enveloping algebra $U_q\mathfrak{sl}(N+1)$; The Jones polynomial and skein categories; From ribbon categories to topological invariants of links and 3-manifolds; The representation theory of $U_q\mathfrak{sl}(N+1)$; Vassiliev invariants of links; Advanced topics; Guide to the literature; Index.

Panoramas et Synthèses, Number 5

October 1997, 115 pages, Softcover, ISBN 2-85629-055-8, 1991 *Mathematics Subject Classification*: 16W30, 17B37, 18D10, 20F36, 57M24, 57N10, 81R50, **Individual member $22**, List $24, Order code PASY/5N



Relations Related to Betweenness: Their Structure and Automorphisms

S. A. Adeleke, *Western Illinois University, Macomb*, and **Peter M. Neumann**, *Queen's College, Oxford University, England*

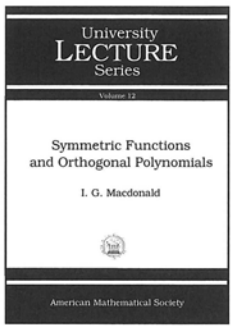
This volume is about tree-like structures, namely semilinear ordering, general betweenness relations, C-relations and D-relations. It contains a systematic study of betweenness and introduces C- and D-relations to describe the behavior of points at infinity ("leaves" or "ends" or "directions") of trees. The focus is on structure theorems and on automorphism groups, with applications to the theory of infinite permutation groups.

Features:
- Offers the first systematic treatment of betweenness relations
- Introduces important new concepts of C-relations and D-relations
- Elucidates the close relationships between semilinear orderings, betweenness relations, C- and D-relations
- Considers their automorphism groups as important examples of Jordan permutation groups

Contents: Preparation; Semilinear order relations; Abstract chain sets; General betweenness relations; Abstract direction sets; Applications and commentary; References.

Memoirs of the American Mathematical Society, Volume 131, Number 623

January 1998, 138 pages, Softcover, ISBN 0-8218-0623-8, LC 97-35546, 1991 *Mathematics Subject Classification*: 08A02, 06A06, 03C35, 20B07, 20E08, 54F50, **Individual member $26**, List $43, Institutional member $34, Order code MEMO/131/623N



Symmetric Functions and Orthogonal Polynomials

I. G. Macdonald, *Queen Mary College, University of London, England*

One of the most classical areas of algebra, the theory of symmetric functions and orthogonal polynomials, has long been known to be connected to combinatorics, representation theory, and other branches of mathematics. Written by perhaps the most famous author on the topic, this volume explains some of the current developments regarding these connections. It is based on lectures presented by the author at Rutgers University. Specifically, he gives recent results on orthogonal polynomials associated with affine Hecke algebras, surveying the proofs of certain famous combinatorial conjectures.

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

Contents: Symmetric functions; Orthogonal polynomials; Postscript; References.

University Lecture Series, Volume 12

December 1997, 63 pages, Softcover, ISBN 0-8218-0770-6, LC 97-26100, 1991 *Mathematics Subject Classification*: 05, 22, 33, **All AMS members $15**, List $19, Order code ULECT/12N

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.

Members of the Canadian Mathematical Society may order at the AMS member price.

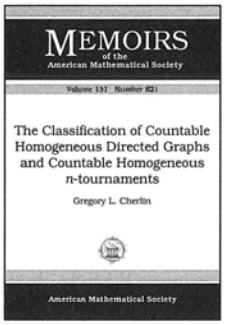
Contents: V. V. Bavula, Filter dimension and its application; **V. Drensky**, Automorphisms of polynomial, free and generic matrix algebras; **P. Gabriel**, Matrix problems and representation-theory; **K. R. Goodearl** and **E. S. Letzter**, Prime and primitive spectra of multiparameter quantum affine spaces; **A. Kemer**, *PI*-algebras and nil algebras of bounded index; **H. Lenzing**, Representations of finite dimensional algebras and singularity theory; **Z. S. Marciniak** and **S. K. Sehgal**, Zassenhaus conjectures for infinite groups; **J. Okniński**, Graded rings — an approach via semigroups of matrices; **D. S. Passman**, Semiprimitivity of group algebras: Past results and recent progress; **A. Regev**, Asymptotics of codimensions of some P.I.

algebras; **K. W. Roggenkamp**, Problems on group rings; **A. Skowroński**, Tame module categories of finite dimensional algebras; **A. E. Zalesskii**, Direct limits of finite dimensional algebras and finite groups.

Conference Proceedings, Canadian Mathematical Society, Volume 22

November 1997, 239 pages, Softcover, ISBN 0-8218-0849-4, LC 97-30267, 1991 *Mathematics Subject Classification*: 16-06, **Individual member $29**, List $49, Institutional member $39, Order code CMSAMS/22N

Discrete Mathematics and Combinatorics



The Classification of Countable Homogeneous Directed Graphs and Countable Homogeneous n-tournaments

Gregory L. Cherlin, *Rutgers University, New Brunswick, NJ*

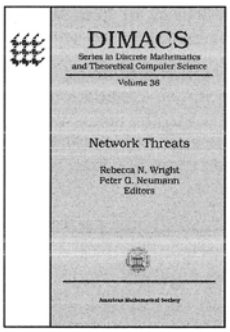
In this book, Ramsey theoretic methods introduced by Lachlan are applied to classify the countable homogeneous directed graphs. This is an uncountable collection, and this book presents the first explicit classification result covering an uncountable family. The author's aim is to demonstrate the potential of Lachlan's method for systematic use.

Features:
- Interface between combinatorics and model theory
- Unusual use of Ramsey's theorem to classify structures
- An extension of an already elaborate branch of model theory
- The first monograph on Lachlan's method

Contents: Results and open problems; Homogeneous 2-tournaments; Homogeneous n-tournaments; Homogeneous symmetric graphs; Homogeneous directed graphs omitting I_∞; Propositions 16 to 20 and MT 2.2; Homogeneous directed graphs embedding I_∞; Theorems 7.6–7.9; Appendix: Examples for richer languages; Bibliography; Index of Notation; Index.

Memoirs of the American Mathematical Society, Volume 131, Number 621

January 1998, 161 pages, Softcover, ISBN 0-8218-0836-2, LC 97-31683, 1991 *Mathematics Subject Classification*: 05C20; 03C10, 03C15, 03C50, 05D10, 20B22, 20B27, **Individual member $28**, List $47, Institutional member $38, Order code MEMO/131/621N



Network Threats

Rebecca N. Wright, *AT&T Labs Research, Florham Park, NJ*, and **Peter G. Neumann**, *SRI International, Menlo Park, CA*, Editors

This volume presents papers from a DIMACS workshop on network threats. The workshop brought together computer scientists (theorists and practitioners) working in this area to discuss topics such as network security, prevention and detection of security attacks, modeling threats, risk management, threats to individual privacy, and methods of security analysis. The book demonstrates the wide and diverse range of topics involved in electronic interactions and transactions—including the less desirable aspects: security breaches.

The volume offers a timely assessment of avoiding or minimizing network threats. Presented here is an interdisciplinary, system-oriented approach that encompasses security requirements, specifications, protocols, and algorithms. The text includes implementation and development strategies using real-world applications that are reliable, fault-tolerant, and performance oriented. The book would be suitable for a graduate seminar on computer security.

Features:
- Discussion of Internet, Web and Java security
- Information on new attacks and weaknesses
- Formal and informal analysis methods to identify, quantify, and combat security threats

This text will also be of interest to those working in general interest and interdisciplinary areas.

Contents: C. Meadows, A representation of protocol attacks for risk assessment; **D. Zhou** and **S.-K. Chin**, Verifying privacy enhanced mail functions with higher order logic; **M. Joye** and **J.-J. Quisquater**, Cryptanalysis of RSA-type cryptosystems: A visit; **S. Patel**, Information leakage in encrypted key exchange; **A. Shostack**, Observed weaknesses in security dynamics' client/server protocol; **D. Dean**, Web security: A high level view; **D. S. Wallach**, **J. A. Roskind**, and **E. W. Felten**, Flexible, extensible Java security using digital signatures; **M. Burmester**, **Y. Desmedt**, and **G. Kabatianski**, Trust and security: A new look at the Byzantine generals problem; **R. J. Hall**, Channels: Avoiding unwanted electronic mail; **C. Cullen**, Demonstration of hacker techniques.

DIMACS: Series in Discrete Mathematics and Theoretical Computer Science, Volume 38

December 1997, 110 pages, Hardcover, ISBN 0-8218-0832-X, LC 97-30683, 1991 *Mathematics Subject Classification*: 68-06, 68M10, 94B12; 68P25, 94A60, 68N99, **All AMS members $23**, List $29, Order code DIMACS/38N

Analysis

Hodge Theory in the Sobolev Topology for the de Rham Complex

Luigi Fontana, *Universita 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.

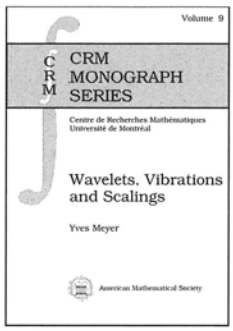
Features:

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

Contents: Preliminaries; The problem on the half space; The case of smoothly bounded domains.

Memoirs of the American Mathematical Society, Volume 131, Number 622

January 1998, 100 pages, Softcover, ISBN 0-8218-0830-3, LC 97-31684, 1991 *Mathematics Subject Classification*: 35J55, 35S15, 35N15, 58A14, 58G05, **Individual member $23**, List $39, Institutional member $31, Order code MEMO/131/622N



Wavelets, Vibrations and Scalings

Yves Meyer, *University of Paris-Dauphine, France*

Physicists and mathematicians are intensely studying fractal sets of fractal curves. Mandelbrot advocated modeling of real-life signals by fractal or multifractal functions. One example is fractional Brownian motion, where large-scale behavior is related to a corresponding infrared divergence. Self-similarities and scaling laws play a key role in this new area.

There is a widely accepted belief that wavelet analysis should provide the best available tool to unveil such scaling laws. And orthonormal wavelet bases are the only existing bases which are structurally invariant through dyadic dilations.

This book discusses the relevance of wavelet analysis to problems in which self-similarities are important. Among the conclusions drawn are the following: 1) A weak form of self-similarity can be given a simple characterization through size estimates on wavelet coefficients, and 2) Wavelet bases can be tuned in order to provide a sharper characterization of this self-similarity.

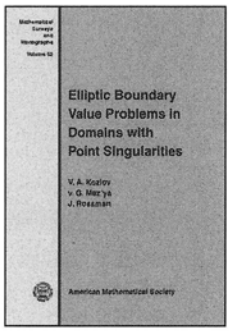
A pioneer of the wavelet "saga", Meyer gives new and as yet unpublished results throughout the book. It is recommended to scientists wishing to apply wavelet analysis to multifractal signal processing.

Contents: Introduction; Scaling exponents at small scales; Infrared divergences and Hadamard's finite parts; The 2-microlocal spaces $C^{s,s'}_{x_0}$; New characterizations of the two-microlocal spaces; An adapted wavelet basis; Combining a Wilson basis with a wavelet basis; Bibliography; Index; Greek symbols; Roman symbols.

CRM Monograph Series, Volume 9

December 1997, 133 pages, Hardcover, ISBN 0-8218-0685-8, LC 97-34730, 1991 *Mathematics Subject Classification*: 26A16, 26A30, 26A69, 26B35, 42A16, **All AMS members $23**, List $29, Order code CRMM/9N

Differential Equations



Elliptic Boundary Value Problems in Domains with Point Singularities

V. A. Kozlov and **V. G. Maz´ya**, *Linköping University, Sweden*, and **J. Rossmann**, *Rostock University, Germany*

This monograph systematically treats a theory of elliptic boundary value problems in domains without singularities and in domains with conical or cuspidal points. This exposition is self-contained and a priori requires only basic knowledge of functional analysis. Restricting to boundary value problems formed by differential operators and avoiding the use of pseudo-differential operators makes the book accessible for a wider readership.

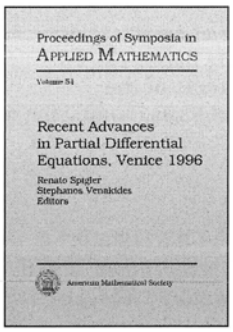
The authors concentrate on fundamental results of the theory: estimates for solutions in different function spaces, the Fredholm property of the operator of the boundary value problem, regularity assertions and asymptotic formulas for the solutions near singular points. A special feature of the book is that the solutions of the boundary value problems are considered in Sobolev spaces of both positive and negative orders. Results of the general theory are illustrated by concrete examples. The book may be used for courses in partial differential equations.

Contents: Introduction; *Part 1:* Boundary value problems for ordinary differential equations on the half-axis; Elliptic boundary value problems in the half-space; Elliptic boundary value problems in smooth domains; Variants and extensions; *Part 2:* Elliptic boundary value problems in an infinite cylinder; Elliptic boundary value problems in domains with conical points; Elliptic boundary value problems in weighted Sobolev spaces with nonhomogeneous norms; Variants and extensions; Part 3; Elliptic boundary value problems in domains with exterior cusps; Elliptic boundary value problems in domains with inside cusps; Bibliography; Index; List of symbols.

Continued

Mathematical Surveys and Monographs, Volume 52

August 1997, 414 pages, Hardcover, ISBN 0-8218-0754-4, LC 97-20695, 1991 *Mathematics Subject Classification*: 35-02; 35J40, 35B40, 35D05, 35D10, **Individual member $59**, List $99, Institutional member $79, Order code SURV/52N



Recent Advances in Partial Differential Equations, Venice 1996

Renato Spigler, *University of Padova, Italy*, and **Stephanos Venakides**, *Duke University, Durham, NC*, Editors

Lax and Nirenberg are two of the most distinguished mathematicians of our times. Their work on partial differential equations (PDEs) over the last half-century has dramatically advanced the subject and has profoundly influenced the course of mathematics. A huge part of the development in PDEs during this period has either been through their work, motivated by it or achieved by their post-docs and students.

A large number of mathematicians honored these two exceptional scientists in a week-long conference in Venice (June, 1996) on the occasion of their 70th birthdays.

This volume contains the proceedings of the conference, which focused on the modern theory of nonlinear PDEs and their applications. Among the topics treated are turbulence, kinetic models of a rarefied gas, vortex filaments, dispersive waves, singular limits and blow-up of solutions, conservation laws, Hamiltonian systems and others. The conference served as a forum for the dissemination of new scientific ideas and discoveries and enhanced scientific communication by bringing together such a large number of scientists working in related fields. The event allowed the international mathematics community to honor two of its outstanding members.

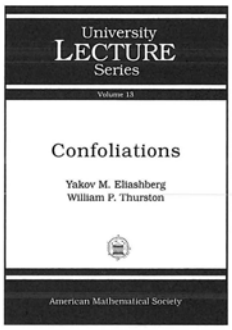
This text will also be of interest to those working in mathematical physics.

Contents: G. I. Barenblatt and **A. J. Chorin**, Scaling laws and vanishing viscosity limits in turbulence theory; **P. Cannarsa** and **G. Da Prato**, Potential theory in Hilbert spaces; **C. Cercignani**, Recent developments in the theory of the Boltzmann equation; **P. Deift**, **T. Kriecherbauer**, and **K. T-R McLaughlin**, New results for the asymptotics of orthogonal polynomials and related problems via the Lax-Levermore method; **A. Fannjiang**, **L. Ryzhik**, and **G. C. Papanicolaou**, Evolution of trajectory correlations in steady random flows; **A. S. Fokas**, Integrability: From d'Alembert to Lax; **G. Gallavotti**, Methods in the theory of quasi periodic motions; **S. Klainerman**, Fourier analysis and nonlinear wave equations; **C. D. Levermore**, The KdV zero-dispersion limit and densities of Dirichlet spectra; **P.-L. Lions**, On Boltzmann equation and its applications; **A. J. Majda**, Simplified asymptotic equations for slender vortex filaments; **D. W. McLaughlin** and **J. Shatah**, Homoclinic orbits for Pde's; **U. Mosco**, Lagrangian metrics on fractals; **E. Tadmor**, Approximate solutions of nonlinear conservation laws and related equations; **S. Venakides**, The small dispersion KdV equation with decaying initial data.

Proceedings of Symposia in Applied Mathematics, Volume 54

December 1997, 393 pages, Hardcover, ISBN 0-8218-0657-2, LC 97-29150, 1991 *Mathematics Subject Classification*: 34-XX, 35-XX, 42-XX, 60-XX, 65-XX, 70-XX, 76-XX, **Individual member $35**, List $59, Institutional member $47, Order code PSAPM/54N

Geometry and Topology



Confoliations

Yakov M. Eliashberg, *Stanford University, CA*, and **William P. Thurston**, *University of California, Davis*

This book presents the first steps of a theory of confoliations designed to link the geometry and topology of three-dimensional contact structures with the geometry and topology of codimension-one foliations on three-dimensional manifolds. Developing almost independently, these theories at first glance belonged to two different worlds: The theory of foliations is part of topology and dynamical systems, while contact geometry is the odd-dimensional "brother" of symplectic geometry.

However, both theories have developed a number of striking similarities. Confoliations—which interpolate between contact structures and codimension-one foliations—should help us to understand better links between the two theories. These links provide tools for transporting results from one field to the other.

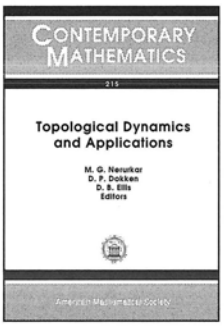
Features:

- A unified approach to the topology of codimension-one foliations and contact geometry.
- Insight on the geometric nature of integrability.
- New results, in particular on the perturbation of confoliations into contact structures.

Contents: Geometric nature of integrability; Perturbation of confoliations into contact structures; Taut vs. tight; Bibliography.

University Lecture Series, Volume 13

December 1997, 66 pages, Softcover, ISBN 0-8218-0776-5, LC 97-32128, 1991 *Mathematics Subject Classification*: 53C15, 57N10; 58F05, 57R30, **All AMS members $13**, List $16, Order code ULECT/13N



Topological Dynamics and Applications

M. G. Nerurkar, *Rutgers University, Camden, NJ*, **D. P. Dokken**, *St. Paul, MN*, and **D. B. Ellis**, *Beloit College, WI*, Editors

This book is a very readable exposition of the modern theory of topological dynamics and presents diverse applications to such

areas as ergodic theory, combinatorial number theory and differential equations. There are three parts: 1) The abstract theory of topological dynamics is discussed, including a comprehensive survey by Furstenberg and Glasner on the work and influence of R. Ellis. Presented in book form for the first time are new topics in the theory of dynamical systems, such as weak almost-periodicity, hidden eigenvalues, a natural family of factors and topological analogues of ergodic decomposition. 2) The power of abstract techniques is demonstrated by giving a very wide range of applications to areas of ergodic theory, combinatorial number theory, random walks on groups and others. 3) Applications to non-autonomous linear differential equations are shown. Exposition on recent results about Floquet theory, bifurcation theory and Lyapanov exponents is given.

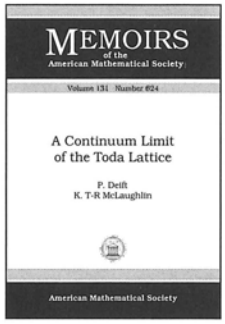
This text will also be of interest to those working in analysis.

Contents: *Part I:* **H. Furstenberg** and **E. Glasner**, Robert Ellis and the algebra of dynamical systems; **J. Auslander**, Weak mixing and pure weak mixing minimal flows; **E. Glasner, M. Mentzen**, and **A. Siemaszko**, A natural family of factors for minimal flows; **E. Akin** and **E. Glasner**, Topological ergodic decomposition and homogeneous flows; **D. Penazzi**, On the proximal and regionally proximal relation of an extension between minimal flows; **E. Akin, J. Auslander**, and **K. Berg**, Almost equicontinuity and the enveloping semigroup; **V. Pestov**, Some universal constructions in abstract topological dynamics; **T. Downarowicz**, Weakly almost periodic flows and hidden eigenvalues; **E. Akin**, Enveloping linear maps; **H. Keynes, K. Madden, N. Markley**, and **M. Sears**, An overview of the construction of suspension flows using continuous cocycles; **D. Ellis**, Suspensions, inheritance, and flows on homogeneous spaces; **H. Ikeshoji** and **T. Wu**, On the lifting of transformation semigroups; *Part II:* **D. Dokken**, Idempotent measures associated to a locally compact topological group; **S. Adams**, Another proof of Moore's ergodicity theorem for $SL(2,\mathbb{R})$; **B. Weiss**, Multiple recurrence and doubly minimal systems; **H. Furstenberg** and **E. Glasner**, Subset dynamics and van der Waerden's theorem; **V. Bergelson** and **R. McCutcheon**, Recurrence for semigroup actions and a noncommutative Schur theorem; **Z. Coelho, W. Parry**, and **R. Williams**, A note on Livš ic's periodic point theorem; **E. Glasner** and **J. King**, A zero-one law for dynamical properties; **D. Rudolph**, Residuality and orbit equivalence; **J. Feldman**, Uncountably many Vershik-inequivalent group actions of equal entropy; *Part III:* **M. Nerurkar**, Positive Lyapunov exponents for a dense set of continuous $SL(2,\mathbb{R})$ valued cocycles which arise as solutions to strongly accessible linear differential systems; **G. Sell, W. Shen**, and **Y. Yi**, Topological dynamics and differential equations; **S. Novo** and **R. Obaya**, An ergodic and topological approach to almost periodic bidimensional linear systems; **R. Johnson**, An application of topological dynamics to bifurcation theory.

Contemporary Mathematics, Volume 215

December 1997, 336 pages, Softcover, ISBN 0-8218-0608-4, LC 97-38715, 1991 *Mathematics Subject Classification*: 54H20, 28D05, 34C35, 28D15, **Individual member $41**, List $69, Institutional member $55, Order code CONM/215N

Mathematical Physics



A Continuum Limit of the Toda Lattice

P. Deift, *New York University-Courant Institute, NY*, and **K. T-R McLaughlin**, *Ohio State University, Columbus*

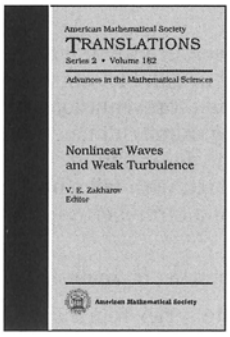
In this book, the authors describe a continuum limit of the Toda ODE system, obtained by taking as initial data for the finite lattice successively finer discretizations of two smooth functions. Using the integrability of the finite Toda lattice, the authors adapt the method introduced by Lax and Levermore for the study of the small dispersion limit of the Korteweg de Vries equations to the case of the Toda lattice. A general class of initial data is considered which permits, in particular, the formation of shocks. A novel feature of the analysis in this book is an extensive use of techniques from the theory of Riemann-Hilbert problems.

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

Contents: Introduction; Analysis of Log formula; An example; Monotone initial data; Shock 1; Shock 2; Shock 3; Shock 4; Symmetric data; Global description; Large time calculations; Appendix I—WKB; Appendix II; Bibliography.

Memoirs of the American Mathematical Society, Volume 131, Number 624

January 1998, 216 pages, Softcover, ISBN 0-8218-0691-2, LC 97-31680, 1991 *Mathematics Subject Classification*: 58F07, 58E99, **Individual member $31**, List $51, Institutional member $41, Order code MEMO/131/624N



Nonlinear Waves and Weak Turbulence

V. E. Zakharov, *Landau Institute for Theoretical Physics, Moscow, Russia*, Editor

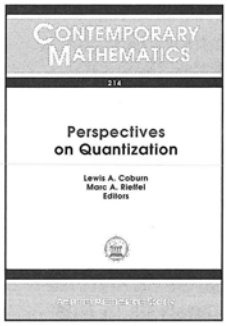
This book is a collection of papers on dynamical and statistical theory of nonlinear wave propagation in dispersive conservative media. Emphasis is on waves on the surface of an ideal fluid and on Rossby waves in the atmosphere. Although the book deals mainly with weakly nonlinear waves, it is more than simply a description of standard perturbation techniques. The goal is to show that the theory of weakly interacting waves is naturally related to such areas of mathematics as Diophantine equations, differential geometry of waves, Poincaré normal forms and the inverse scattering method.

Contents: **A. M. Balk** and **E. V. Ferapontov**, Invariants of wave systems and web geometry; **A. M. Balk** and **V. E. Zakharov**, Stability of weak-turbulence Kolmogorov spectra; **V. A. Kalmykov**, Energy transfer in the spectrum of surface gravity waves by resonance five wave-wave interactions; **E. Kartashova**, Wave resonances in systems with discrete

spectra; **L. I. Piterbarg**, Hamiltonian formalism for Rossby waves; **V. E. Zakharov**, Weakly nonlinear waves on the surface of an ideal finite depth fluid.

American Mathematical Society Translations—Series 2, *Advances in the Mathematical Sciences*, Volume 182

November 1997, 197 pages, Hardcover, ISBN 0-8218-4113-0, LC 91-640741, 1991 *Mathematics Subject Classification*: 76B15, 76C20; 35Q35, 35Q53, **Individual member $53**, List $89, Institutional member $71, Order code TRANS2/182N



Perspectives on Quantization

Lewis A. Coburn, *State University of New York at Buffalo*, and **Marc A. Rieffel**, *University of California, Berkeley*, Editors

This book presents the proceedings of a 1996 Joint Summer Research Conference sponsored by AMS-IMS-SIAM on "Quantization" held at Mount Holyoke College (Northampton, MA). The purpose of the conference was to bring together researchers focusing on various mathematical aspects of quantization.

In the early work of Weyl and von Neumann at the beginning of the quantum era, the setting for this enterprise was operators on Hilbert space. This setting has been expanded, especially over the past decade, to involve C^*-algebras—noncommutative differential geometry and noncommutative harmonic analysis—as well as more general algebras and infinite-dimensional manifolds. The applications now include quantum field theory, notable conformal and topological field theories related to quantization of moduli spaces, and constructive quantum field theory of supersymmetric models and condensed matter physics (the fractional quantum Hall effect in particular).

The spectrum of research interests which significantly intersects the topic of quantization is unusually broad, including, for example, pseudodifferential analysis, the representation theory of Lie groups and algebras (including infinite-dimensional ones), operator algebras and algebraic deformation theory. The papers in this collection originated with talks by the authors at the conference and represent a strong cross-section of the interests described above.

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

Contents: J. Arazy and **H. Upmeier**, Discrete series representations and integration over boundary orbits of symmetric domains; **D. Borthwick**, Microlocal techniques for semiclassical problems in geometric quantization; **J. Dimock**, A non-Gaussian fixed point for the renormalization group; **B. C. Hall**, Quantum mechanics in phase space; **T. J. Hodges**, Nonstandard quantum groups associated to certain Belavin-Drinfeld triples; **S. Klimek** and **A. Leśniewski**, Ergodic theorems for quantum Kronecker flows; **S. Klimek** and **A. Leśniewski**, Quantum maps; **G. W. Mackey**, The relationship between classical mechanics and quantum mechanics; **G. Nagy**, Deformation quantization and K-theory; **J. H. Przytycki**, A q-analogue of the first homology group of a 3-manifold; **I. Segal**, Constructive non-linear quantum field theory in four space-time dimensions; **A. J. L. Sheu**, Groupoids and quantization; **A. Unterberger**, Quantization, symmetries, and relativity; **A. A. Voronov**, Quantizing Poisson manifolds.

Contemporary Mathematics, Volume 214

December 1998, 195 pages, Softcover, ISBN 0-8218-0684-X, LC 97-34607, 1991 *Mathematics Subject Classification*: 81-06, **Individual member $23**, List $39, Institutional member $31, Order code CONM/214N

Classified Advertisements

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

ARIZONA

ARIZONA STATE UNIVERSITY
Department of Mathematics

The Department of Mathematics at Arizona State University invites applications for several tenure-track and visiting positions at the assistant and associate professor levels, pending budgetary approval, commencing fall 1998. All candidates must have a Ph.D. in mathematics, statistics, or a closely related area and demonstrated potential for excellence in research and teaching at the undergraduate level. For candidates at the associate professor level, additional requirements include an outstanding research record and proven commitment to excellence and innovation in teaching at all levels.

Tenure-track candidates must have research strengths in one or more of the following areas: i) applied and theoretical statistics, ii) computationally oriented applied mathematics, iii) differential equations (ordinary and/or stochastic), or iv) operator algebras. Candidates in the first three areas should also have experience in modeling and computation, encompassing applications from industry, the life sciences or engineering, and expect to participate fully in a cross-disciplinary environment.

Applications for visiting positions are invited from candidates who must have research strengths in applied mathematics or discrete mathematics and interests in modeling, computation, and participation in multidisciplinary activities.

The main campus of Arizona State University has approximately 43,000 students and is located in the rapidly growing metropolitan Phoenix area, which provides a wide variety of recreational and cultural opportunities. The Department of Mathematics currently has 58 full-time faculty members, 27 lecturers, and over 70 supported graduate students. Departmental computing facilities include networked clusters of high-end workstations as well as several graphics computers and access to the university's central computing facilities.

Applicants must send i) their résumé, ii) an AMS Cover Sheet, iii) a letter stating for which position they wish to be considered and addressing their research agenda, iv) a statement of teaching philosophy, and v) at least three letters of recommendation by the deadline to: R. A. Renaut, Chair, Department of Mathematics, P. O. Box 871804, Arizona State University, Tempe, AZ 85287-1804.

Review of the applications will begin on November 30, 1997, and will continue weekly until the positions are filled.

ARIZONA STATE UNIVERSITY
Senior Joint Positions: (i) Departments of Mathematics and Chemical, Bio and Materials Engineering; (ii) Departments of Mathematics and Electrical Engineering.

We invite applications for two associate or full professor positions commencing fall, 1998.

One is to be jointly appointed in the mathematics and chemical, bio and materials engineering departments. Candidates must have a Ph.D. degree in mathematics, materials science or engineering, or a closely related degree; experience in mathematical modeling and simulation of semiconductor materials processing, computation, and contact with applications from industry.

One is to be jointly appointed in the mathematics and electrical engineering departments. Candidates must have a Ph.D. degree in mathematics, electrical engineering, or a closely related degree. Candidates must have expertise in control systems and in differential equations. Experience in modeling of complex dynamical systems and computation, encompassing applications from industry or the life sciences, desired.

All candidates must have an outstanding research record, an established record of research funding, and a proven commitment to excellence and innovation in teaching. Candidates are expected to participate fully in cross-disciplinary programs, teaching, research, and professional service.

The main campus of Arizona State University has approximately 43,000 students and is located in the rapidly growing metropolitan Phoenix area, which provides a wide variety of recreational and cultural opportunities. The Phoenix area supports a high concentration of high technology industries. The Department of Mathematics has 58 full-time faculty; the Department of Chemical, Bio and Materials Engineering has 26 full-time faculty; and the De-

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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 1997 rate is $100 per inch or fraction thereof on a single column (one-inch minimum), calculated from top of headline. Any fractional text of 1/2 inch or more will be charged at the next inch rate. No discounts for multiple ads or the same ad in consecutive issues. For an additional $10 charge, announcements can be placed anonymously. Correspondence will be forwarded.

Advertisements in the "Positions Available" classified section will be set with a minimum one-line headline, consisting of the institution name above body copy, unless additional headline copy is specified by the advertiser. Headlines will be centered in boldface at no extra charge. Ads will appear in the language in which they are submitted.

There are no member discounts for classified ads. Dictation over the telephone will not be accepted for classified advertising.

Upcoming deadlines for classified advertising are as follows: January 1998 issue–October 23, 1997; February issue–November 18, 1997; March issue–December 19, 1997; April issue–January 21, 1998; May issue–February 23, 1998; June/July issue–April 24, 1998.

U.S. laws prohibit discrimination in employment on the basis of color, age, sex, race, religion, or national origin. "Positions Available" advertisements from institutions outside the U.S. cannot be published unless they are accompanied by a statement that the institution does not discriminate on these grounds whether or not it is subject to U.S. laws. Details and specific wording may be found on page 1373 (vol. 44).

Situations wanted advertisements from involuntarily unemployed mathematicians are accepted under certain conditions for free publication. Call toll-free 800-321-4AMS (321-4267) in the U.S. and Canada, or 401-455-4084 worldwide, for further information.

Submission: Promotions Department, AMS, P.O. Box 6248, Providence, Rhode Island 02940, or via fax, 401-331-3842, or send e-mail to `classads@ams.org`. AMS location for express delivery packages is 201 Charles Street, Providence, Rhode Island 02904. Advertisers will be billed upon publication.

partment of Electrical Engineering has 39 full-time faculty. The SSERC has associated with it approximately 100 faculty from various engineering, science, and mathematics disciplines. It presently sponsors many active collaborations with semiconductor, aerospace, biotechnology, and chemical industries. In addition, the Center for Solid State Engineering Research and the Center for Solid State Science at ASU have programs and facilities that complement these positions. The SSERC is described on the World Wide Web at `http://www.asu.edu/~sserc/`, where links to other information about ASU are also available.

Applicants must i) send their résumé and publication list, ii) send a letter stating that they wish to be considered for the position listed here and addressing their teaching and their research agenda, and iii) arrange for at least three letters of recommendation to be sent by the deadline to: Professor F. C. Hoppensteadt, 606 Goldwater Center, SSERC- 877606, Arizona State University, Tempe, AZ 85287-7606.

Review of the applications will begin on December 31, 1997, and will continue weekly until the positions are filled. AA/EOE.

CALIFORNIA

CALIFORNIA STATE UNIVERSITY, NORTHRIDGE

The Department of Mathematics invites applications for a tenure-track appointment at the assistant professor level effective fall 1998, although in exceptional cases a more advanced appointment may be considered. Since about half of our majors graduate with a secondary teaching option and the department has recently instituted a graduate option in applied mathematics, candidates with specialties in teacher education or applied mathematics will be given particular consideration. Excellence in teaching, research, and a willingness to participate in departmental and University affairs, in addition to a Ph.D. in the mathematical sciences, are required. Please send a vita, the AMS Standard Cover Sheet, and three letters of recommendation, one of which addresses the candidate's teaching abilities, to the Hiring Committee, Department of Mathematics, CSUN, Northridge, CA 91330-8313, by January 15, 1998. CSU Northridge is an Equal Opportunity/Affirmative Action Employer.

HARVEY MUDD COLLEGE Associate or Assistant Professor of Mathematics

Harvey Mudd College invites applications for one tenure-track position in mathematics at the associate professor or assistant professor level. Excellence in teaching is absolutely essential, as is evidence of a strong and ongoing research program. Candidates for associate professor must have a demonstrated record of superior teaching and an established research program. Preference will be given to applicants in applied mathematics, especially in the areas of applied analysis, PDEs, ODEs, continuous dynamical systems, or integral equations. Applicants should also have wide mathematical interests and be able to teach across the undergraduate mathematics curriculum. Candidates must be willing to supervise undergraduate research and work with others in the development of departmental programs.

Harvey Mudd College is a highly selective undergraduate institution of science and engineering. One year of high school calculus is required for admission to HMC. More than one-third of the student body are National Merit Scholarship finalists. The college enrolls about 630 students and is associated with four other undergraduate colleges and the Claremont Graduate University, forming together an academic community of about 5,000 students. There are over 40 mathematicians in Claremont.

Applicants should send a curriculum vitae, a description of their teaching philosophy and accomplishments, and a description of their current research and research goals. Applicants should also arrange to have three letters of reference sent directly to the address that appears below. Letters should, as much as possible, assess the quality of the applicant's scholarship, record and potential as a mathematician, and abilities as a teacher. Preference will be given to applications received before January 15, 1998. Harvey Mudd College is an Equal Opportunity Employer and is strongly committed to the recruitment of candidates historically underrepresented on college faculties.

Address for applications:
Search Committee
Department of Mathematics
Harvey Mudd College
Claremont, CA 91711-5990

OCCIDENTAL COLLEGE Los Angeles, California

Pending final approval, applications are invited for a tenure-track position in the Department of Mathematics at the assistant professor level. Field of specialty is open, but some preference may be given to candidates with expertise in one or more of the following areas: computer science, discrete mathematics, foundations, geometry, and topology.

Occidental College is a selective college of liberal arts and sciences which serves a diverse undergraduate student body of 1,600. The teaching environment encourages curricular and pedagogical innovation.

The mathematics department consists of nine full-time faculty members. The program supports students pursuing a range of professional and intellectual goals. The normal teaching schedule is the equivalent of five semester courses per year. A semester leave is granted every four years. The college is located in northeast Los Angeles with easy access to a number of research institutions. For more information visit our departmental home page, `http://www.oxy.edu/departments/math/`.

Salary is competitive. The benefits package includes a mortgage subsidy program, on-campus child care, tuition grants for children of faculty, and a choice of health care plans.

Applicants must submit a current résumé and three letters of recommendation, at least one of which evaluates teaching experience, performance, and potential. In addition, applicants must submit a statement of professional plans, interests, and goals. The statement should address teaching and curriculum for undergraduate mathematics at a liberal arts college, as well as mathematical interests and research plans.

All materials must be received by February 3, 1998. Address all materials to: Faculty Search Committee, Department of Mathematics, Occidental College, 1600 Campus Road, Los Angeles, CA 90041-3314.

Members of the department will be attending the Annual Joint Meetings in Baltimore. Occidental College is committed to equity and excellence in education and strongly encourages applications from women and minorities.

UNIVERSITY OF CALIFORNIA, BERKELEY Department of Statistics

Pending final budgetary approval, applications are invited for a special full-time Neyman Visiting Assistant Professor position, beginning fall 1998 or spring 1999. The appointment is of a two-year duration (but can be shorter by mutual agreement) and is not renewable. Applicants should have exhibited exceptional research potential in any of the following areas: theoretical or applied statistics, computational statistics, probability theory, applied probability. Appointees will be expected to teach effectively as well as carry out a vigorous program of research. Minimum salary $39,600; salary commensurate with experience. Apply, including résumé, names, and (preferably e-mail) addresses of three references, by January 20, 1998, to: Chair, Department of Statistics #3860, University of California, Berkeley, CA 94720; fax 510-642-7892; e-mail: `recruit@stat.berkeley.edu`. The University of California is an Equal Opportunity/Affirmative Action Employer.

UNIVERSITY OF CALIFORNIA, IRVINE Department of Mathematics Irvine, CA 92697-3875

Applications are invited for several one- or two-year Visiting Assistant Professor positions in the following areas of research: 1)

applied and computational mathematics, 2) analysis and PDE (includes mathematical physics), 3) geometry and topology (includes geometric analysis), 4) logic and set theory, 5) probability, 6) algebra and number theory (includes algebraic and arithmetic geometry). Candidates must possess a Ph.D. Strong promise in research and teaching is required. Current annual salary is set at $39,600. Teaching load: five to six quarter courses per year. Applicants should send a résumé, preprints, dissertation abstract, and three letters of recommendation to: Visiting Assistant Professor Search Committee at the above address. The deadline for applications is December 31, 1997, or until the positions are filled. The University of California is an Equal Opportunity Employer committed to excellence through diversity.

UNIVERSITY OF CALIFORNIA, IRVINE
Department of Mathematics
Irvine, CA 92697-3875

Applications are invited for three tenure-track or tenured positions. Priorities will be placed on the following areas: 1) applied and computational mathematics, 2) analysis and PDE (includes mathematical physics), 3) geometry and topology (includes geometric analysis), 4) logic and set theory, 5) probability, 6) algebra and number theory (includes algebraic and arithmetic geometry). Candidates must possess a Ph.D. Very strong record and potential in research and teaching are required for the positions. Applicants should send a curriculum vitae, a list of publications, preprints, reprints, and a research plan to the Search Committee at the above address. They should also arrange for four letters of recommendation to be sent to the Search Committee. Applicants are encouraged to use the AMS Cover Sheet.

The deadline for applications is December 31, 1997, or until the positions are filled. The University of California is an Equal Opportunity Employer committed to excellence through diversity.

UNIVERSITY OF CALIFORNIA, LOS ANGELES
Department of Mathematics
Regular Positions in Pure and Applied Mathematics

The UCLA Department of Mathematics invites applications for three or more tenure-track positions in mathematics. Exceptional promise in research and teaching is required. Positions are generally budgeted at the assistant professor level, but sufficiently outstanding candidates will be considered at higher levels. Teaching load is an average of 4.5 quarter courses per year. Positions subject to availability of resources and administrative approval. To apply, send electronic mail to search@math.ucla.edu, or open http://www.math.ucla.edu/~search/ on the World Wide Web, or write to Tony Chan, Chair, Department of Mathematics, University of California, Los Angeles, CA 90095-1555, Attn: Staff Search. UCLA is an Equal Opportunity/Affirmative Action Employer.

UNIVERSITY OF CALIFORNIA, LOS ANGELES
Department of Mathematics
Temporary Positions

Subject to availability of resources and administrative approval: (1) Three E. R. Hedrick Assistant Professorships. Applicants must show very strong promise in research and teaching. Salary $45,000. Three-year appointment. Teaching load: four quarter courses per year, which may include one advanced course in the candidate's field. Preference will be given to applications completed by January 6, 1998.

(2) One or two Research Assistant Professorships in Computational and Applied Mathematics. Applicants must show very strong promise in research and teaching. Salary $45,000. One-year appointment, probably renewable up to two times. Teaching load: at most four quarter courses per year, which may include one advanced course in the candidate's field. Preference will be given to applications completed by January 6, 1998.

(3) One Adjunct Assistant Professorship or Lectureship in the Program in Computing (PIC). Applicants for the adjunct position must show very strong promise in teaching and research in an area related to computing. Teaching load: four quarter programming courses and one more advanced quarter course per year. One-year appointment, probably renewable once. Salary $48,400. Applicants for the lectureship must show very strong promise in the teaching of programming. An M.S. in computer science or equivalent degree is preferred. Teaching load: six quarter programming courses per year. One-year appointment, probably renewable one or more times depending on the needs of the program. Salary is $40,656 or more depending on experience. Preference will be given to applications completed by February 1, 1998.

(4) An Adjunct Assistant Professorship. One-year appointment, probably renewable once. Strong research and teaching background required. Salary $41,900–$43,900. Teaching load: five quarter courses per year.

(5) Possibly one or more positions for visitors.

To apply, send electronic mail to: search@math.ucla.edu, or open http://www.math.ucla.edu/~search/ on the World Wide Web, or write to: Tony Chan, Chair, Department of Mathematics, University of California, Los Angeles, CA 90095-1555. Attn: Staff Search. UCLA is an Equal Opportunity/Affirmative Action Employer.

UNIVERSITY OF CALIFORNIA, SANTA CRUZ
Mathematics Department

The department expects to have Visiting Assistant Professorships in Mathematics beginning fall 1998 (subject to availability of funding). Appointees will be expected to teach, pursue their research, and perform service. These positions are available for periods ranging from one quarter to the full academic year, with a possible extension. Minimum Qualifications: Ph.D. (or equivalent) in mathematics or a closely related field and demonstrated achievements or potential for excellence in research, teaching, and service. Salary: $39,600. Available: fall 1998. Application deadline: January 16, 1998. Please refer to #T97-15. Applicants should send vita, summary of research and teaching experience, and three letters of recommendation (at least one letter addressing teaching experience and ability) to: Recruitment Committee, Mathematics Department, University of California, Santa Cruz, CA 95064. *Full consideration is guaranteed only for applications received by the deadline. UCSC is an AA/EEO/IRCA employer. *Inquiries (only) can be sent to mathrcr@cats.ucsc.edu.

UNIVERSITY OF CALIFORNIA, SANTA CRUZ
Mathematics Department

The Mathematics Department at the University of California, Santa Cruz, is recruiting for one or more tenure-track assistant professors Step I–III in the areas of algebra and number theory, Position #510. The position(s) would be effective July 1, 1998, contingent on budgetary approval. The teaching load is four one-quarter courses per year. Minimum qualifications: Ph.D. (or equivalent) in mathematics and demonstrated achievements or potential for excellence in research, teaching, and professional service. Step commensurate with experience. Salary Range: $39,600–$43,900. Application deadline: January 16, 1998. Please refer to position number indicated above in your correspondence. Applicants should send a curriculum vitae, a summary of their research and teaching experience, and four confidential letters of recommendation (at least one letter addressing teaching experience and ability) to: Recruitment Committee, Mathematics Department, University of California, Santa Cruz, CA 95064. Inquiries (not applications) can be sent to mathrcr@cats.ucsc.edu. UCSC is an AA/EEO/IRCA Employer.

UNIVERSITY OF CALIFORNIA, SANTA CRUZ
Applied Mathematics and Statistics

The Santa Cruz campus of the Univer-

sity of California invites applications for outstanding faculty members in applied mathematics and statistics. Successful candidates at the senior level will be expected to play a leadership role in the development of this new academic program. We are particularly, but not exclusively, interested in the following areas: 1) scientific computing and numerical methods, mechanics and dynamics, applied dynamical systems, and control theory; 2) applied probability, statistics, and stochastic processes; 3) discrete mathematics and related areas.

Rank: Assistant to full professor.

Position available: fall 1998, contingent upon final budgetary approval.

Minimum qualifications: Ph.D. or equivalent in applied mathematics or related field. Outstanding record as researcher and educator, appropriate to the level of appointment.

Closing date: Nominations and applications received by January 15, 1998, will be assured of receiving full consideration.

For assistant professor applicants, refer to Position #442. For associate to full professor applicants, refer to Position #443.

For additional information on this position, see `http://www.cse.ucsc.edu/events/ams-recruit.html`.

UCSC is an EEO/AA/IRCA Employer.

STANFORD UNIVERSITY
Department of Mathematics
Assistant Professorships in Honor of Gabor Szego

The department expects to make one or more appointments in 1998-99 for these special three-year positions. Applicants are expected to show outstanding promise in research and clear evidence of achievement. They should have received the Ph.D. prior to the start of the appointment, but not before 1996. Stanford is committed to excellence in teaching, and applicants should count this as one of their goals. Candidates should send a letter of application with a curriculum vitae, a list of publications, information concerning teaching experience, and three letters of recommendation to Prof. Gunnar Carlsson, Chairman, Department of Mathematics, Stanford University, Stanford, CA 94305-2125, by December 15, 1997. Stanford is an Affirmative Action/Equal Opportunity Employer and welcomes applications from women and minorities.

STANFORD UNIVERSITY
Department of Mathematics

The department expects to make at least one tenure-track or tenured appointment beginning September 1998 among the following fields: (1) analysis; (2) geometry or topology; (3) algebra, number theory, or logic; (4) applied mathematics or probability. In the last case there are also possibilities for joint appointments with other departments. At the tenured level, preference would go to individuals in the earlier years of their ranks, though a more senior appointment may be possible for an extremely well-qualified individual.

Candidates should send a letter of application and a curriculum vitae, a list of publications, and a cover sheet clearly stating the following information: name, area of specialization, institution, (expected) date of Ph.D., and Ph.D. advisor. Also, the candidate should arrange to have three letters of recommendation and some evidence of commitment to excellence in teaching sent to Prof. Gunnar Carlsson, Department of Mathematics, Stanford University, Stanford, CA 94305-2125, by January 15, 1998.

Stanford is an Equal Opportunity/Affirmative Action Employer and welcomes applications from women and minorities.

COLORADO

UNIVERSITY OF COLORADO AT BOULDER
Department of Mathematics

Applications are invited for two tenure-track faculty positions at the assistant professor level beginning in the fall of 1998, one in probability and one in classical analysis. Candidates should have earned a Ph.D. in mathematics by August 1998, have demonstrated interest and ability in teaching, and have experience in and commitment to mathematical research.

These positions require teaching at various levels, mathematical research, and service.

Applications, including a résumé and four letters of reference, should be sent to: Search Committee, Department of Mathematics, Campus Box 395, University of Colorado, Boulder, CO 80309-0395. Review of applications will begin December 15, 1997, and will continue until the positions are filled.

The University of Colorado at Boulder strongly supports the principle of diversity in all its forms. We are interested in receiving applications from women, ethnic minorities, persons with disabilities, veterans, and veterans of the Vietnam era.

FLORIDA

FLORIDA ATLANTIC UNIVERSITY
Department of Mathematics

The department invites applications for a tenure-track faculty position, beginning in the fall of 1998, in the area of computational PDE/ODE and related numerical analysis. Applicants must have a Ph.D. in mathematics or an equivalent discipline. Demonstrated potential for quality research and teaching is essential. Preference will be given to candidates whose work has an applied component that can be related to industrial applications and/or other sciences.

Applicants should send a curriculum vitae, including a list of publications and a statement of research and teaching interests, and three letters of recommendation to: Hiring Committee, Department of Mathematical Sciences, Florida Atlantic University, Boca Raton, FL 33431. Applications received before January 31, 1998, will receive full consideration. For more information visit `http://www.math.fau.edu/`.

Florida Atlantic University is an Affirmative Action/Equal Opportunity Employer. Women and minorities are strongly encouraged to apply. As an agency of the State of Florida, FAU will make application materials and selection procedures available for review, in accordance with the State Sunshine Law.

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 1998. The School intends to expand its areas of expertise and foresees the potential for 10–15 new appointments in the next five years. Candidates with strong research and teaching records or potential should arrange for a résumé, at least three letters of reference, and a summary of future research plans to be sent to The Hiring Committee, School of Mathematics, Georgia Institute of Technology, Atlanta, GA 30332-0160. Georgia Tech, an institution of the University System of Georgia, is an Equal Opportunity/Affirmative Action Employer.

GEORGIA SOUTHERN UNIVERSITY
Department of Mathematics and Computer Science

Two tenure-track positions starting August 1, 1998. Salary dependent upon qualifications. Indicated degrees are required by the position starting date. All deadlines are postmark deadlines. Commitment to excellence in teaching and scholarly activity, as well as excellent command of written and spoken English, are required. College teaching experience is desirable. Departmental representatives will be available at the national AMS/MAA meeting in Baltimore in January 1998 to discuss these positions with interested parties. Send letter of application indicating position desired, curriculum vitae, unofficial transcripts of all college work, evidence of commitment to excellence in teaching and scholarship, a brief description of planned scholarly activities, and a letter of reference from each of three references by the

indicated deadline to appropriate search chair (Applied Math or Math Ed.), [search number, see below], Department of Mathematics and Computer Science, Post Office Box 8093, Georgia Southern University, Statesboro, GA, 30460-8093.

The names of applicants and nominees, résumés, and other general nonevaluative information are subject to public inspection under the Georgia Open Records Act. Georgia Southern is an Equal Opportunity/Affirmative Action Institution. Persons who need accommodation(s) in the application process under the Americans with Disabilities Act should notify the search chair.

Applied Mathematics, Assistant Professor. Ph.D. in an applied math area required. Preference will be given to applicants in the areas of discrete math, numerical analysis, scientific computing, modeling, and differential equations, but consideration will be given to applicants in all areas of applied math. At least one year of experience with the use of computational packages (such as Mathematica, Maple, or Matlab) is required. Interest in teaching freshman/sophomore-level mathematics courses required. Three years' college teaching experience preferred. Send applications and supporting materials to Applied Math Search Chair. Search # 34925. Deadline: January 16, 1998.

Mathematics Education, Assistant Professor. Doctorate in a mathematical science required; Ph.D. or Ed.D. in mathematics education preferred. Must be broadly trained in mathematics with at least 24 semester hours of graduate level courses in pure or applied mathematics. Must exhibit evidence of a strong commitment to excellence in teaching and continued scholarly activity and have familiarity with current directions in mathematics education, including the use of technology in the classroom. Primary interest in mathematics education required; experience in working with K–12 mathematics teachers preferred. At least three years' teaching experience preferred. Candidates must be able to work effectively with professional and community groups. Duties include teaching undergraduate mathematics courses and undergraduate/graduate mathematics courses for mathematics education majors. Send applications and supporting materials to Math Ed. Search Chair. Search # 34927. Deadline: January 16, 1998.

Georgia Southern University, a unit of the University System of Georgia, was founded in 1906 and became a regional university in 1990. The 601-acre campus is located in Statesboro, a community of approximately 30,000 residents fifty miles northwest of historic Savannah and two hundred miles southeast of Atlanta. Anticipated fall quarter 1997 headcount of over 14,000 reflects a 115% enrollment growth since the fall of 1984, resulting in the addition of over 200 faculty positions. The university offers 23 baccalaureate degrees in 81 major fields of study, 10 master's degrees in 40 fields, the Education Specialist degree with 16 majors, and Ed.D. programs in Educational Administration and Curriculum Studies.

GEORGIA STATE UNIVERSITY
Department of Mathematics and Computer Science

Two anticipated tenure-track positions for Ph.D.s beginning August 1998, Department of Mathematics and Computer Science, Georgia State University. One position is in mathematics education for an assistant or associate professor. Another position is in applied statistics for an assistant professor. Ph.D. and excellent record in publications are required with preference for extramural funding. Applications should include a letter of application, a vita without birthdate but including citizenship status, three letters of reference, and transcripts of all graduate and undergraduate work. Applicants should have letters of reference and other materials sent to: Chair, Department of Mathematics and Computer Science, Georgia State University, University Plaza, Atlanta, GA 30303-3083. Applications must be postmarked no later than 1/16/98. Georgia State University, a unit of the University System of Georgia, is an Equal Opportunity Educational Institution and an EEO/AA employer.

ILLINOIS

ELMHURST COLLEGE
Mathematics Department

Tenure-track position beginning fall 1998 (pending approval of the Board of Trustees). qualifications desired: Ph.D. in mathematics at time of hire, interest in continued scholarship, and a strong commitment to undergraduate teaching in a liberal arts college. Teaching load: 6 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. Jon L. Johnson, Dept. of Mathematics, Elmhurst College, 190 Prospect Ave., Elmhurst, IL 60126, by February 1, 1998. Minority and women candidates are strongly urged to apply. EOE.

ILLINOIS WESLEYAN UNIVERSITY
Bloomington, Illinois 61702
Department of Mathematics

The Department of Mathematics of Illinois Wesleyan University invites applications for one tenure-track position and one or more one-year visiting positions. Employment would begin in August 1998, and the teaching load would be six courses per year. All candidates should possess a Ph.D. in mathematics and a dedication to quality teaching in an independent liberal arts university. For any position, preference may be given to those candidates having experience in the integration of technology into undergraduate instruction.

Candidates for the tenure-track position must have a Ph.D. with research specialty in either probability or mathematical statistics. The successful candidate will be expected to work closely with undergraduate mathematics majors who are planning careers in actuarial science. In particular, candidates for this position should be interested in directing undergraduate research projects. Preference may be given to candidates who have passed actuarial exams and to candidates who are willing to develop upper-level special topics courses in mathematics for these students. Candidates for this position should submit transcripts of all graduate work.

For a visiting position, preference may be given to those candidates who have good teaching credentials. Preference may also be given to those candidates who have special qualifications to address curricular needs in our department for the 1998–99 academic year.

Illinois Wesleyan University has approximately 1,900 undergraduate students. It is a highly selective university. For example, in 1994 the average ACT for Illinois Wesleyan's entering class of freshmen was 27.9, while the average ACT for freshman mathematics majors was 30.0. In past years over 4 percent of the undergraduate population at Illinois Wesleyan have declared majors in mathematics. Our mathematics faculty possesses a healthy balance between applied and pure mathematics. Our current areas of professional expertise include algebra, approximation theory, differential equations, dynamical systems, electrical engineering, linear algebra, logic, operations research, operator theory, topology, topos theory, and wavelet analysis. We encourage our majors to complete undergraduate research projects. Our department is also actively involved in the integration of technology into many of our courses. For example, we have four different ways to complete freshman calculus, one of which is a three-course sequence in calculus/Mathematica taught in an NSF-sponsored Sun/Spark computer lab. We also maintain a Sun/Spark computer lab for mathematical modeling and one other Unix-based computer lab.

Candidates for any of the positions should submit a letter of application, a vita, an AMS Standard Cover Sheet, and three letters of recommendation to Melvyn W. Jeter, Head, Department of Mathematics, Illinois Wesleyan University, P. O. Box 2900, Bloomington, IL 61702-2900. Candidates who submit their applications after January 30, 1998, may not receive full consideration. Applications before December 30, 1997, are encouraged. Women and minorities are encouraged to apply. Illi-

nois Wesleyan is an Equal Opportunity Employer.

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
Postdoctoral Positions
J. L. Doob Research Assistant Professor

The Department of Mathematics of the University of Illinois at Urbana-Champaign is soliciting applications for postdoctoral positions. Two appointments will be made starting August 21, 1998; each appointment is for three years and is not renewable. The positions are for recent Ph.D. recipients (with a strong preference for those not more than one year past the Ph.D. degree). The Department of Mathematics will provide an excellent scientific environment to pursue research in pure and applied mathematics. The position carries a salary of $39,000 per year.

Applications should include a curriculum vitae and a brief statement of research interests and activities. The use of the AMS Cover Sheet will be appreciated.

Applications should be sent by regular mail to the Postdoctoral Search Committee, Department of Mathematics, University of Illinois at Urbana-Champaign, 1409 W. Green St., Urbana, Illinois 61801-2975.

Applicants should arrange for at least three letters of recommendation to be sent to the same address.

For more information visit our Web page at `http://www.math.uiuc.edu/`.

Inquiries may be sent to: `postdocs@math.uiuc.edu`.

For full consideration the application must be received by December 7, 1997.

The University of Illinois is an Affirmative Action/Equal Opportunity Employer. Women and minorities are strongly encouraged to apply.

NORTHWESTERN UNIVERSITY
Department of Mathematics

Applications are invited for anticipated tenure-track or tenured positions starting September 1998. 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.

Candidates should arrange to have their application materials sent to Chairperson, Personnel Committee, Department of Mathematics. Applications should include: (1) the American Mathematical Society's Application Cover Sheet for Academic Employment in Mathematics, (2) a curriculum vitae, and (3) at least four letters of recommendation, including one which discusses in some detail the candidate's teaching qualifications. Inquiries may be sent via e-mail to `hiring@math.nwu.edu`. In order to receive full consideration, applications should be received by November 15, 1997.

Northwestern is an Affirmative Action/Equal Opportunity Employer committed to fostering a diverse faculty; women and minority candidates are especially encouraged to apply.

SOUTHERN ILLINOIS UNIVERSITY AT EDWARDSVILLE
Mathematics Department

Southern Illinois University at Edwardsville, a comprehensive state university located 20 miles from downtown St. Louis, Missouri, invites applications for a tenure-track position in mathematics at the rank of assistant professor beginning August 1998. Higher ranks may be considered for outstanding candidates. Applicants should have a Ph.D. in an applied area of mathematics, a strong commitment to teaching, and a demonstrated capacity to perform research. The successful candidate will teach precalculus, calculus, differential equations, and some upper-level courses in mathematics, applied mathematics, and numerical analysis. The Department of Mathematics and Statistics has 17 full-time faculty members and offers undergraduate programs in mathematics, applied mathematics, statistics, actuarial science, and secondary education, and master's programs in mathematics, statistics and operations research, and computational mathematics. Send a letter of application, curriculum vitae, transcripts (unofficial transcripts are acceptable for now), and three letters of recommendation to Chair of Search Committee, Department of Mathematics and Statistics, Campus Box 1653N, Southern Illinois University at Edwardsville, Edwardsville, IL 62026-1653. Review of applications will begin on January 1, 1998, and will continue until the position is filled. Please use the AMS Standard Cover Sheet. As an Affirmative Action Employer, SIUE offers equal opportunity without regard to race, color, creed or religion, age, sex, national origin, or handicap.

INDIANA

PURDUE UNIVERSITY
Professor of Mathematics and Director, Center of Applied Mathematics
Department of Mathematics

Since Purdue is Indiana's state-supported land-grant university and has a world-class engineering school and widely recognized departments in science, management, and agriculture, Purdue's mathematics department has the opportunity—indeed, the obligation—to have a strong and influential group in applied mathematics with strong ties to the rest of the University.

Purdue's Center for Applied Mathematics (CAM) was started in 1985 under the directorship of Avner Friedman and has been led by Jim Douglas Jr. since 1987. CAM provides an umbrella for the activities of faculty, postdoctoral staff, graduate students, and long- and short-term visitors in applied mathematics. Currently there are a dozen mathematics faculty who identify themselves as applied mathematicians and several other faculty in and out of the department who work in applied areas and are loosely associated with CAM. The Purdue mathematics department is committed to deepening and expanding its contributions to research and education in applied mathematics. Because of its solid foundation and the support of the school and university administrations, the department is well positioned to achieve its goals in this area.

The director should be a senior full professor or distinguished professor of mathematics with the stature and experience to lead outstanding research and educational programs in applied mathematics. In addition to carrying on a strong research program in her or his own area, the director will be expected to coordinate the development of other applied areas in the department, facilitate research contacts between mathematics faculty and faculty in other departments, oversee the applied mathematics visitor and seminar programs, and help create an atmosphere in which the educational programs of graduate students and postdoctoral staff in applied mathematics can flourish.

To this end, the Purdue mathematics department seeks applicants for the position of professor of mathematics and director, Center for Applied Mathematics, with a strong national reputation in research in applied mathematics; proven ability to work with graduate students, postdocs, and colleagues; a record of funding success; and flexibility in pursuing opportunities. Applicants should possess a broad vision compatible with Purdue's strong traditions in mathematics, the sciences, and engineering and demonstrate the ability to promote applied mathematics as a part of mathematics.

Persons interested in applying for this position or discussing it in confidence should contact

Carl C. Cowen, Head
Department of Mathematics
Purdue University
West Lafayette, IN 47907-1395
`cowen@math.purdue.edu`
765-494-1908 (voice)
765-494-0548 (fax)

Purdue University is an Affirmative Action/Equal Opportunity Employer.

IOWA

THE UNIVERSITY OF IOWA

The Department of Mathematics at The University of Iowa invites applications for the following positions:

1. Tenure-track assistant or early associate professorship, starting in August 1998, in the broadly interpreted area of numerical analysis. Exceptional candidates at higher rank may be considered. Selection will be based on evidence of outstanding research accomplishments or potential and excellent teaching. A Ph.D. or equivalent is required.

2. Pending availability of funds, one or more visiting positions for all or part of the 1998–99 academic year. Selection will be based on research expertise and teaching ability. Preference will be given to applicants whose scholarly activity is of particular interst to members of the current faculty.

Women and minority candidates are especially urged to apply for the above positions.

Formal screening will begin December 15, 1997; applications will be accepted until the positions are filled. To apply, send a complete vita and three letters of recommendation to:

Professor Bor-Luh Lin, Chair
Department of Mathematics
The University of Iowa
Iowa City, IA 52242

The University of Iowa is an Equal Employment Opportunity/Affirmative Action Employer.

KANSAS

KANSAS STATE UNIVERSITY
Department of Mathematics

Subject to budgetary approval, applications are invited for tenure-track and visiting positions commencing August 9, 1998; 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. For one of the tenure-track positions, a preference will be given to specialists in harmonic analysis or operator theory.

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 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 8, 1997, but applications for positions will be reviewed until February 1, 1998, or until positions are closed. AA/EOE.

UNIVERSITY OF KANSAS
Henry J. Bischoff Professor of Mathematics

The Department of Mathematics of the University of Kansas seeks an internationally renowned scholar for the Henry J. Bischoff professorship. This position is one of 23 distinguished chairs in the College of Liberal Arts and Sciences. In addition to an outstanding research record, applicants for the position must have a demonstrated interest in teaching mathematics.

Interested individuals should submit a letter of inquiry and a vita. All inquiries will be kept confidential. Review of applications will begin January 15, 1998, and will continue until the position is filled. The University of Kansas is an EO/AA Employer.

Send correspondence to: Charles J. Himmelberg, Chairman, Department of Mathematics, 405 Snow Hall, University of Kansas, Lawrence, KS 66045.

UNIVERSITY OF KANSAS
Department of Mathematics

Applications are invited for a tenure-track position at the assistant professor level beginning August 18, 1998, or as negotiated. (This position is contingent on final budgetary approval.) Preference will be given to candidates in algebra/algebraic geometry, and otherwise to candidates in pure or applied mathematics whose specialties mesh well with those already represented in the department. Candidates must have a Ph.D. or its requirements completed by August 15, 1998. Postdoctoral experience is preferred.

Letter of application, detailed résumé with description of research, completed AMS standardized application form, and three recommendation letters should be sent to C. J. Himmelberg, Chairman, Department of Mathematics, 405 Snow Hall, University of Kansas, Lawrence, KS 66045-2142.

Deadlines: Review of applications will begin on January 1, 1998, and will continue until the position is filled.

EO/AA Employer.

LOUISIANA

TULANE UNIVERSITY
Department of Mathematics

Applications are invited for two tenure-track positions beginning in the fall 1998 semester, subject to final administrative and budgetary approval. Applications will be guaranteed full consideration if complete by December 19, 1997. The search will be closed only after a suitable pool of qualified applicants is obtained. Applicants should have completed their Ph.D. by the beginning of the fall 1998 semester and provide evidence of excellence in both teaching and research. Our highest priority for one position is in the field of scientific computation. Applications in all fields of pure and applied mathematics will be considered in filling the second position.

Tulane University is an Affirmative Action/Equal Opportunity Employer which is committed to increasing the diversity of its faculty. We therefore especially encourage applications from members of underrepresented groups. Applications should be sent c/o Search Committee, Mathematics Department, Tulane University, New Orleans, LA 70118. Electronic applications will be accepted and the use of the AMS Cover Sheet is encouraged. A complete application should include a vita, statements on research and teaching, as well as three letters of recommendation commenting on both research and teaching.

MAINE

UNIVERSITY OF SOUTHERN MAINE
Assistant Professor
Mathematics and Statistics

The Department of Mathematics and Statistics at the University of Southern Maine invites applications for a tenure-track position at the rank of assistant professor starting in the fall of 1998.

The search will focus on the areas of numerical analysis, graph theory and combinatorics, or related fields.

Candidates must have a Ph.D. or must accompany the application with a statement from the institution in which enrolled for doctoral studies confirming that the degree will be completed by August 1, 1998. Candidates must demonstrate a strong commitment to teaching at all levels of the curriculum and show potential for productive research.

Women and minorities are encouraged to apply.

Send letter of application, curriculum vitae, graduate transcripts, and three letters of recommendation to: Search Committee, Department of Mathematics and Statistics, University of Southern Maine, P.O. Box 9300, Portland, ME 04104-9300. Please include e-mail address if available. USM is an EEO/AA Employer committed to diversity, quality, and reasonable accommodation.

Review of applications will begin February 1, 1998, and will continue until position is filled.

MARYLAND

TOWSON UNIVERSITY

Mathematics: Entry-level tenure-track assistant professor, pure mathematics, beginning in fall 1998. Preference will be given to applicants with a strong research program and commitment to teaching innovative courses with technology or mathematics across the disciplines. Ph.D. in mathematics is required. Teaching assignment is twelve contact hours per semester. The salary is commensurate with that of an entry-level position. The mathematics department (http://www.towson.edu/~math/) offers bachelor's programs in various concentrations and a master's program in applied and industrial mathematics. Submit cover letter, vita, transcripts, and three letters of recommendation addressing both teaching and research by February 1, 1998, to:

Dr. J. Chollet, Chair
Search Committee
Mathematics Department
Towson University
8000 York Road
Towson, MD 21252-0001
fax: 410-830-4149
e-mail: jchollet@towson.edu

Towson University is an Equal Opportunity/Affirmative Action Employer and has a strong institutional commitment to diversity. Women, minorities, persons with disabilities, and veterans are encouraged to apply.

MASSACHUSETTS

SMITH COLLEGE
Department of Mathematics

The mathematics department of Smith College invites applications for a three-year, renewable, tenure-track position of assistant professor to begin in the fall of 1998. Candidates must have a Ph.D. in mathematics or statistics and must provide evidence of excellent teaching and an active research program. All specializations will be considered. Send a curriculum vitae and three letters of recommendation to: Mathematics Search Committee, Clark Science Center, Smith College, Northampton, MA 01063. To receive full consideration, you must provide a completed application before **January 1, 1998**. Smith College is an Equal Opportunity/Affirmative Action Institution. Minorities and women are encouraged to apply.

WILLIAMS COLLEGE
Department of Mathematics
Williamstown, MA 01267

Anticipated tenure-eligible position in statistics beginning fall 1998, 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.

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 will continue until the position is filled. As an EEO/AA Employer, Williams especially welcomes applications from women and minority candidates.

WILLIAMS COLLEGE
Department of Mathematics
Williamstown, MA 01267

Anticipated visiting position(s) in mathematics or statistics for the 1998–99 year, probably full-time, probably at the rank of assistant professor; in exceptional cases, however, more advanced appointments may be considered. Excellence in teaching and research and Ph.D. required.

Please have a vita and three letters of recommendation on teaching and research sent to Visitor Hiring Committee. Evaluation of applications will begin November 15 and will 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
Chairperson

Applications or nominations are invited for the position of department chairperson, beginning fall 1998. The department includes pure and applied mathematics, statistics, and mathematics education in both K–12 and collegiate mathematics. It offers bachelor's and master's degrees and a Ph.D. in mathematics with a concentration in the teaching of college mathematics. Applicants should have academic credentials qualifying for appointment at or near full professor. He or she should have the following qualifications: a strong and ongoing research record, excellence in teaching, demonstrated administrative ability, a commitment to faculty development, compassion for faculty and students, effective communication skills, and openness to instructional innovation. The applicant should have a strong interest in the continued development of our Ph.D. program. The following experiences will be viewed favorably: successful grant writing, curriculum and program development, expository writing, and involvement with professional organizations.

Central Michigan University has an enrollment of 16,600, of which 2,000 are graduate students. The Department of Mathematics has 32 tenure-track faculty. Research strengths are in applied mathematics in polymer science, approximation theory, combinatorics, operator theory, mathematics education, and statistics.

The selection process will begin January 19, 1998. Applicants should submit a letter of application that includes a statement of academic leadership philosophy, vita, and the names of at least three references to:

Chair, Search Committee
Central Michigan University
Mt. Pleasant, MI 48859
517-774-3596
math@cmich.edu
www.cst.cmich.edu/units/mth/

CMU (an AA/EO Institution) encourages diversity and resolves to provide equal opportunity regardless of race, sex, disability, sexual orientation, or other irrelevant criteria.

KALAMAZOO COLLEGE
Assistant Professor of Mathematics

Kalamazoo College invites applications for a tenure-track position at the assistant professor level beginning September 1998. A Ph.D. in mathematics, statistics, or operations research is required, with preference given to candidates of broader experience in mathematics, science, or the liberal arts. Teaching load is two courses per quarter, three quarters per year. Salary is competitive and consistent with level of experience.

Experience with and interest in the application of statistics to problems in the life or social sciences is essential. The ideal candidate will also have an interest in developing an active research program that involves undergraduate student participation. Candidates are expected to have high aptitude and interest in undergraduate teaching, a commitment to the liberal arts, and a desire to involve undergraduates in scholarship both inside and outside the classroom.

Kalamazoo College is a selective, private, four-year liberal arts institution of 1,200 students known for its innovative program and strong tradition in the sciences. Founded in 1833, it is the oldest institution of higher education in Michigan. The campus is located midway between Chicago and Detroit in Kalamazoo, Michigan, a community of 80,000 in a metropolitan area of 225,000 which supports four college and university campuses along with numerous civic, arts, and cultural associations. Thirty-five miles from Lake Michigan, the area offers many opportunities for outdoor activities. For more information about the college, visit our Web home page at http://www.kzoo.edu/.

Completed applications received by December 31, 1997, will receive full consideration, with later applications reviewed as needed until the position is filled. Send curriculum vitae, undergraduate and graduate transcripts (unofficial acceptable), a two- to three-page statement of teaching

philosophy and research plans, and three letters of recommendation to

Prof. John Fink
Chair, Department of Mathematics
Kalamazoo College
1200 Academy Street
Kalamazoo, MI 49006-3295
fink@cc.kzoo.edu

Kalamazoo College encourages candidates who will contribute to the cultural diversity of the College to apply and to identify themselves if they wish. Equal Opportunity Employer.

MISSISSIPPI

MISSISSIPPI STATE UNIVERSITY
Department of Mathematics and Statistics
Faculty Positions

Applications are invited for four tenure-track or visiting positions at the rank of assistant/associate/full professor for the 1998–99 academic year. Requirements include a doctoral degree, demonstrated success or a strong potential for research, and a commitment to effective undergraduate and graduate teaching. Preference will be given to candidates with research interests in algebra/combinatorics, mathematics education, numerical analysis, or statistics, but especially strong candidates in any area of research are encouraged to apply. Salary is competitive and commensurate with qualifications.

The department is housed in the College of Arts and Sciences and offers the B.A. and B.S. in mathematics, the M.S. in both mathematics and statistics, and a Ph.D. in mathematical sciences. Opportunities exist for applicants with an interest in interdisciplinary research or consulting. Applicants should submit a résumé with a completed AMS Application Cover Sheet and arrange for three letters of recommendation to be sent to:

Mohsen Razzaghi, Chair
Screening Committee
Department of Mathematics
and Statistics
Mississippi State University
Mississippi State, MS 39762

The screening process will begin on December 1, 1997, and will continue until all positions are filled.

The department especially welcomes applications from women and minority candidates. Mississippi State University is an AA/EEO Employer.

MISSOURI

UNIVERSITY OF MISSOURI-KANSAS CITY
Department of Mathematics & 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 August 1998. 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 master's programs. The salary is competitive.

Please apply to:

Search Committee
Department of Mathematics & Statistics
4825 Troost, Room 101
University of Missouri-Kansas City
Kansas City, MO 64110-2499

Applications should include a vita and three letters of recommendation. 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.

UNIVERSITY OF MISSOURI-ROLLA
Department of Mathematics and Statistics
Rolla, MO 65409-0020

Tenure-track positions at the assistant professor level, one approved and another anticipated, are available for fall 1998. We specifically seek applicants who work in complex dynamical systems, complex analysis, or functional analysis and its applications. We prefer applicants whose research will complement the ongoing research efforts of the department. The Ph.D. is required and should be completed by August 15, 1998. Both research potential and teaching ability will be considered in the selection. Submit an AMS Cover Sheet, curriculum vitae, a summary of research, copies of transcripts, and three letters of reference to W. T. Ingram, Chair. In your cover letter and on the outside of the envelope please clearly identify your area of training. Applicant review will begin in January 1998. Applications which are complete on or before January 1, 1998, will receive full consideration. AA/EOE.

NEW HAMPSHIRE

DARTMOUTH COLLEGE
John Wesley Young Research Instructorship 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 (at instructor's option) graduate courses. Nine-month salary of $39,000 supplemented by summer research stipend of $8,667 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 1998–99 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 responsibility in mathematics is four courses spread over two or three quarters. The department encourages good teaching with a combination of committed colleagues and bright, responsive students.

To apply, send a letter of application, curriculum vitae, and a brief statement of research results and interests. Also arrange for four letters of reference to be sent, at least one of which addresses teaching and, if the applicant's native language is not English, the applicant's ability to use English in a classroom. All application materials should be addressed to Betty Harrington, Recruiting Secretary, Department of Mathematics, 6188 Bradley Hall, Dartmouth College, Hanover, NH 03755-3551. Applications completed by January 1 will receive first consideration. Dart-

mouth is committed to Affirmative Action and encourages applications from African Americans, Asian Americans, Hispanics, Native Americans, and women. Inquiries about the progress of the selection process can be directed to C. Dwight Lahr, Recruiting Chair.

DARTMOUTH COLLEGE

The Department of Mathematics anticipates an opening for a professor of mathematics, with appointment effective in the 1998–99 academic year. Field open. A candidate for the position must demonstrate evidence of an exceptional research program that has achieved peer recognition and research leadership in the mathematical community. Moreover, a candidate must demonstrate a record of exceptional teaching and continued interaction with students at all levels of undergraduate and graduate study. Leadership in guiding Ph.D. theses is also essential. Applications are welcome in all fields of mathematics.

To create an atmosphere supportive of research, Dartmouth offers new faculty members grants for research-related expenses, a quarter of sabbatical leave for each three academic years in residence, and flexible scheduling of teaching responsibilities. The teaching responsibility in mathematics is four courses spread over two or three quarters. The department encourages good teaching with a combination of committed colleagues and bright, responsive students.

To apply, send a letter of application, curriculum vitae, and a brief statement of research results and interests, and the names of four references, at least one of whom can specifically address teaching. These materials should be sent to Betty Harrington, Recruiting Secretary, Department of Mathematics, Dartmouth College, 6188 Bradley Hall, Hanover, NH 03755-3551. Applications complete by January 1, 1998, including reference letters (allow enough lead-time for us to make the solicitations from the names you provide), will receive consideration. Dartmouth is committed to Affirmative Action and encourages applications from African Americans, Asian Americans, Hispanics, Native Americans, and women. Inquiries about the progress of the selection process can be directed to C. Dwight Lahr, Recruiting Chair.

NEW JERSEY

DIMACS CENTER
Postdoctoral Fellowships

DIMACS, the Center for Discrete Mathematics and Theoretical Computer Science, invites applications for several postdoctoral fellowships for 1998–99. DIMACS, an NSF Science and Technology Center, is a partnership of Rutgers University, Princeton University, AT&T Labs - Research, Bell Laboratories, and Bellcore. Research at DIMACS focuses on such areas as analysis of algorithms, combinatorics, complexity, computational algebra, discrete and computational geometry, discrete optimization, and graph theory. Recent Ph.D.s in all areas of theoretical computer science and discrete math are invited to apply. Some positions will be in special year and focus areas of large scale discrete optimization, massive data sets, DNA computing, networks, mathematical and computational support for molecular biology and simulations.

Postdoctoral Fellows conduct research and may collaborate with many visitors and permanent members at the partner sites. They are encouraged to participate in the research, outreach, and educational activities of the Center.

Application procedure: The Center's WWW site, `http://dimacs.rutgers.edu/Participation/`, contains full information about these postdoctoral positions and should be consulted for application information. Applications are due December 12, 1997, for full consideration. DIMACS Center, P.O. Box 1179, Rutgers University, Piscataway, NJ 08855-1179; tel: 732-445-5928; e-mail: `postdoc@dimacs.rutgers.edu`.

DIMACS is an EO/AA Employer.

RUTGERS UNIVERSITY
Mathematics Department

The Rutgers University mathematics department invites applications for the following positions, which may be open beginning September 1998.

(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 6 hours.

(2) Hill Assistant Professorship (nontenure track). The Hill Assistant Professorships are three-year nonrenewable 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 6 or 7 hours.

Applicants should send résumé, with the AMS Application Cover Sheet attached, and at least three letters of recommendation 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, 1998. Please indicate position(s) desired and give the AMS Subject Classification number of your area(s) of specialization. Applicants who applied in 1996–97 may, if they wish, request to have their previous application reactivated and submit only such new materials as they choose. Rutgers is an Affirmative Action/Equal Opportunity Employer and encourages applications from women and minority-group members.

INSTITUTE FOR ADVANCED STUDY AND PRINCETON UNIVERSITY

The School of Mathematics at the Institute for Advanced Study and the Department of Mathematics at Princeton University have recently established the Veblen Research Instructorship. Commencing with the 1998–99 academic year, 3 three-year instructorships will be offered each year to candidates who have received their Ph.D. within the last three years. The first and third year of the instructorship will be spent at Princeton University and will carry regular teaching responsibilities. The second year will be spent at the Institute and will be dedicated to independent research of the instructor's choice.

Application materials for the instructorship position may be requested either from Scott Kenney, Department of Mathematics, Princeton University, Princeton, NJ 08544; 609-258-4200; e-mail address: `skenney@princeton.edu`; or from Applications, School of Mathematics, Institute for Advanced Study, Olden Lane, Princeton, NJ 08540; 609-734-8112; e-mail address: `applications@math.ias.edu`. Forms may also be accessed via a Web connection to `http://www.math.ias.edu/`.

NEW YORK

RENSSELAER POLYTECHNIC INSTITUTE
Department of Mathematical Sciences

Applications are invited for a tenure-track assistant professor position in applied mathematics to begin in August 1998. Applicants are expected to have demonstrated outstanding research potential and to have a strong interest and ability in teaching. Of particular interest are candidates with a commitment to interdisciplinary research who are knowledgeable in scientific computation.

Applicants should submit a letter of application, a curriculum vitae, a description of research interests, and three letters of recommendation to: Search Committee Chair, Department of Mathematical Sciences, Rensselaer Polytechnic Institute, Troy, NY 12180. Evaluation of applications will begin October 15, 1997, and will continue until a candidate is selected.

Rensselaer is an Equal Opportunity/Affirmative Action Employer and strongly encourages applications from women and underrepresented minorities.

THE STATE UNIVERSITY OF NEW YORK COLLEGE AT POTSDAM

The State University of New York College at Potsdam invites applications for one (possibly two) anticipated full-time tenure-track position(s) effective September 1, 1998, at the rank of assistant professor. Responsibilities of the position are to teach twelve hours per semester of undergraduate and first-year graduate courses. Required qualifications are a Ph.D. in any area of mathematics with a strong interest in and preparation for teaching undergraduate major mathematics courses. In addition, some preparation in computer science is desirable though not essential. Applications, which must include a letter of interest, a statement of the applicant's philosophy of teaching, a résumé, three letters of recommendation describing teaching experience and abilities, and a transcript (a copy is acceptable), should be sent to Dr. Cheryl Chute Miller, Staffing Committee Chair, Math. Department, SUNY Potsdam, Potsdam, NY 13676 (millercc@potsdam.edu). To ensure full consideration, complete applications must be received by January 21, 1998.

STATE UNIVERSITY OF NEW YORK, STONY BROOK

The mathematics department and the Institute for Mathematical Sciences plan to make several appointments beginning fall 1998. These include two 3-year James H. Simons Instructorships, two tenure-track assistant professorships, two or more postdoctoral or visiting positions. We seek candidates with an outstanding research potential and a strong commitment to teaching. Some preference will be given to candidates in algebra, algebraic geometry, or analysis. Applicants should submit one application (automatically considered for both department and Institute) together with a C.V. and three letters of recommendation to: Appointments Committee, Dept. of Mathematics, SUNY at Stony Brook, Stony Brook, NY 11794-3651. Application deadline: March 1, 1998. Application forms must also be submitted electronically to the department Web site. These forms and further information are available at the Web site (http://www.math.sunysb/hiring/) or can be obtained by sending a blank e-mail message to hiring@math.sunysb.edu with subject "information".

SUNY at Stony Brook is an EEO/AA Employer.

NORTH CAROLINA

DUKE UNIVERSITY
W. W. Elliott Assistant Research Professorship of Mathematics

Applications are invited for two positions as assistant research professor of mathematics. Candidates should have completed a doctorate as of September 1, 1997, and show definite promise in research and teaching. The teaching load will be six hours per week during one semester and three hours per week during the other, so that the appointee will have additional time for research. Duke University is an Affirmative Action/Equal Opportunity Employer.

The appointments are for one year and will be renewable for two additional years. The salary will be $38,000, covering work in the regular two-semester year.

Applicants please send (a) a vita, (b) a description of current and past research (1–3 pages), and (c) plan for future research. The AMS Standard Cover Sheet should be completed electronically from the address below. Each applicant is requested to include in their materials the name(s) of one or more members of the faculty of the Department of Mathematics at Duke working in their general area of research.

Applications should be filed by December 20; early application is advisable. The applicant should have at least three letters of recommendation, including one which evaluates teaching, sent directly to Duke by mid-January. All correspondence, including references, **except** AMS Cover Sheet, should be addressed to:

Appointments Committee
Department of Mathematics
Box 90320
Duke University
Durham, NC 27708-0320

AMS Cover Sheets should be completed at http://www.phds.org/jobs/. E-mail inquiries: appts@math.duke.edu.

DUKE UNIVERSITY
Professorship in Mathematics

The Duke University mathematics department is seeking to fill a new position at the full professor level beginning July 1, 1998. We invite applications or inquiries from senior mathematicians with a distinguished record of leadership in research and teaching. Minority and women candidates are encouraged to apply. Duke University is an Affirmative Action/Equal Opportunity Employer.

We are especially interested in mathematicans who will interact well with our established groups in differential geometry, geometric analysis, mathematical physics, and nonlinear analysis. For further information about our department, its faculty, and their specific areas of interest, please consult our departmental Web pages at http://www.math.duke.edu/.

Applicants should send a curriculum vitae, list of publications, a few selected reprints or preprints, and the names and addresses of three references to the Senior Search Committee at the address below. The department will assume responsibility for soliciting letters of evaluation. Applications received by January 15 will receive our full consideration.

Senior Search Committee
Department of Mathematics
Box 90320
Duke University
Durham, NC 27708-0320
e-mail: search@math.duke.edu

DUKE UNIVERSITY
Lecturer in Mathematics

Applications are invited for one position as Lecturing Fellow in the Department of Mathematics at Duke University. Candidates should have completed a doctorate as of September 1, 1997, have excellent teaching credentials, and have a strong interest in curriculum development.

The teaching load will be six hours per week per semester. In addition, Lecturing Fellows are expected to participate in the department's ongoing revision of laboratory calculus and to continue their own research program in mathematics. Duke University is an Affirmative Action/Equal Opportunity Employer.

The appointment is for two years and is not renewable. The nine-month salary will be $35,000, covering work in the regular two-semester year.

Applicants please send (a) a vita (b) a teaching statement and a description of any experience in curriculum development, (c) a description of current and past research (1–3 pages), and (d) a plan for future research. The AMS Standard Cover Sheet should be completed electronically from the address below. Each applicant is requested to include in their materials the name(s) of one or more members of the faculty of the Department of Mathematics at Duke working in their general area of research.

Applications should include at least three letters of recommendation, including two which evaluate teaching, and should be sent directly to Duke. All correspondence, including references, **except** AMS Cover Sheet, should be addressed to:

Lecturer Committee
Department of Mathematics
Box 90320
Duke University
Durham, NC 27708-0320

AMS Cover Sheet should be completed at http://www.pphds.org/jobs/. E-mail inquiries: appts@math.duke.edu.

DUKE UNIVERSITY
Assistant Professor

Applications and nominations are invited for one tenure-track position as assistant professor in applied mathematics. Salary is open; the position is to start September 1, 1998. Duke University is an Affirmative Action/Equal Opportunity Employer.

Applicants please send (a) a vita, (b) a description of past research (1–3 pages), and (c) a plan for future research. The AMS

Standard Cover Sheet should be completed electronically from the address below.

Applications should be filed by December 15; early application is advisable. The applicant should have at least three letters of recommendation, including one which evaluates teaching, sent directly to Duke by mid-January. All correspondence, including references, **except** AMS Cover Sheet, should be addressed to:

Faculty Search Committee
Department of Mathematics
Box 90321
Duke University
Durham, NC 27708-0321

AMS Cover Sheets should be completed at `http://www.phds.org/jobs/`. E-mail inquiries: `appts@math.duke.edu`.

NORTH CAROLINA STATE UNIVERSITY
Department of Mathematics

The Department of Mathematics invites applications for a tenure-track position at the assistant or associate professor level in representation theory and combinatorics beginning in the fall of 1998. Candidates must have a doctoral degree in mathematics, a strong ongoing research program in representation theory and/or algebraic combinatorics, and a commitment to effective teaching at the undergraduate and graduate levels. Preference will be given to candidates with postdoctoral experience. Applicants should send a vita and at least three letters of recommendation to Algebra Search Committee, Department of Mathematics, North Carolina State University, Raleigh, NC 27695-8205. Review of completed applications will begin immediately. Applications will continue to be accepted until the position is filled. All qualified applicants will receive consideration for employment without regard to race, color, religion, sex, national origin, veteran status, or disability.

WAKE FOREST UNIVERSITY
Department of Mathematics and Computer Science

Applications are invited for a tenure-track position in mathematics at the assistant professor level beginning August 1998. Duties include teaching mathematics at the undergraduate and graduate levels and continuing research. A Ph.D. in mathematics is required. Leadership and participation in the departmental major in mathematical economics is also required; this is a joint major with the Department of Economics. Research areas of interest include optimization, control theory, and dynamical systems, but other areas of research will be considered. Women and minorities are encouraged to apply. The department has 24 members and offers a B.S. and M.A. in mathematics, a B.S. and M.S. in computer science, and a B.S. in each of mathematical economics and mathematical business. Send a letter of application and résumé to Richard D. Carmichael, Chair, Department of Mathematics and Computer Science, Wake Forest University, P. O. Box 7388, Winston-Salem, NC 27109-7388. AA/EO Employer.

UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL
Chapel Hill, NC 27599
Tenure-Track Position

Applications are invited for one tenure-track assistant or associate professor position in applied mathematics effective fall 1998. An associate professor position would be available for 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 a five-year plan to build a strong applied and computational mathematics group interacting with existing strengths at UNC in mathematics and in materials, marine, biomedical, and environmental sciences. A copy of this ad may be found on our World Wide Web page at `http://www.math.unc.edu/General/Job.announcements/`. Send curriculum vitae, abstract of current research, and four letters of recommendation to Professor M. Gregory Forest, Chair, Applied Mathematics Search Committee, Dept. of Mathematics, CB #3250, Phillips Hall, UNC-Chapel Hill, Chapel Hill, NC 27599-3250. EO/AA Employer. Women and minorities are encouraged to apply and to identify themselves. Applicants are encouraged to submit a statement of teaching interests and goals. Completed applications received by January 1, 1998, are assured of full consideration.

OHIO

DENISON UNIVERSITY

Denison University has a three-semester position in the Department of Mathematics and Computer Science beginning January 1998. Ph.D. required in mathematics. A commitment to quality instruction of undergraduates is essential.

Denison University is a liberal arts college of 1,800 students located in a village of 4,000 seven miles from Newark (population 50,000) and twenty-five miles east of Columbus, Ohio. The Department of Mathematics and Computer Science offers B.A. and B.S. degrees in mathematics and computer science.

Send résumé and transcripts of graduate work to:

Dr. Joan Krone, Chair
Department of Mathematics
and Computer Science
Denison University
Granville, OH 43023

Also ask three persons whom know you well to send reference letters in support of your application.

Applications will be processed until the position is filled.

OBERLIN COLLEGE
Department of Mathematics

Full-time, tenure-track position beginning in the 1998–99 academic year. Responsibilities include teaching undergraduate courses in statistics and mathematics (5/year), supervising honors students, and sustained scholarly production. Ph.D. degree in statistics or mathematics (in hand or expected by August 31, 1998) required. All research specialties in statistics and related fields considered. Candidates must demonstrate potential excellence in teaching. Send letter of application, curriculum vitae, academic transcripts (graduate and undergraduate), and three letters of reference to Jeffrey Witmer, Department of Mathematics, Oberlin College, Oberlin, OH 44074, by December 15, 1997. Oberlin College has admitted women since its founding in 1833 and has been historically a leader in the education of blacks. AA/EOE.

OBERLIN COLLEGE
Department of Mathematics

Full-time, tenure-track position beginning in the 1998–99 academic year. Responsibilities include teaching undergraduate courses in mathematics (5/year), supervising honors students, and sustained scholarly production. Ph.D. degree (in hand or expected by August 31, 1998) required. Candidates must demonstrate potential excellence in teaching. All specialities considered except statistics and related fields. Send letter of application, curriculum vitae, academic transcripts (graduate and undergraduate), and three letters of reference to Michael Henle, Department of Mathematics, Oberlin College, Oberlin, OH, 44074 by December 15, 1997. Oberlin College has admitted women since its founding in 1833 and has been historically a leader in the education of blacks. AA/EOE.

THE OHIO STATE UNIVERSITY
Department of Mathematics

The Department of Mathematics of The Ohio State University expects to have available at least one tenure-track/tenured position and several visiting positions, effective autumn quarter 1998. Candidates in all areas of applied and pure mathematics are invited to apply. Preference will be given to those in applied mathematics for one tenure-track position. The

department will also have available a few Hans J. Zassenhaus Assistant Professorships. These term positions are renewable annually up to a total of three years. Significant mathematical research accomplishments or exceptional promise and evidence of excellent teaching ability are required.

Please send a C.V. and at least three letters of recommendation to Professor Ruth Charney, Interim Chair, Department of Mathematics, The Ohio State University, 231 W. 18th Avenue, Columbus, OH 43210.

The Ohio State University is an Equal Opportunity/Affirmative Action Employer. Women and minority candidates are encouraged to apply.

OKLAHOMA

OKLAHOMA STATE UNIVERSITY
Department of Mathematics
Tenure-Track Positions

The department anticipates the availability of three tenure-track positions: two at the assistant professor level and one at the associate professor level beginning fall 1998. Applicants should have demonstrated outstanding research potential and have made major contributions beyond their doctoral dissertation. Applicants for the associate professor position should have in addition demonstrated outstanding leadership in research. Duties include a blend of research and teaching, and all applicants should have a commitment to excellence in undergraduate and graduate education; the usual teaching load is 5 or 6 hours each semester. The department has several research groups, and preference will be given to applicants whose research interests relate to one or more of these groups or to applied mathematics.

Applicants should submit a curriculum vitae, abstracts of completed research, a statement regarding teaching experience and philosophy, and four letters of recommendation to the address below. One letter of recommendation should address the applicant's teaching experiences.

Oklahoma State University is located in Stillwater, a town of approximately 40,000 in north central Oklahoma. The department boasts a very dynamic faculty, with over 40 members successfully engaged in mathematics research and education. An active Ph.D. program, support for colloquium speakers and other visitors, approximately 8–10 postdoctoral fellows, as well as involvement of undergraduates in research experiences add to the lively and scholarly atmosphere of the department. The department has received national recognition for the research of its faculty and for the faculty's contributions to mathematics education. More information on the department and the University can be obtained through its Web page, `http://www.math.okstate.edu/`.

Applicants should use the AMS standardized form, Academic Employment in Mathematics, Application Cover Sheet, and indicate their subject area using the AMS Subject Classification Numbers.

Full consideration will be given to applications received by December 15, 1997; however, all applications will be given consideration until the available positions are filled. Application materials should be sent to the address below. Electronic applications are encouraged and may be sent to `mathposition@math.okstate.edu`. Oklahoma State University is an Equal Opportunity/Affirmative Action Employer. Women and minorities are encouraged to apply.

Prof. Sheldon Katz, Chair
Appointments Committee
Department of Mathematics
401 Math Science
Oklahoma State University
Stillwater, OK 74078-1058
`mathposition@math.okstate.edu`

OKLAHOMA STATE UNIVERSITY
Department of Mathematics
Postdoctoral Positions

The department invites applications for several temporary postdoctoral positions beginning fall 1998. The positions are for new or recent recipients of the Ph.D. and are a one-year appointment with possibility of renewal. Applications are welcome from individuals who have held postdoctoral appointments; an appointment to one of these positions does not exclude an individual from future consideration for a tenure-track position. The duties incorporate a blend of research and teaching; the usual teaching load is 5 or 6 hours each semester. Applicants should submit a curriculum vitae, abstracts of completed research, a statement regarding teaching experience and philosophy, and four letters of recommendation to the address below. One letter of recommendation should address the applicant's teaching experiences. Mathematicians with research interests close to a member of the regular faculty or in applied mathematics will receive preference. Applicants should use the AMS standardized form, Academic Employment in Mathematics, Application Cover Sheet, and indicate their subject area using the AMS Subject Classification Numbers.

Oklahoma State University is located in Stillwater, a town of approximately 40,000 in north central Oklahoma. The department boasts a very dynamic faculty, with over 40 members successfully engaged in mathematics research and education. An active Ph.D. program, support for colloquium speakers and other visitors, approximately 8–10 postdoctoral fellows, as well as involvement of undergraduates in research experiences add to the lively and scholarly atmosphere of the department. The department has received national recognition for the research of its faculty and for the faculty's contributions to mathematics education. More information on the department and the University can be obtained through its Web page, `http://www.math.okstate.edu/`.

Full consideration will be given to applications received by January 1, 1998; however, all applications will be given consideration until the available positions are filled. Application materials should be sent to the address below. Electronic applications are encouraged and may be sent to `mathposition@math.okstate.edu`. Oklahoma State University is an Equal Opportunity/Affirmative Action Employer. Women and minorities are encouraged to apply.

Prof. Sheldon Katz, Chair
Appointments Committee
Department of Mathematics
401 Math Science
Oklahoma State University
Stillwater, OK 74078-1058
`mathposition@math.okstate.edu`

PENNSYLVANIA

DICKINSON COLLEGE
Carlisle, Pennsylvania
Faculty Position in Mathematics

The Department of Mathematics and Computer Science invites applications for a tenure-track position in mathematics at the assistant professor level starting August 1998. Applicants should have a Ph.D. in mathematics and a strong commitment to liberal arts education. Excellence in undergraduate teaching and strong research potential are expected.

Dickinson is a private, highly selective liberal arts college with 1,800 students located in south central Pennsylvania. The department has eight full-time members. We offer major and minor programs in both mathematics and computer science.

Please send a cover letter, C.V., and separate statements on teaching philosophy and research interests to: Prof. Barry Tesman, Department of Mathematics and Computer Science, Dickinson College, Carlisle, PA 17013. Also arrange for three letters of recommendation and copies of graduate transcripts to be sent to the same address. Review of completed applications will begin on December 15. Please indicate whether you will be attending the Joint AMS-MAA Meetings in Baltimore, where we will be conducting preliminary interviews. Inquiries may be made to `tesman@dickinson.edu`. Further information is available from `http://www.dickinson.edu/departments/mathcs/`.

Dickinson is an Affirmative Action/Equal Opportunity Employer. Women and minorities are especially encouraged to apply.

SOUTH CAROLINA

UNIVERSITY OF SOUTH CAROLINA
Department of Mathematics

The Department of Mathematics expects openings for tenure-track positions starting in fall 1998 and invites applications primarily at the junior level. Applications completed by January 8, 1998, will receive full consideration. While applications in all areas of mathematics will be considered, those whose interests mesh well with the strengths of the department will be given preference. The Ph.D. degree or its equivalent is required as well as an established record of significant research accomplishments. All appointments will be consistent with the department's commitment to excellence in research and in teaching at the undergraduate and graduate levels. A complete application should include a detailed résumé with a summary of research accomplishments and goals, a completed copy of the AMS Standard Cover Sheet (see the *Notices*), and four letters of recommendation. All material should be sent to:

Robert M. Stephenson Jr., Chairman
Department of Mathematics
University of South Carolina
Columbia, SC 29208

We encourage applicants to use the AMS Cover Sheet located on our World Wide Web site, `http://www.math.sc.edu/~jobs98/`. The University of South Carolina is an Affirmative Action/Equal Opportunity Employer.

COLLEGE OF CHARLESTON
Department of Mathematics

Applications are invited for at least one tenure-track position in mathematics at the assistant professor level starting in August 1998. The Mathematics Department at the College of Charleston has 27 full-time faculty and offers the B.S. and M.S. degrees in mathematics. Candidates must have a Ph.D. in one of the mathematical sciences, a commitment to undergraduate and graduate teaching, and potential for continuing research. Preference for one position will be given to applicants in some area of computational mathematics. The normal teaching load is 9 hours per week for those engaged in research. The salary is competitive. Faculty from the College of Charleston will be available to meet with applicants at the AMS-MAA Annual Meeting in Baltimore. Applicants should send a vita and three letters of recommendation to Deanna Caveny, Chair, Department of Mathematics, College of Charleston, Charleston, SC 29424-0001. Questions or requests for additional information may be addressed to `caveny@math.cofc.edu`. The process of evaluating applications will begin on January 12, 1998, but applications will be considered until the positions are filled. The College of Charleston is an Equal Opportunity /Affirmative Action Employer and encourages applications from minority and women candidates.

TENNESSEE

VANDERBILT UNIVERSITY
Department of Mathematics
Nashville, TN 37240
Position in Computational Mathematics

We invite applications for a tenure-track assistant professorship beginning fall 1998. This position carries an initial three-year appointment and requires a Ph.D. in mathematics. We are looking for someone whose primary research involves computing and who can interact with existing groups in approximation theory, wavelets, and biomedical modeling and imaging. Outstanding research potential and evidence of effective teaching are required. To apply, send a letter of application (including e-mail address and fax number), a curriculum vitae, and a brief research summary to Professor Larry Schumaker, Chair of the Search Committee, at the above address. Do not send additional information (including letters of recommendation) unless requested to do so after the initial screening.

Vanderbilt University is an Affirmative Action/Equal Opportunity Employer.

UNIVERSITY OF TENNESSEE
Mathematics Department

The Mathematics Department of The University of Tennessee (`www.math.utk.edu`) seeks to fill a tenure-track assistant professorship with an Outreach Mathematician (OM). The duties of the OM will be to foster close relations between the University and the community colleges and/or high schools across the state as well as to teach in the department.

A Ph.D. in mathematics or a doctoral degree in another discipline with a Master's of Science degree in mathematics is required, together with a clear commitment to outreach activities. Some postdoctoral experience is preferred but not required. Dedication to teaching is paramount. Employment begins August 1, 1998.

Interested applicants should arrange to have a vita, three reference letters, a statement of accomplishments, qualifications, plans for outreach activities, and evidence of quality teaching sent to Professor John B. Conway, OM Search, Mathematics Department, University of Tennessee, Knoxville, TN 37996-1300. Electronic applications are not acceptable. Use of the recent AMS application form is encouraged. Review of applications will begin January 1 and will continue until the position is filled.

UTK is an EEO/AA/Title IX/Section 504/ADA Employer.

TEXAS

BAYLOR UNIVERSITY
Department of Mathematics

The Department of Mathematics invites applications for a tenure-track position at the assistant professor level starting in August 1998. A Ph.D. is required, excellence in teaching is essential, and research/scholarship is expected. While exceptional candidates in all areas of mathematics will be considered, the department especially encourages people in numerical linear algebra, stochastic analysis, analysis, and applied mathematics to apply.

Applicants should provide a curriculum vitae, three letters of reference, transcripts, and a professional statement describing their philosophy about both teaching and research. Completed applications received by January 2, 1998, will be given full consideration.

Baylor is a Baptist university affiliated with the Baptist General Convention of Texas. As an Affirmative Action/Equal Opportunity Employer, Baylor encourages minorities, women, veterans, and persons with disabilities to apply. Send all materials to: Mathematics Search Committee, P. O. Box 97328, Waco, TX 76798-7328; e-mail address: `Ed_Oxford@baylor.edu`.

SOUTHERN METHODIST UNIVERSITY
Department of Mathematics
Assistant Professorship and Lecturer

Applications are invited for two positions starting in the fall semester of 1998. The first is a tenure-track assistant professorship. Applicants for this position must provide evidence of outstanding potential for research in applied mathematics or scientific computation and a strong commitment to teaching at all levels. The Department of Mathematics has an active doctoral program in applied mathematics, numerical analysis, and scientific computation. The second position is a two-year appointment as a non-tenure-track lecturer whose duty is to teach introductory courses.

Applications will be accepted until February 2, 1998, or until the position is filled. The Search Committee will notify applicants of its employment decision after the position is filled. Applicants should arrange for three letters of recommendation, as well as their vita, to be sent to: Search Committee, Department of Mathematics, Southern Methodist University, 208 Clements Hall, P. O. Box 750156, Dallas, TX 75275-0156; tel: 214-768-2506; fax: 214-768-2355.

SMU is an Equal Opportunity/Affirmative Action/Title IX Employer.

Visit the department's WWW site at `http://www.smu.edu/~math/`, and contact the Search Committee by sending e-mail to: `search@mail.smu.edu`.

VIRGINIA

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
Department of Mathematics

Applications are invited for senior faculty positions in the area of numerical analysis with emphasis on computational methods for partial differential equations. We expect to make several offers at the associate professor level and above.

Successful candidates must possess a strong continuing record of internationally recognized research in computational mathematics and applications. A proven record of academic leadership, demonstrated by the candidate's dedication to excellence in research, teaching, graduate student advising, and postgraduate supervision, is desirable. The Department of Mathematics has strong traditional links with the College of Engineering, and appointees would be expected to foster and encourage these ties.

The intellectual climate for applied mathematics at Virginia Tech is lively and challenging. The department has an active group of applied mathematicians in the areas of control and optimization, numerical analysis, stochastic processes, ordinary differential equations, partial differential equations, and integro-differential equations. In addition, the Interdisciplinary Center for Applied Mathematics (ICAM) is a University Center which facilitates interactions among the faculty at Virginia Tech, industry, and other research institutions. Faculty in the Virginia Tech mathematics department have access to excellent computational facilities as well as to several national high-performance computing centers.

Applications will be accepted until all positions are filled. Applicants should send a vita and five letters of recommendation to:

Numerical Analysis Search Committee
Department of Mathematics
Virginia Tech
Blacksburg, VA 24061-0123

Virginia Tech has a strong commitment to the principle of diversity and in that spirit seeks a broad spectrum of candidates, including women, minorities, and people with disabilities. Individuals with disabilities desiring accommodations in the application process should contact Werner Kohler, Department of Mathematics, 540-231-8283 (TDD/PC 1-800-828-1120, Voice 1-800-828-1140).

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
Department of Mathematics

Applications are solicited for tenure-track positions at the assistant or associate professorship levels in the area of numerical analysis/scientific computing; we anticipate making one or more appointments. Candidates must have a Ph.D. in mathematics or equivalent, with a strong record or demonstrated potential in research and teaching. We seek candidates who will augment existing faculty focus in the areas of the numerical treatment of PDEs, control and optimization, and computational linear algebra.

Send a letter of application, curriculum vitae, summary of research plans, together with four letters of recommendation (one of which addresses teaching skills) to:

Computational Mathematics
Search Committee
Department of Mathematics
Virginia Tech
Blacksburg, VA 24061-0123

Review of applications will begin on December 15, 1997, and will continue until available positions are filled.

Virginia Tech has a strong commitment to the principle of diversity and in that spirit seeks a broad spectrum of candidates, including women, minorities, and people with disabilities. Individuals with disabilities desiring accommodations in the application process should contact Werner Kohler, Department of Mathematics, 540-231-8283 (TDD/PC 1-800-828-1120, Voice 1-800-828-1140).

GEORGE MASON UNIVERSITY
Department of Mathematical Sciences

The department expects to fill two tenure-track positions, preferably at the assistant professor level in the fall of 1998. Successful candidates must demonstrate the potential to make significant contributions to both the B.S. and M.S. programs in either actuarial mathematics or computational and applied mathematics. Candidates are expected to teach at both the undergraduate and graduate levels, maintain an active research program, and pursue external funding opportunities. Computational and applied mathematics faculty also teach courses and supervise Ph.D. students in the interdisciplinary Institute for Computational Sciences and Informatics.

Arrange for a vita, statement of teaching and research interests, and at least three letters of reference to be sent to Ittai Kan, Chair of Search Committee, Department of Mathematical Sciences, George Mason University, MS 3F2, 4400 University Drive, Fairfax, VA 22030-4444 (e-mail: `ikan@gmu.edu`). To ensure consideration, apply before December 31, 1997; late applications will be accepted until the positions are filled. George Mason University is an AA/EEO Employer. Women and minorities are encouraged to apply.

WASHINGTON

UNIVERSITY OF WASHINGTON
Department of Mathematics

Applications are invited for several positions starting September 1998. The positions are initially budgeted as tenure-track assistant professorships, but extremely outstanding candidates may be considered at the associate professor and professor levels. Applicants must have the Ph.D. degree in hand by the starting date. Duties include undergraduate and graduate teaching and independent research. Applications should include a curriculum vitae, statement of research and teaching interests, three letters of recommendation, and a Mathematics Subject Classification (as found in the December index volume of *Mathematical Reviews*) of the primary research interest.

Applications should be sent to: Appointments Committee Chair, Department of Mathematics, Box 354350, University of Washington, Seattle, WA 98195-4350. Priority will be given to applications received by December 15, 1997. The University of Washington is building a culturally diverse faculty and strongly encourages applications from female and minority candidates. The University is an Equal Opportunity/Affirmative Action Employer. Availability of positions is subject to budgetary approval.

WESTERN WASHINGTON UNIVERSITY
Tenure-Track Assistant Professor
Mathematics

Begin fall 1998. Candidates with experience in statistics or stochastic processes preferred. Ph.D., refereed publications, and evidence of effective teaching required. Independent and collaborative grant-funded research expected. Commitment to innovative undergraduate instruction essential. Teaching assignments include large lower-division classes. WWU, beside Bellingham Bay between Seattle and Vancouver, has 500 faculty and 12,000 students. Access to excellent recreational opportunities and metropolitan facilities. Get Position Announcement and WWU Summary from `http://www.wwu.edu/~mathweb/` or address below, and submit summary, vita, transcripts, description of research and teaching accomplishments and interests, and four letters of recommendation addressing both teaching and research by January 16, 1998, to: Search Committee, Math, WWU, Bellingham, WA 98225-9063; fax: 360-650-7788; tel: 360-650-3785; e-mail: `mathdept@henson.cc.wwu.edu`. No electronic applications. AA/EOE.

WYOMING

UNIVERSITY OF WYOMING
Applied Mathematics

The Department of Mathematics invites applications for a tenure-track assistant professorship in applied mathematics. We seek candidates with an earned doctorate, proven teaching ability, and strong

research in areas of interest in the department, including numerical analysis, partial differential equations, fluid mechanics, and porous media. Applications received by January 15, 1998, will receive first consideration. For more information visit our Web site, http://math.uwyo.edu/.

The University of Wyoming is an Equal Opportunity/Affirmative Action Employer, and we encourage applications from women and underrepresented minorities. Please send vita, three letters of reference, and a statement of teaching qualifications to Myron B. Allen, Head, Department of Mathematics, University of Wyoming, Laramie, WY 82071-3036.

UNIVERSITY OF WYOMING
Department of Mathematics
Tenure-Track Position in Analysis

The University of Wyoming mathematics department (Web site http://math.uwyo.edu/) invites applications for a tenure-track assistant professorship in analysis to start August 1998. Applicants must demonstrate strong ability in research, breadth of mathematical knowledge, strong commitment to undergraduate and graduate teaching, and willingness to supervise master's and doctoral students. Candidates in all areas of analysis will be considered; however, we are particularly interested in strengthening our existing research in function theory, functional, geometric, and harmonic analysis.

Complete applications consist of curriculum vitae, including publication list, a summary of research interests, a statement of teaching qualifications, and three letters of recommendation, sent directly to Myron B. Allen, Head, Department of Mathematics, University of Wyoming, Laramie, WY 82071-3036. Applications received by January 15, 1998, will receive first consideration. The University of Wyoming is an Affirmative Action/Equal Opportunity Employer, and we encourage women and underrepresented minorities to apply.

CANADA

UNIVERSITY OF VICTORIA

The Department of Mathematics and Statistics at the University of Victoria invites applications for two tenure-track positions at the assistant professor level to commence on July 1, 1998. Applicants for the first position should have a Ph.D. in a subject of modern applied mathematics (e.g., wavelet analysis, computational fluid dynamics, neural networks); applicants for the second position should have a Ph.D. in statistics or a related discipline and should possess the expertise to teach both applied and theoretical courses in statistics and probability theory. A strong commitment to undergraduate and graduate teaching and a demonstrated record of research is expected from all applicants.

In consideration of the current gender imbalance in the department, women are especially encouraged to apply.

The positions are subject to approval by the Board of Governors of the University of Victoria. The University of Victoria is committed to employment equity and encourages applications from all qualified individuals, including women, members of visual minorities, aboriginal peoples, and persons with a disability. In accordance with the Canadian Immigration Requirements, priority will be given to Canadian citizens and permanent residents.

Applications should include a curriculum vitae and should identify the date of availability. In addition, applicants should arrange for three letters of reference to be sent to:

Office of the Chair
Department of Mathematics
and Statistics
University of Victoria
P.O. Box 3045
Victoria, BC V8W 3P4, Canada
tel: (250) 721-7436
fax: (250) 721-8962
e-mail: acme@uvvm.uvic.ca

The closing date for applications is December 31, 1997.

SWITZERLAND

THE SWISS FEDERAL INSTITUTE OF TECHNOLOGY, ZURICH (ETHZ)
Professorship in Mathematics

The Swiss Federal Institute of Technology, Zurich (ETHZ) invites applications for a professorship in mathematics. Duties of this position include teaching and research in mathematics. Together with the other members of the department, the new professor will be responsible for undergraduate and graduate courses for students of mathematics, engineering, and the natural sciences.

We are seeking candidates with strong research records and proven ability to direct research of high quality. Willingness to teach at all university levels and to collaborate with colleagues is expected.

Applications with curriculum vitae and a list of publications should be submitted to the President of ETH Zurich, ETH Zentrum, CH-8092 Zurich, no later than January 31, 1998. The ETHZ specifically encourages female candidates to apply, with a view toward increasing the proportion of female professors.

THE SWISS FEDERAL INSTITUTE OF TECHNOLOGY, ZURICH (ETHZ)
Professorship in Mathematics/ Statistics

The Swiss Federal Institute of Technology, Zurich (ETHZ) invites applications for a professorship in mathematics/statistics, with specialization in statistical computing. Duties of this position include teaching and research in statistics and mathematics. We expect the appointee to play an active role in fostering connections between mathematics and statistics on the one hand and applications and computer science on the other. Together with the other members of the department, he or she will be responsible for undergraduate and graduate courses in statistics and mathematics for students of mathematics, engineering, and the natural sciences.

We are seeking candidates with strong research records and proven ability to direct research of high quality. Willingness to teach at all university levels and to collaborate with colleagues is expected.

Applications with curriculum vitae and a list of publications should be submitted to the President of ETH Zurich, ETH Zentrum, CH-8092 Zurich, no later than January 31, 1998. The ETHZ specifically encourages female candidates to apply, with a view toward increasing the proportion of female professors.

UNIVERSITY OF ZURICH
Professor in Mathematics

The Institute of Mathematics invites applications for a position in applied mathematics at the associate or full professor level, to start in September 1998. Preference will be given to candidates in numerical analysis or algorithmics, but applications from other applied areas are also welcome.

Candidates are expected to have a strong research record and to be willing to teach at all university levels.

Applications should include a curriculum vitae and a list of publications and should reach the Dekan der Philosophischen Fakultät II, University of Zurich, Winterthurerstrasse 190, CH-8057 Zurich, Switzerland, before December 31, 1997.

UNIVERSITY OF ZURICH
Assistant Professor in Mathematics

The Institute of Mathematics invites applications for an assistant professorship in pure mathematics, starting in September 1998 or earlier. Preference will be given to candidates in algebra/arithmetic or topology, but applications from all areas of pure mathematics are welcome.

The initial appointment is for three years, with the possibility of renewal for an additional three years. In addition to research, the duties include active participation in the teaching of students of mathematics and the natural sciences.

Candidates are expected to have demonstrated outstanding research potential and the ability to carry out independent research.

To apply, submit a curriculum vitae, a list of publications, a summary of current research plans, and a few selected articles,

and ask three people to send letters of recommendation.

This material should arrive at the Dekanat der Philosophischen Fakultät II, University of Zurich, Winterthurerstrasse 190, CH-8057 Zurich, Switzerland, before December 31, 1997.

PUBLICATIONS FOR SALE

For Sale

Long runs, mostly bound volumes of the following journals: Monthly, Proceedings AMS, Am. Scientist, AAUP, Proceedings, Edinburgh Math. Soc., Notices, Bulletin AMS. Respond to applicant code 000392, AMS Notices Adv. Dept., P.O. Box 6248, Providence, RI 02940-6248.

PUBLICATIONS WANTED

MATHEMATICS BOOKS PURCHASED

Pure & appl. adv. & research level, any age, usable cond. Reprints OK. One box to whole libraries sought. Contact: Collier Brown or Kirsten Berg @ **Powell's Technical Bks.**, Portland, OR. Call 800-225-6911, fax 503-228-0505, or e-mail: kirsten@technical.powells.com.

AMERICAN MATHEMATICAL SOCIETY

Electronic Research Announcements OF THE AMERICAN MATHEMATICAL SOCIETY

Volume 3, 1997

CONTENTS (year to date)

The American Mathematical Society's electronic-only journal, *Electronic Research Announcements of the AMS* (ERA-AMS), is available on the World Wide Web at the URL: http://www.ams.org/era/

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. Beginning with Volume 3, papers will be posted as soon as they are accepted and processed by the AMS.

ERA-AMS offers you ...
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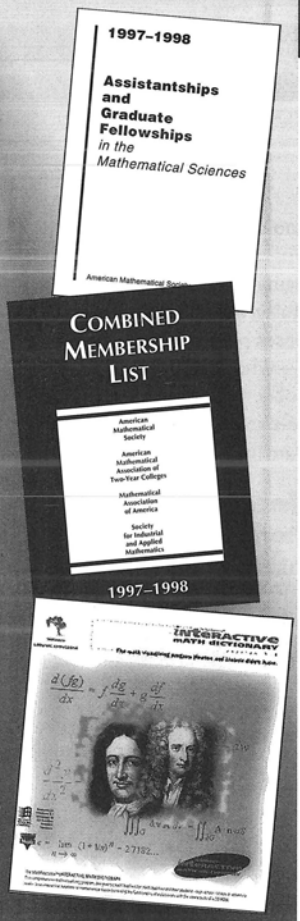
- fast access to your specific area of interest
- up-to-the-minute research information

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**
800-321-4267, 401-455-4000, fax 401-455-4046



American Mathematical Society

Professional Resources from the AMS

Assistantships and Graduate Fellowships in the Mathematical Sciences 1997–1998

This publication is an indispensible source of information for students seeking support for graduate study in the mathematical sciences. Providing data from a broad range of academic institutions, it is also a valuable resource for mathematical sciences departments and faculty.

Assistantships and Graduate Fellowships brings together a wealth of information about resources available for graduate study in the U.S. and Canada. Information on the number of faculty, graduate students, and degrees awarded (bachelor's, master's, and doctoral) is listed for each department when provided. Stipend amounts and the number of awards available are given, as well as information about foreign language requirements. Numerous display advertisements from mathematical sciences departments throughout the country provide additional information.

Also listed are sources of support for graduate study and travel, summer internships, and graduate study in the U.S. for foreign nationals. Finally, a list of reference publications for fellowship information makes *Assistantships and Graduate Fellowships* a centralized and comprehensive resource.

AMS Publications Not in Series; 1997; 135 pages; Softcover; ISBN 0-8218-0814-1; List $20; Individual member $12; Order code ASST/97NA

Combined Membership List 1997–1998

The *Combined Membership List* (CML) is a comprehensive directory of the membership of the American Mathematical Society, the American Mathematical Association of Two-Year Colleges (AMATC), the Mathematical Association of America (MAA), and the Society for Industrial and Applied Mathematics (SIAM).

There are two lists of individual members. The first is a complete alphabetical list of members in all four organizations. For each member, the CML provides his or her address, title, department, institution, telephone number (if available), and electronic address (if indicated), and also indicates membership in the four participating societies. The second is a list of individual members according to their geographic locations. In addition, the CML lists academic, institutional, and corporate members of the four participating societies that provide addresses and telephone numbers of mathematical sciences departments.

The CML is distributed on request to AMS members in even-numbered years. MAA members can request the CML in odd-numbered years from the MAA. The CML is an invaluable reference for keeping in touch with colleagues and for making connections in the mathematical sciences community in the United States and abroad.

1997; 392 pages; Softcover; ISBN 0-8218-0767-6; List $62; Individual member $37; Order code CML/97/98NA

The MathResource™ Interactive Math Dictionary

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

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. ... In my opinion, every Mathematics Department should have a copy available for the staff and students. A great reference/investigative item.

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

Finally, courseware I can order for my students with no learning curve. The MathResource put 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.

The MathResource Interactive Math Dictionary allows you to ...

- Input your own data and do "What if?" analyses.
- Generate numerical and graphical solutions.
- Access the information contained in the CD via the following search options:
  - Word search
  - Alphabetical search
  - Curriculum guide search: Each topic, such as algebra, calculus, linear algebra, etc., has its own table of contents. Simply click on the item and the dictionary opens to the appropriate topic.

Published by MathResources, Inc., Halifax, NS, Canada, and distributed worldwide by the American Mathematical Society.

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

Preparing for Careers in Mathematics

Video

Annalisa Crannell, *Franklin & Marshall College, Lancaster, PA,* Organizer
Steven J. Altschuler, *Microsoft Corporation, Redmond, WA,* **William Browning,** *Applied Mathematics, Inc., Gales Ferry, CT,* **Ray E. Collings,** *DeKalb College, Clarkston, GA,* **Margaret Holen,** *Lehman Brothers, New York, NY,* **Sandra L. Rhoades,** *Keene State College, NH,* **James R. Schatz,** *National Security Agency, Ft. George G. Meade, MD,* **Anita Solow,** *DePauw University, Greencastle, IN,* and, **Francis Edward Su,** *Harvey Mudd College, Claremont, CA,* Speakers

This video presents an edited version of a panel discussion that took place at the Joint Mathematics Meetings in Seattle in August 1996. The panel, sponsored by the AMS Committee on the Profession, discussed how Ph.D. students in mathematics can prepare themselves for finding jobs once they finish their degrees. The panelists ranged from new Ph.D.s who had recently been on the job market, to senior mathematicians in academia and industry. Among the topics discussed are how to start preparing for a job search while still a graduate student, specific job search strategies, tips on interviewing, and perspectives on what academic and industrial employers are looking for in a job applicant. The video ends with a look at the range of employment resources offered by the AMS.

1997; NTSC format on one-half inch VHS videotape, approximately 30 minutes; ISBN 0-8218-0839-7; List $15; Order code VIDEO/99NA

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 02206-5904, USA. For credit card orders, fax (401) 455-4046 or call toll free 800-321-4AMS (4267) in the U. S. and Canada, (401) 455-4000 worldwide. Or place your order through the AMS bookstore at http://www.ams.org/bookstore/. Residents of Canada, please include 7% GST.

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.

. . . .
Family Name ***First*** ***Middle***

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

. . . .

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Telephone number(s) . . . .

Electronic address . . . .

. . . .
Signature

Prepayment Methods and Mailing Addresses

All prices quoted in U.S. dollars.
Payment by check must be drawn on U.S. bank if paid in U.S. dollars.

Send checks, money orders, UNESCO coupons to American Mathematical Society, P.O. Box 5904, Boston, MA 02206-5904

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***

M8NO

Application for Membership 1998

(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
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

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.

*For **ordinary members** whose annual professional income is below $45,000, the dues are $96; for those whose annual professional income is $45,000 or more, the dues are $128.*

*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 $45,000 or less, the dues are $82; for those whose annual professional income is above $45,000, the dues are $109.*

*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 $192. The amount paid which exceeds the higher ordinary dues level and is purely voluntary may be treated as a charitable contribution.*

*For either **students** or **unemployed individuals,** dues are $32, and annual verification is required.*

*The annual dues for **reciprocity members** who reside outside the U.S. and Canada are $64. 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 member dues ($96 or $128).*

*The annual dues for **category-S members,** those who reside in developing countries, are $16. Members can chose 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.*

1998 Dues Schedule (January through December)

Ordinary member . . . . . ☐ $96 ☐ $128

CMS cooperative rate . . . . . ☐ $82 ☐ $109

Joint family member (full rate) . . . . . ☐ $96 ☐ $128

Joint family member (reduced rate) . . . . . ☐ $76 ☐ $108

Contributing member (minimum $192) . . . . . ☐

Student member (please verify)[1] . . . . . ☐ $32

Unemployed member (please verify)[2] . . . . . ☐ $32

Reciprocity member (please verify)[3] . . . . . ☐ $64 ☐ $96 ☐ $128

Category-S member[4] . . . . . ☐ $16

Multi-year membership . . . . . $ . . . . . for . . . . . years

[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
- ☐ Berliner Mathematische Gessellschaft e.V.
- ☐ Calcutta Mathematical Society
- ☐ Croatian Mathematical Society
- ☐ Cyprus Mathematical Society
- ☐ Dansk Matematisk Forening
- ☐ 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 the Philippines
- ☐ Mathematical Society of the Republic of China
- ☐ Mongolian Mathematical Society
- ☐ Nepal Mathematical Society
- ☐ New Zealand Mathematical Society
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- ☐ Österreichische Mathematische Gesellschaft
- ☐ Palestine Society for Mathematical Sciences
- ☐ Polskie Towarzystwo Matematyczne
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- ☐ Société de Mathématiques Appliquées et Industrielles
- ☐ Société Mathématique de Belgique
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- ☐ Society of Associations of Mathematicians & Computer Science of Macedonia
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- ☐ South African Mathematical Society
- ☐ Southeast Asian Mathematical Society
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Besides mailing addresses for members, the Society's records contain information about members' positions and their employers (for publication in the Combined Membership List). In addition, the AMS maintains records of members' honors, awards, and information on Society service.

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The 1997 *Notices* Index

Authors of Articles

Feature Articles

Forum

From the Editor

Invited Speakers

Letters to the Editor

Mathematicians

Mathematics

The Profession

Cosponsored Conference

American Association for the Advancement of Science

Philadelphia, Pennsylvania, February 12–18, 1998

The 1998 Annual Meeting of the American Association for the Advancement of Science (AAAS) will feature many outstanding expository talks by prominent mathematicians. These include the following symposia (three-hour sessions) and invited addresses sponsored by Section A (Mathematics) of the AAAS. The Society provides travel support to speakers in these sessions and has a committee to cooperate with AAAS on scientific activities. The AMS believes that strengthening its ties with the AAAS will create new opportunities for mathematicians to interact with scientists from all disciplines. Session titles and names and affiliations of the organizers are:

- *Exploring New Frontiers in Geometry: In the World around Us and in Our Classrooms I and II*, **Colm K. Mulcahy**, Spelman College, and **David Henderson**.
- *The Chaotic Mathematical Mysteries of the Social Sciences*, organized by **Donald G. Saari**, Northwestern University.
- *Changing Pedagogy in Undergraduate Science and Mathematics Education*, **Deborah Hughes Hallett**, Harvard University, and **Brad G. Osgood**, Stanford University.
- *From Riemann to Strings, The 150-Year Romance of Geometry and Physics*, **Robert Osserman**, Stanford University.
- *Wavelets and Applications*, **Colm K. Mulcahy** and **Farid Dowla**.
- *Elementary Methods in Number Theory*, **Melvyn B. Nathanson**, Herbert H. Lehman College (CUNY).
- *Frontiers of the Physical Sciences I and II*, **Warren Page**, New York City Technical College (CUNY).
- Topical Theme Lecture: *How Geometry Is Changing Hollywood*, **Anthony DeRose**, Pixar.

Other symposia that will be of interest to mathematicians and mathematics educators include:

- *Paradigms for the Sciences: Past, Present, and Future*
- *Not Merely by Science Alone: The Role of Values in Scientific Inquiry*
- *Population and Carrying Capacity: Beyond Malthus after Two Centuries*
- *Educational Technology, Contemporary Theories of Learning, and Some Applications*
- *The Role of Models in Science*
- *How Scientists Really Think*
- *Properties of Mind*
- *Data Selection: Good Research or Fudging the Data?*

The above symposia are only a few of the 150 or so AAAS program offerings in the physical, life, social, and biological sciences that will broaden the perspectives of students and professionals alike. Indeed, AAAS annual meetings are the showcases of American science, deserving greater participation by mathematicians. The AAAS Program Committee is genuinely interested in more symposia on mathematical topics of current interest. The Section A Committee seeks organizers and speakers who can present substantial new material in understandable ways. This task is not easy, but the meetings prove that effort and inspiration can accomplish wonders. The mathematics programs at these meetings show that first-rate mathematical researchers and educators can also effectively reach a broad scientific audience.

Section A of the AAAS knows that increasing the representation and participation of mathematicians at AAAS annual meetings is an important means for deepening public awareness and appreciation of the manifold ways that mathematics contributes to science and society. The secretary of Section A welcomes suggestions for symposia topics and individuals who might be able to organize them. Participants are invited to attend the Section A committee meeting, 7:30 p.m. to 10:30 p.m. on Friday, February 13, 1998, in Room 110B of the Philadelphia Convention Center. This meeting is open to all who wish to stimulate interest in activities of the mathematical sciences within the AAAS. Symposia proposals for future AAAS meetings should be sent to Warren Page, Secretary of Section A, Department of Mathematics, New York City Technical College (CUNY), 300 Jay St., Brooklyn, NY 11201.

For up-to-date details on all sessions, as well as registration information, follow the links to the meeting on the AAAS Web page at `http://www.aaas.org/`. Details will be published in the October 31, 1997, issue of *Science*.

Meetings & Conferences of the AMS

The most comprehensive and up-to-date information on AMS meetings and conferences is available on e-MATH at `http://www.ams.org/meetings/`.

Oaxaca, Mexico

Oaxaca, Mexico

December 3–6, 1997

Meeting #929

Third Joint Meeting of the American Mathematical Society and the Sociedad Mathematica Mexicana.
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: September 1997
Program issue of *Notices*: December 1997
Issue of *Abstracts*: To be announced

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired

Invited Addresses

Javier Bracho, IMATE-UNAM, *Title to be announced.*

Jorge Ize, IIMAS-UNAM, *Title to be announced.*

Gian-Carlo Rota, Massachusetts Institute of Technology, *Title to be announced* (SMM Invited Address).

Ronald Stern, University of California, Irvine, *Title to be announced* (SMM Invited Address).

Alberto Verjovsky, CIC and IMATE-UNAM, *Title to be announced.*

Raymond O. Wells, Rice University, *Title to be announced.*

Special Sessions

Algebraic Geometry and Commutative Algebra, **Leticia Brambila**, UAM-Iztapalapa, and **Rick Miranda**, Colorado State University.

Applied Nonlinear Analysis, **Gustavo Cruz** and **Pablo Padilla**, IIMAS-UNAM, **Susan J. Friedlander**, University of Illinois at Chicago, and **Rafael de la Llave**, University of Texas at Austin.

Complex and Functional Analysis, **William Abikoff**, University of Connecticut, **Raul E. Curto**, University of Iowa, **Salvador Perez-Esteva**, IMATE-UNAM, and **Michael Porter**, CINVESTAV-IPN.

Differential Geometry and Topology, **Kevin Corlette**, University of Chicago, **Luis Hernandez**, CIMAT, **Max Neumann**, IMATE-UNAM, and **Peter Scott**, University of California, Berkeley, and University of Michigan.

General Topology, **Charles L. Hagopian**, California State University Sacramento, and **Isabel Puga**, FC-UNAM.

Graphs and Combinatorial Geometry, **Janos Pach**, City College, City University of New York, and **Eduardo Rivera**, IMATE-UNAM and UAM-Iztapalapa.

Mathematical Physics, **Eric Carlen**, Georgia Institute of Technology, **Micho Durdevich**, IMATE-UNAM, **Roberto Quezada**, UAM-Iztapalapa, and **Nicolai Reshetikhin**, University of California Berkeley.

Nonlinear Models in Biology and Celestial Mechanics, **Enesto Perez** and **Jorge X. Velasco**, UAM-Iztapalapa, and **Stephen R. Wiggins**, California Institute of Technology.

Numerical Analysis, **Bernardo Cockburn**, University of Minnesota, and **Jean P. Hennart**, IIMAS-UNAM.

Representation Theory of Algebras and Groups, **Martha Takane** and **Ernesto Vallejo**, IMATE-UNAM, and **Dan Zacharia**, Syracuse University.

Rings and Category Theory, **Sergio Roberto Lopez-Permouth**, Ohio University, and **Jose Rios** and **Leopoldo Roman**, IMATE-UNAM.

Stochastic Systems, **Guillermo Segundo Ferreyra**, Louisiana State University, and **Daniel Hernandez**, CINVESTAV-IPN.

Baltimore, Maryland

Baltimore Convention Center

January 7–10, 1998

Meeting #930

Joint Mathematics Meetings, including the 104th Annual Meeting of the AMS, 81st Annual Meeting of the Mathematical Association of America (MAA), the winter meeting of the Association for Symbolic Logic (ASL), and the annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and .

Associate secretary: Robert J. Daverman
Announcement issue of *Notices*: October 1997
Program issue of *Notices*: January 1998
Issue of *Abstracts*: Volume 19, 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

Program Updates

U. S. Secretary of Education, **Richard W. Riley**, will speak on the proposed National Test in Mathematics, on Friday, January 9 at 3:10 p.m. Sponsored by the AMS and MAA Committees on Science Policy and AMS Committee on Education.

Lieutenant General **Kenneth A. Minihan**, USAF, Director, National Security Agency, will give the AMS-MAA Science Policy Address on Friday, January 9, at 4:20 p.m. Sponsored by the AMS and MAA Committees on Science Policy. A reception will follow.

Building Connections to Industry within Graduate Departments, Wednesday, 4:30 p.m., sponsored by the AMS Committee on the Profession. Panelists will discuss industrial and commercial projects that lie within traditional mathematics graduate programs—how and why these projects were started and the implications for graduate students and faculty involved in the projects. The goals of this presentation are to provide information on professional development to the mathematics community, to help graduate advisors help their students to cross from academia into industry, and to enhance senior mathematician awareness of opportunities for working with industry. Panelists include **L. Pamela Cook-Ioannidis**, University of Delaware (Industrial Applied Mathematics); **Niels Nygaard**, The University of Chicago (Program in Financial Mathematics); **H. T. Banks**, Director of the North Carolina State University Industrial Math Modeling Workshops; **James Glimm**, SUNY at Stony Brook (Program in Industrial Mathematics); and **Robert Williamson**, The Claremont Graduate School Master of Science Degree in Financial Engineering. The moderator is **Annalisa Crannell**, Franklin & Marshall College.

Louisville, Kentucky

University of Louisville

March 20–21, 1998

Meeting #931

Southeastern Section
Associate secretary: Robert J. Daverman
Announcement issue of *Notices*: January 1998
Program issue of *Notices*: May 1998
Issue of *Abstracts*: Volume 19, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: December 3, 1997
For abstracts: January 28, 1998

Invited Addresses

Anders Bjorner, Royal Institute of Technology, Stockholm, Sweden, *Title to be announced.*

Andrew Bruckner, University of California at Santa Barbara, *Title to be announced.*

Philippe DiFrancesco, University of North Carolina at Chapel Hill, *Title to be announced.*

Abigail Thompson, University of California at Davis, *Title to be announced.*

Special Sessions

Algebraic Combinatorics (Code: AMS SS N1), **Anders Bjorner**, Royal Institute of Technology, and **Michelle L. Wachs**, University of Miami.

Applied Probability and Actuarial Science (Code: AMS SS P1), **Bogdan Gapinski**, **Ewa M. Kubicka**, **Krzysztof Ostraszewski**, and **Grzegorz Rempala**, University of Louisville.

Banach Space Theory (Code: AMS SS F1), **Patrick N. Dowling** and **Beata Randrianantoanina**, Miami University, Ohio.

Boundary Value Problems for Differential Equations (Code: AMS SS J1), **Paul W. Eloe**, University of Dayton.

Combinatorics and Enumerative Geometry (Code: AMS SS A1), **Kequan Ding**, University of Illinois, Urbana-Champaign, and **Chi Wang**, University of Louisville.

Combinatorics and Graph Theory (Code: AMS SS B1), **Andre E. Kezdy**, **Grzegorz Kubicki**, and **Jenoe Lehel**, University of Louisville.

Discrete Mathematics, Classification Theory and Consensus (Code: AMS SS C1), **Robert C. Powers**, University of Louisville.

Fractal Geometry and Related Topics (Code: AMS SS D1), **Ka-Sing Lau**, University of Pittsburgh, and **Weibin Zeng**, University of Louisville.

Functional Equations and Inequalities (Code: AMS SS E1), **Thomas Riedel** and **Prasanna Sahoo**, University of Louisville.

Geometry of Affine Space (Code: AMS SS M1), **Gene Freudenburg**, University of Southern Indiana, and **David Wright**, Washington University.

Low-Dimensional Topology (Code: AMS SS R1), **Martin Scharlemann**, University of California, Santa Barbara, and **Abigail A. Thompson**, University of California, Davis.

Modern Function Theory (Code: AMS SS Q1), **David A. Herron** and **David Minda**, University of Cincinnati.

Real Analysis (Code: AMS SS G1), **Udayan B. Darji** and **Lee Larson**, University of Louisville.

Semigroups, Algorithms, and Universal Algebra (Code: AMS SS H1), **Ralph N. McKenzie**, Vanderbilt University, and **Steven Seif**, University of Louisville.

Spectral Geometry (Code: AMS SS K1), **Ruth Gornet**, Texas Tech University, and **Peter Anton Perry**, University of Kentucky.

Spectral Theory, Mathematical Physics and Disordered Media (Code: AMS SS L1), **Peter David Hislop**, University of Kentucky, and **Gunter H. Stolz**, University of Alabama at Birmingham.

The Use of the History of Mathematics and Science in the University and School Classroom (Code: AMS SS I1), **Richard M. Davitt**, University of Louisville.

Manhattan, Kansas

Kansas State University

March 27–28, 1998

Meeting #932

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: January 1998
Program issue of *Notices*: June 1998
Issue of *Abstracts*: Volume 19, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: December 10, 1997
For abstracts: February 2, 1998

Invited Addresses

Gopal Prasad, University of Michigan-Ann Arbor, *Title to be announced.*

Mikhail Vishik, University of Texas at Austin, *Title to be announced.*

Clarence Eugene Wayne, Pennsylvania State University, University Park, *Title to be announced.*

Zihong Jeff Xia, Northwestern University, *Title to be announced.*

Special Sessions

Abstract Harmonic Analysis (Code: AMS SS H1), **Sadahiro Saeki**, Kansas State University.

Cohomology of Finite Groups (Code: AMS SS F1), **John S. Maginnis**, Kansas State University, and **Stephen F. Siegel**, University of Massachusetts.

Groups and Geometry (Code: AMS SS I1), **Ernest E. Shult**, Kansas State University.

Integrable Systems and Their Applications. (Code: AMS SS M1), **Kirill L. Vaninsky**, Kansas State University.

Lie Groups, Algebraic Groups, Their Arithmetic and Representation Theory (Code: AMS SS O1), **Gopal Prasad**, University of Michigan-Ann Arbor.

Linear Operators and Holomorphic Function Spaces (Code: AMS SS G1), **V. V. Peller**, Kansas State University.

Mathematics Education and the Internet (Code: AMS SS C1), **Andrew G. Bennett**, Kansas State University.

Nonlinear Problems (Code: AMS SS D1), **Lev Kapitanski**, Kansas State University, and **Clarence Eugene Wayne**, Pennsylvania State University.

Numerical Analysis and Computational Mathematics (Code: AMS SS L1), **Huanan Yang** and **Qisu Zou**, Kansas State University.

Partial Differential Equations and Inverse Problems (Code: AMS SS A1), **Alexander G. Ramm**, Kansas State University.

Pictorial Methods in Low-Dimensional Topology (Code: AMS SS B1), **David R. Auckly**, University of California Berkeley.

Quantum Groups and Applications (Code: AMS SS J1), **Volodymyr V. Lyubashenko** and **Ya S. Soibelman**, Kansas State University.

Quantum Topology (Code: AMS SS K1), **Louis Crane** and **David N. Yetter**, Kansas State University.

Representation Theory of Lie Algebras, Algebraic Groups and Quantum Groups (Code: AMS SS E1), **Zongzhu Lin**, Kansas State University, and **Daniel Ken Nakano**, Utah State University.

Philadelphia, Pennsylvania

Temple University

April 4–6, 1998

Meeting #933

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: February 1998
Program issue of *Notices*: June 1998
Issue of *Abstracts*: Volume 19, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: December 17, 1997
For abstracts: February 11, 1998

Invited Addresses

Tobias H. Colding, Courant Institute-New York University, *Title to be announced.*

Martin Davis, University of California, Berkeley, *Title to be announced.*

Ezra Getzler, Max-Planck-Institute and Northwestern University, *Title to be announced.*

Yanyan Li, Rutgers University, *Title to be announced.*

Elias M. Stein, Princeton University, *Title to be announced.*

Special Sessions

Differential Geometric Methods in Hydrodynamics (Code: AMS SS J1), **Gerard K. Misiolek**, University of Notre Dame and California Institute of Technology.

Harmonic Analysis and Its Applications to PDEs (Code: AMS SS G1), **Cristian E. Gutierrez**, Temple University, and **Guozhen Lu**, Wright State University.

Heat Kernel Analysis on Lie Groups (Code: AMS SS H1), **Leonard Gross**, Cornell University, and **Omar Hijab**, Temple University.

Mathematical Pedagogy (Code: AMS SS I1), **Orin N. Chein**, Temple University.

Modular Identities and Q-Series in Number Theory (Code: AMS SS A1), **Boris Datskovsky** and **Marvin I. Knopp**, Temple University.

Nonlinear Partial Differential Equations (Code: AMS SS K1), **Yanyan Li**, Rutgers University.

PDEs in Several Complex Variables (Code: AMS SS B1), **Shiferaw Berhanu** and **Gerardo Mendoza**, Temple University.

Radon Transforms and Tomography (Code: AMS SS C1), **Eric L. Grinberg**, Temple University, and **Eric Todd Quinto**, Tufts University.

Rings and Representations (Code: AMS SS E1), **Maria E. Lorenz**, Ursinus College, and **Martin Lorenz**, Temple University.

Sparse Elimination Methods in Polynomial System Solving (Code: AMS SS L1), **Ioannis Z. Emiris**, INRIA, Sophia-Antipolis, France, and **J. Maurice Rojas**, Massachusetts Institute of Technology.

Sparse Matrix Computations (Code: AMS SS M1), **Jesse Barlow**, Pennsylvania State University, and **Daniel B. Szyld**, Temple University.

The History of American Mathematics (Code: AMS SS D1), **Karen H. Parshall**, University of Virginia, and **David E. Zitarelli**, Temple University.

Topology of Manifolds and Varieties (Code: AMS SS F1), **Sylvain E. Cappell**, Courant Institute-New York University, and **Georgia Triantafillou**, Temple University.

Davis, California

University of California

April 25–26, 1998

Meeting #934

Western Section
Associate secretary: William A. Harris Jr.
Announcement issue of *Notices*: February 1998
Program issue of *Notices*: June 1998
Issue of *Abstracts*: Volume 19, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: January 7, 1998
For abstracts: March 4, 1998

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

Deadlines

For organizers: December 12, 1997
For consideration of contributed papers in Special Sessions: May 26, 1998
For abstracts: July 21, 1998

Invited Addresses

Vitaly Bergelson, Ohio State University, *Title to be announced.*

Sheldon Katz, Oklahoma State University, *Title to be announced.*

Ralf Spatzier, University of Michigan, *Title to be announced.*

Vladimir Voevodsky, Northwestern University, *Title to be announced.*

Special Sessions

Algebraic Coding (Code: AMS SS C1), **William C. Huffman**, Loyola University of Chicago, and **Vera S. Pless**, University of Illinois at Chicago.

Fourier Analysis (Code: AMS SS E1), **Marshall Ash**, DePaul University, and **Mark A. Pinsky**, Northwestern University.

K-Theory and Motivic Cohomology (Code: AMS SS D1), **Kevin Knudson**, Northwestern University, and **Mark Walker**, University of Nebraska-Lincoln.

Stochastic Analysis (Code: AMS SS A1), **Elton P. Hsu**, Northwestern University, and **Richard B. Sowers**, University of Illinois-Urbana.

Topics in Mathematics and Curriculum Reform (Code: AMS SS B1), **Richard J. Maher**, Loyola University Chicago.

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

Deadlines

For organizers: January 6, 1998
For consideration of contributed papers in Special Sessions: June 23, 1998
For abstracts: August 18, 1998

Special Sessions

Noncommutatuve Algebra (Code: AMS SS C1), **Ellen Kirkman** and **James Kuzmanovich**, Wake Forest University.

Recent Results on the Topology of Three-Manifolds (Code: AMS SS D1), **Hugh Nelson Howards**, Wake Forest University.

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

Deadlines

For organizers: January 22, 1998
For consideration of contributed papers in Special Sessions: July 7, 1998
For abstracts: September 1, 1998

Invited Addresses

Jeffrey Adams, University of Maryland, College Park, *Title to be announced.*

Nigel D. Higson, Pennsylvania State University, *Title to be announced.*

Tasso J. Kaper, Boston University, *Title to be announced.*

Kate Okikiolu, University of California, San Diego and MIT, *Title to be announced.*

Special Sessions

C-Algebraic Methods in Geometry and Topology* (Code: AMS SS B1), **Erik Guentner** and **John D. Trout Jr.**, Dartmouth College, and **Nigel D. Higson**, Pennsylvania State University.

Modeling of Phase Transitions of Partially Ordered Physical Systems (Code: AMS SS C1), **Maria-Carme T. Calderer**, Pennsylvania State University.

Partitions and q-Series (Code: AMS SS A1), **George E. Andrews** and **Ken Ono**, Pennsylvania State University.

Tucson, Arizona

University of Arizona-Tucson

November 14–15, 1998

Meeting #938

Western Section
Associate secretary: William A. Harris Jr.
Announcement issue of *Notices*: September 1998
Program issue of *Notices*: To be announced
Issue of *Abstracts*: Volume 19, Issue 4

Deadlines

For organizers: February 12, 1998
For consideration of contributed papers in Special Sessions: July 29, 1998
For abstracts: September 23, 1998

San Antonio, Texas

San Antonio Convention Center

January 13–16, 1999

Joint Mathematics Meetings, including the 105th Annual Meeting of the AMS, 82nd Meeting of the Mathematical Association of America (MAA), and annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM).
Associate secretary: Susan J. Friedlander

Announcement issue of *Notices*: October 1998
Program issue of *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 14, 1998
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

Gainesville, Florida

University of Florida

March 12–13, 1999

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 11, 1998
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Urbana, Illinois

University of Illinois, Urbana-Champaign

March 18–21, 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: June 18, 1998
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Special Sessions

Number Theory (Code: AMS SS B1), **Jeremy T. Teitelbaum** and **Yuri Tschinkel**, University of Illinois at Chicago.

Recent Progress in Elementary Geometry (Code: AMS SS A1), **Clark Kimberling**, University of Evansville, and **John E. Wetzel**, University of Illinois-Urbana.

Las Vegas, Nevada

University of Nevada-Las Vegas

April 10–11, 1999

Western Section
Associate secretary: William A. Harris Jr.
Announcement issue of *Notices*: To be announced
Program issue of *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: July 10, 1998
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Buffalo, New York

State University of New York at Buffalo

April 24–25, 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: July 24, 1998
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Invited Addresses

Michele M. Audin, University Louis Pasteur, Strasbourg, *Title to be announced.*

Jeff Smith, Purdue University, *Title to be announced.*

Alexander A. Voronov, Massachusetts Institute of Technology, *Title to be announced.*

Gregg J. Zuckerman, Yale University, *Title to be announced.*

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

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

Washington, District of Columbia

Sheraton Washington 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: William A. Harris Jr
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

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), and theannual 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

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

The Invited Addresses are one hour long. The talks marked with a "*" are invited survey lectures of the Special Sessions and they are fifty minutes long. All the other talks, including the contributed papers of the General Sessions, are twenty minutes long, plus five minutes for questions and discussion.

Program of the Sessions

WEDNESDAY, DECEMBER 3

Opening Ceremony

18:30–19:00 TEATRO A. CARRILLO

Invited Address

19:15–20:15 TEATRO A. CARRILLO

Topological degree and symmetries.

1✦ **Jorge Ize,** IIMAS-FENOMEC, UNAM.

THURSDAY, DECEMBER 4

Special Session on Algebraic Geometry and Commutative Algebra, I

9:00–12:00 ROOM NO. 1

9:00 *Title to be announced.*

*2** **Cilliberto.**

10:00 *A stratification of the moduli space of vector bundles.*

3 **Leticia Brambila-Paz,** UNIVERSIDAD AUTÓNOMA METROPOLITANA-IZTAPALAPA.

10:30 *Some conjectures on linear systems on rational surfaces.*

4 **Giuseppe Castellacci,** MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

11:00 *The tangent space to the moduli space of vector bundles on a curve and the singular locus of the theta divisor of the jacobian.* PRELIMINARY REPORT.

5 **Elham Izadi**✦**,** UNIVERSITY OF GEORGIA, AND **Lambertus van Geemen,** UNIVERSITÀ DI TORINO, ITALIA.

11:30 *Vector bundles on* $\mathbf{P}^n$.

6 **Mohan Kumar Neithalath,** WASHINGTON UNIVERSITY.

Special Session on Applied Nonlinear Analysis, I

9:00–12:00 ROOM NO. 2

9:00 *Geometric singular perturbation and Melnikov methods for PDEs: Part I.*

*7** **David W. McLaughlin**✦**, Jalal Shatah**✦**,** COURANT INSTITUTE, NEW YORK UNIVERSITY.

10:00 *Multi-peaked solutions to some semilinear elliptic equations.*

8 **Peter Bates.**

10:30 *Plume analysis in Boussinesq convection.*

9 **Stephen Childress**✦**,** NYU-COURANT INSTITUTE, **Albert Libchaber, and Jun Zhang,** ROCKEFELLER UNIVERSITY.

11:00 *Euler equations of an ideal incompressible fluid and action of volume preserving maps on function classes.* PRELIMINARY REPORT.

10 **Misha Vishik,** UNIVERSITY OF TEXAS AT AUSTIN.

11:30 *Phase diagram for a model liquid crystal confined by antisymmetric wall fields.*

11 **Jacqueline Quintana**✦**,** INSTITUTO DE QUÍMICA, UNAM, AND **Alberto Robledo,** INSTITUTO DE FÍSICA, UNAM.

Special Session on Complex and Functional Analysis, I

9:00–12:00 ROOM NO. 3

9:00 *Flat structures of complete minimal surfaces in* E^3. PRELIMINARY REPORT.

*12** **Michael Wolf**✦**,** RICE UNIVERSITY, AND **Matthias Weber,** UNIVERSITAT BONN.

10:00 *Parabolic splittings of Kleinian groups and embedding properties.*

13 **Leonid Potyagailo**✦**, and T. Delzant,** UNIVERSITÉ DE LILLE, FRANCE.

10:30 *Multipoles on* CP^1 *and geometry of degenerate Riemann surfaces.* PRELIMINARY REPORT.

14 **Robert B. Kusner,** UNIVERSITY OF MASSACHUSETTS AT AMHERST.

11:00 *Hausdorff dimension and limits of Kleinian groups.*

15 **Ed Taylor**✦**, and Richard Canary,** UNIVERSITY OF MICHIGAN.

11:30 *Quasiconformal images of circles and spheres.*
16 **Matti K. Vuorinen,** MATHEMATICS DEPARTMENT, UNIVERSITY OF HELSINSKI.

Special Session on Differential Geometry and Topology, I

9:00–12:00 ROOM NO. 4

9:00 *Einstein metrics and smooth topology.*
*17** **Claude R. LeBrun,** SUNY STONY BROOK.

10:00 *The Lusternik-Schnirelmann category and some related invariants in low dimensions.* PRELIMINARY REPORT.
18 **José Carlos Gómez-Larrañaga✦,** CIMAT, A.C. AND FLORIDA STATE UNIVERSITY, **Francisco J. González-Acuña,** INSTITUTO DE MATEMÁTICAS, UNAM, AND **W. Heil,** FLORIDA STATE UNIVERSITY.

10:30 *Seiberg-Witten Floer Theory.*
19 **Matilde Marcolli,** MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

11:00 *The disjoint curve property and genus 2 manifolds.*
20 **Abigail A. Thompson,** UNIVERSITY OF CALIFORNIA, DAVIS.

11:30 *Normal surfaces and practical algorithms to study 3-manifolds.* PRELIMINARY REPORT.
21 **David Letscher✦,** UNIVERSITY OF CALIFORNIA, SAN DIEGO, AND **Hyam Rubinstein,** UNIVERSITY OF MELBOURNE.

Special Session on General Topology, I

9:00–12:00 ROOM NO. 5

9:00 *Fixed and periodic points in plane and tree-like continua.*
*22** **Piotr Minc,** AUBURN UNIVERSITY.

10:00 *The class of fans is not C-determined.*
23 **Alejandro Illanes,** UNIVERSIDAD NACIONAL AUTÓNOMA DE MÉXICO.

10:30 *Title to be announced.*
24 **Heath.**

11:00 *Title to be announced.*
25 **McCoy.**

11:30 *On p-bounded subsets.*
26 **Ángel Tamariz-Mascarúa✦,** FACULTAD DE CIENCIAS, UNAM, AND **Manuel Sanchis,** UNIVERSITAT JAUME I, CASTELLÓ, ESPAÑA.

Special Session on Graphs and Combinatorial Geometry, I

9:00–12:00 ROOM NO. 6

9:00 *Separoids.* PRELIMINARY REPORT.
27 **Jorge L. Arocha✦, Javier Bracho, Luis Montejano,** IMATE UNAM, AND **Vladimir Schepin.**

9:30 *On the existence of a point subset with a specified number of interior points.* PRELIMINARY REPORT.
28 **David Avis✦,** MCGILL UNIVERSITY, AND **Kiyoshi Hosono, Masatsugu Urabe,** TOKAI UNIVERSITY.

10:00 *The convex hull of integer points in a large ball.* PRELIMINARY REPORT.
29 **Imre Bárány,** MATHEMATICAL INSTITUTE OF THE HUNGARIAN ACADEMY OF SCIENCES.

10:30 *The functional md in combinatorial geometry.*
30 **Vladimir Boltyanski,** CIMAT.

11:00 *Structural results for sets with many unit distances.* PRELIMINARY REPORT.
31 **Peter Brass,** FU BERLIN.

11:30 *Intercalate matrices I: A characterization of Hurwitz-Radon matrices.*
32 **Gilberto Calvillo✦,** BANCO DE MÉXICO, **Isidoro Gitler, and José Martínez,** DEPARTAMENTO DE MATEMÁTICAS, CINVESTAV, IPN.

Special Session on Mathematical Physics, I

9:00–12:00 ROOM NO. 7

9:00 *Nondegenerate $\mathbb{Z}_2$-graded Poisson structures arising from the canonical 1-form of the cotangent bundle of a split supermanifold.* PRELIMINARY REPORT,
*33** **J. Muñoz-Masqué,** IFA-CSIC, MADRID, SPAIN, AND **O. A. Sánchez-Valenzuela✦,** CIMAT.

10:00 *Differential calculus in braided abelian categories.*
34 **Bernhard Drabant✦,** DAMTP, UNIVERSITY OF CAMBRIDGE, AND **Yuri N. Bespalov,** BOGOLYUBOV INSTITUTE FOR THEORETICAL PHYSICS.

10:30 *Quantum and braided spin groups and the physical content of q-deformed Minkowski spaces.*
35 **Marcos Rosenbaum,** INSTITUTO DE CIENCIAS NUCLEARES, UNAM.

11:00 *Fourier–Gauss transforms of the Al-Salam–Chihara polynomials.*
36 **Mesuma K. Atakishiyeva,** FACULTAD DE CIENCIAS, UAEM, AND **Natig M. Atakishiyev✦,** INSTITUTO DE MATEMÁTICAS, UNAM.

11:30 *Methods of quasigroups in mathematical physics.*
37 **Lev V. Sabinin,** MICHOACAN UNIVERSITY, ECFM, MORELIA, MÉXICO.

Special Session on Nonlinear Models in Biology and Celestial Mechanics, I

9:00–12:00 ROOM NO. 8

9:00 *Tractable Newtonian N-body problems.*
*38** **Donald G. Saari,** NORTHWESTERN UNIVERSITY.

10:00 *Rotating billiard systems as toy models for celestial mechanics.*
39 **Luis Benet,** INSTITUTO DE FÍSICA UNAM.

10:30 *Chaos in the Gyldén Problem.*
40 **Florin Diacu.**

11:00 *Dynamics of the collinear three-body problem.*
41 **Sam Kaplan.**

11:30 *Repulsive coulombian problems and geodesic flows on surfaces with negative curvature.*
42 **Ernesto Lacomba✦ and J. G. Reyes,** UAM-I.

Special Session on Numerical Analysis, I

9:00–12:00 ROOM NO. 9

9:00 *Mixed finite elements and finite volume methods for elliptic problems with piecewise constant coefficients.*
*43** **Jean-Marie Thomas,** UNIVERSITÉ DE PAU, FRANCE.

10:00 *Numerical methods for air quality models.*
44 **Aron D. Jazcilevich✦, Luis Gerardo S. Ruiz, and Vicente Fuentes-Gea,** CENTRO DE CIENCIAS DE LA ATMÓSFERA, UNAM.

10:30 *New nodal finite element schemes for the discrete ordinates transport equation.*
45 **Jean-Pierre Hennart✦,** IIMAS-UNAM, AND **Edmundo del Valle,** ESFM-IPN.

11:00 *Transverse integration on composite nodal finite elements for hexagons.*
46 **Jean-Pierre Hennart,** IIMAS-UNAM, **Edmundo del Valle✦,** ESFM-IPN, AND **Ernest H. Mund,** UNIVERSITÉ LIBRE DE BRUXELLES, BELGIUM.

11:30 *Spectral approximation in the numerical stability study of viscous flows on a sphere.*
47 **Yuri N. Skiba,** CENTRO DE CIENCIAS DE LA ATMÓSFERA, UNAM.

Special Session on Representation Theory of Algebras and Groups, I

9:00–12:00 ROOM NO. 10

9:00 *The components $\mathbf{Z}A_\infty^\infty$ in the Auslander-Reiten quiver of $\mathbf{Z}_{p^n}C_p$.* PRELIMINARY REPORT.
48 **María A. Aviñó,** FACULTAD DE CIENCIAS, UNAM.

9:30 *Derived canonical algebras as one-point extensions.* PRELIMINARY REPORT.
49 **Michael S. Barot,** UNAM.

10:00 *Infinite radical for tame algebras.* PRELIMINARY REPORT.
50 **Raymundo Bautista✦, and Rita Zuazua,** INSTITUTO DE MATEMÁTICAS, UNAM.

10:30 *Homological algebra in triangulated categories.* PRELIMINARY REPORT.
51 **Apostolos Beligiannis,** INSTITUTO DE MATEMÁTICAS, UNAM.

11:00 *Weakly triangular Artin algebra.* PRELIMINARY REPORT.
52 **Flávio Ulhoa Coelho✦,** UNIVERSIDADE DE SÃO PAULO, BRASIL, AND **María Inés Platzeck,** UNIVERSIDAD NACIONAL DEL SUR.

11:30 *Derived-tame algebras.*
53 **José A. de la Peña,** UNAM.

Special Session on Rings and Category Theory, I

9:00–12:00 ROOM NO. 11

9:00 *On classification of certain group algebras.*
54 **Sudarshan Sehgal.**

9:30 *Generalized quotient finite dimensional modules.* PRELIMINARY REPORT.
55 **John Dauns,** TULANE UNIVERSITY.

10:00 *Biuniform modules.*
*56** **Alberto Facchini,** UNIVERSITÀ DE UDINE, ITALIA.

11:00 *Decisive dimension in categories of modules.*
57 **Jaime Castro✦,** ITESM, AND **José Ríos,** IMATE-UNAM.

11:30 *Coverings of modules.* PRELIMINARY REPORT.
58 **Mark L. Teply,** UNIVERSITY OF WISCONSIN-MILWAUKEE.

18:00 *Estimation of densities and applications to partial stochastic.*
102 **María Emilia Caballero, Begoña Fernández✦,** UNIVERSIDAD NACIONAL AUTÓNOMA DE MÉXICO, AND **David Nualart,** UNIVERSITAT DE BARCELONA.

18:30 *Existence of solutions to the master equation with time dependent coefficients.* PRELIMINARY REPORT.
103 **Alexander Chebotarev,** MOSCOW STATE UNIVERSITY, **Julio C. García✦, and Roberto Quezada,** UNIVERSIDAD AUTONÓMA METROPOLITANA-IZTAPALAPA.

Special Session on Nonlinear Models in Biology and Celestial Mechanics, II

16:00–19:00 ROOM NO. 8

16:00 *Mathematical models of HIV progression and therapy.*
104 **Glenn Webb,** VANDERBILT UNIVERSITY.

16:30 *Ring dynamics and forced integrate and fire neurons models.*
105 **Humberto Carrillo✦,** UNIVERSIDAD NACIONAL AUTONÓMA DE MÉXICO, AND **Fernando Ongay,** UNIVERSIDAD AUTONÓMA DEL ESTADO DE MÉXICO.

17:00 *Electrical coupling between dissimilar cells in a rhythmic network of neurons.*
106 **Cristina Soto-Treviño,** BOSTON UNIVERSITY.

17:30 *Efficiency of self-control strategies on the spread of the insect vector of Chagas disease.*
107 **Carlos Hernández-Suárez,** UNIVERSIDAD DE COLIMA.

18:00 *Celestial population dynamics.*
108 **Gerardo Hernández,** CINVESTAV-IPN.

Special Session on Numerical Analysis, II

16:00–19:00 ROOM NO. 9

16:00 *Isoparametric high-order finite element approximation of incompressible viscous flow.*
*109** **Wenlong Xu, Ralph W. Metcalfe, and L. Ridgway Scott✦,** UNIVERSITY OF HOUSTON.

17:00 *Title to be announced.*
*110** **Roland Glowinsky.**

Special Session on Representation Theory of Algebras and Groups, II

16:00–19:00 ROOM NO. 10

16:00 *Specializations of the extended Kronecker algebra.* PRELIMINARY REPORT.
111 **Andrew P. Dean,** BISHOP'S UNIVERSITY.

16:30 *Examples of tame repetitive algebras of non-polynomial growth.* PRELIMINARY REPORT.
112 **Peter Draexler,** UNIVERSITY OF BIELEFELD.

17:00 *On reflexive representations of local commutative algebras.* PRELIMINARY REPORT.
113 **Kent R. Fuller,** UNIVERSITY OF IOWA.

17:30 *Homomorphisms between representations of clans.* PRELIMINARY REPORT.
114 **Christof Geiss,** INSTITUTO DE MATEMÁTICAS, UNAM.

18:00 *Szekeres theorem, a new proof.* PRELIMINARY REPORT.
115 **María Alicia Aviñó, Raymundo Bautista, and Mary Glazman✦,** UNAM.

18:30 *Representations of $\mathbf{GL}_n$ and Schur Algebras: Some homological aspects.*
116 **Upendra Kulkarni,** BRANDEIS UNIVERSITY.

Special Session on Rings and Category Theory, II

16:00–19:00 ROOM NO. 11

16:00 *On the existence of certain ideals in semiprime rings.* PRELIMINARY REPORT.
117 **Efraim P. Armendariz,** THE UNIVERSITY OF TEXAS AT AUSTIN.

16:30 *Subgenerators in module categories.*
118 **Robert Wisbauer,** UNIVERSITY OF DUESSELDORF.

17:00 *Some relations between spectral torsion theory and the Kaplansky's theory of types.*
119 **María José Arroyo✦,** UAM-I, AND **José Ríos Montes,** IMATE-UNAM.

17:30 *Finiteness properties for co-Frobenius Hopf Algebras.*
120 **Constantin Nastasescu.**

18:00 *Dimensions of multi-filtered algebras.*
121 **José Gómez Torrecillas,** UNIVERSIDAD DE GRANADA, ESPAÑA.

18:30 *Hereditary pretorsion theories.* PRELIMINARY REPORT.
122 **Francisco F. Raggi,** INSTITUTO DE MATEMÁTICAS. UNAM.

18:00 *Visual averages and computing the Douady-Earle Extension.*
79 **William Abikoff,** UNIVERSITY OF CONNECTICUT AT STORRS.

18:30 *Boundary values versus dilatations of planar harmonic mappings.*
80 **Daoud Bshouty✦,** TECHNION IIT, ISRAEL, AND **Walter Hengartner,** UNIVERSITÉ LAVAL, ST. FOY QUEBEC, CANADA.

Special Session on Differential Geometry and Topology, II

16:00–19:00 ROOM NO. 4

16:00 *The topological approach to enzymology.*
81 **De Witt Sumners,** FLORIDA STATE UNIVERSITY.

16:30 *On moduli spaces of mechanical linkages.* PRELIMINARY REPORT.
82 **Michael Kapovich✦,** UNIVERSITY OF UTAH, AND **John J. Millson,** UNIVERSITY OF MARYLAND.

17:00 *Essential meridional surfaces for tunnel number one knots.* PRELIMINARY REPORT.
83 **Mario Eudave-Muñoz,** INSTITUTO DE MATEMÁTICAS, UNAM.

17:30 *Curvature obstructions for G-structures.*
84 **Gil Bor,** CIMAT.

18:00 *Genera and boundary slopes of incompressible surfaces.* PRELIMINARY REPORT.
85 **Marc Culler, and Peter B. Shalen✦,** UNIVERSITY OF ILLINOIS AT CHICAGO.

18:30 *Quaternionic geometry and Einstein manifolds.*
86 **Charles P. Boyer,** UNIVERSITY OF NEW MEXICO.

Special Session on General Topology, II

16:00–19:00 ROOM NO. 5

16:00 *Continuous images of compact linearly ordered spaces.*
87 **Mary E. Rudin,** UNIVERSITY OF WISCONSIN, MADISON.

16:30 *Title to be announced.*
88 **Zoltan T. Balogh,** MIAMI UNIVERSITY.

17:00 *Aposyndetic properties of symmetric products.*
89 **Sergio Macías,** IMATE-UNAM.

17:30 *Some interesting subclasses of the class of first countable compact spaces.* PRELIMINARY REPORT.
90 **Vladimir V. Tkachuk,** UNIVERSIDAD AUTÓNOMA METROPOLITANA-IZTAPALAPA.

18:00 *Expansive homeomorphisms and indecomposable continua.* PRELIMINARY REPORT.
91 **Wayne Lewis,** TEXAS TECH UNIVERSITY.

18:30 *Fixed-point problems for arc-continua.*
92 **Charles L. Hagopian,** CALIFORNIA STATE UNIVERSITY, SACRAMENTO.

Special Session on Graphs and Combinatorial Geometry, II

16:00–19:00 ROOM NO. 6

16:00 *Intercalate matrices II: an infinite family of minimal obstructions to signability.*
93 **Gilberto Calvillo,** BANCO DE MÉXICO, **Isidoro Gitler✦, and José Martínez,** DEPARTAMENTO DE MATEMÁTICAS, CINVESTAV.

16:30 *Determining multiple Hamiltonian covers: An algebraic approach.* PRELIMINARY REPORT.
94 **Hans L. Fetter,** UNIVERSIDAD AUTÓNOMA METROPOLITANA-IZTAPALAPA.

17:00 *Erdös-Hajnal type problems.*
95 **András Hajnal,** RUTGERS UNIVERSITY.

17:30 *Intersection graphs in the plane: A survey.* PRELIMINARY REPORT.
96 **Jan Kratochvíl,** CHARLES UNIVERSITY, PRAGUE.

18:00 *Packing convex cones in 3-space.*
97 **Andras Bezdek,** MATHEMATICAL INSTITUTE OF THE HUNGARIAN ACADEMY OF SCIENCES AND AUBURN UNIVERSITY, AND **Wlodzimierz Kuperberg✦,** AUBURN UNIVERSITY.

18:30 *On existence problems for chiral polytopes.*
98 **Asia I. Weiss,** YORK UNIVERSITY.

Special Session on Mathematical Physics, II

16:00–19:00 ROOM NO. 7

16:00 *Stability of matter in magnetic fields.*
*99** **Elliott Lieb,** PRINCETON UNIVERSITY, **Michael Loss✦,** GEORGIA INSTITUTE OF TECHNOLOGY, AND **Jan-Philip Solovej,** UNIVERSITY OF AARHUS, DENMARK.

17:00 *Stability of fronts for the Lebowitz-Orlandi-Pressuti equation.*
100 **Eric Anders Carlen,** GEORGIA INSTITUTE OF TECHNOLOGY.

17:30 *Stochastic evolution equations with random generators.*
101 **Jorge A. León,** CINVESTAV-IPN.

Special Session on Stochastic Systems, I

9:00–12:00 ROOM NO. 12

9:00 *Linear programming approximations for stochastic control problems.*
*59** **Onésimo Hernández-Lerma,** DEPARTAMENTO DE MATEMÁTICAS, CINVESTAV-IPN.

10:00 *Embedding in Markov Decision Theory.*
60 **Henk Tijms,** VRIJE UNIVERSITY, THE NETHERLANDS.

10:30 *Adaptive control in stable Markov decision chains endowed with the average reward criterion.*
61 **Rolando Cavazos-Cadena,** UNIVERSIDAD AUTÓNOMA AGRARIA ANTONIO NARRO.

11:00 *The stochastic magneto-hydrodynamic system.* PRELIMINARY REPORT.
62 **P. Sundar✦,** LOUISIANA STATE UNIVERSITY, AND **S. S. Sritharan,** NRAD.

11:30 *Piecewise smooth viscosity solutions of the HJB equation.*
63 **J. R. Dorroh, Guillermo S. Ferreyra✦, and Jesús A. Pascal,** LOUISIANA STATE UNIVERSITY.

Invited Address

12:15–13:15 AUDITORIUM

Wavelet analysis and scaleable information processing.
64✦ **Raymond O. Wells,** RICE UNIVERSITY.

Special Session on Algebraic Geometry and Commutative Algebra, II

16:00–19:00 ROOM NO. 1

16:00 *Degree bounds in monomial subrings.*
65 **Winfried Bruns,** UNIVERSITÄT OSNABRÜCK, **Wolmer V. Vasconcelos,** RUTGERS UNIVERSITY, AND **Rafael H. Villarreal✦,** CINVESTAV-IPN.

16:30 *The complexity of Frobenius powers of ideals.*
66 **Mordechai Katzman,** UNIVERSITY OF MINNESOTA.

17:00 *Commutative algebra methods in coding theory.*
67 **Carlos Rentería-Márquez,** ESCUELA SUPERIOR DE FÍSICA Y MATEMÁTICAS, IPN, AND **Horacio Tapia-Recillas✦,** UNIVERSIDAD AUTÓNOMA METROPOLITANA-IZTAPALAPA.

17:30 *Local-global for similarity of matrices.*
68 **Frank DeMeyer✦, Rick Miranda, and Kim Schneider,** COLORADO STATE UNIVERSITY.

18:00 *Division algebras over p-adic curves.*
69 **David J. Saltman,** UNIVERSITY OF TEXAS AT AUSTIN.

Special Session on Applied Nonlinear Analysis, II

16:00–19:00 ROOM NO. 2

16:00 *The complex Ginzburg-Landau equation: A damped-driven pertubation of a Hamiltonian system.*
*70** **David Levermore,** UNIVERSITY OF ARIZONA.

17:00 *Null-insensitizing controls of the norm of the solution of the semilinear heat equation.* PRELIMINARY REPORT.
71 **Luz de Teresa✦,** INSTITUTO DE MATEMÁTICAS, UNAM, AND **Enrique Zuazua,** DEPARTAMENTO DE MATEMÁTICA APLICADA, UCM.

17:30 *On determining the relevant averaging equations for optical dispersion management systems.*
72 **A. Aceves.**

18:00 *An Ill-posed Cauchy Problem for the heat equation.* PRELIMINARY REPORT.
73 **James R. Dorroh✦,** LOUISIANA STATE UNIVERSITY, AND **Xe Ping Ru.**

18:30 *Nonlocal problems from the study of phase transformations.*
74 **Paul C. Fife.**

Special Session on Complex and Functional Analysis, II

16:00–19:00 ROOM NO. 3

16:00 *On the singular Martinelli-Bochner operator.* PRELIMINARY REPORT.
75 **Reynaldo Rocha✦,** ESFM-IPN, AND **Michael V. Shapiro,** ESFM-IPN, **Frank Sommen,** N.F.W.O. BELGIUM.

16:30 *Almost-Clifford structures on manifolds.*
76 **Enrique Ramírez de Arellano✦,** CINVESTAV, AND **Wieslaw Królikowski.**

17:00 *Toeplitz operators on the Heisenberg group with n-valued symbols.*
77 **Nikolai Vasilevski,** DEPARTAMENTO DE MATEMÁTICAS, CINVESTAV.

17:30 *Tetrahedral groups in complex hyperbolic space.*
78 **Alberto M. Castro,** MATHEMATICS DEPARTMENT, MOUNT HOLYOKE COLLEGE.

General Session, I

16:00–19:00 ROOM NO. 12

16:00 *Maximal and minimal primitive fixing system for convex bodies.*
123 **Efrén Morales,** CENTRO DE INVESTIGACIÓN EN MATEMÁTICAS A.C. AND IMATE, UNAM.

16:30 *Perfect dominating sets in rectangular lattices.*
124 **Italo J. Dejter✦,** UNIVERSITY OF PUERTO RICO, AND **Jorge Urrutia,** UNIVERSITY OF OTTAWA.

17:00 *On the number of cycle covers of the rectangular grid graph.*
125 **H. L. Abbott, and J. W. Moon✦,** UNIVERSITY OF ALBERTA, EDMONTON.

17:30 *On the number of equilateral triangles in Euclidean spaces I.*
126 **Bernardo M. Abrego✦, and Silvia Fernández-Merchant,** RUTGERS UNIVERSITY.

18:00 *On the number of equilateral triangles in Euclidean spaces II.*
127 **Bernardo M. Abrego, and Silvia Fernández-Merchant✦,** RUTGERS UNIVERSITY.

18:30 *Vorticity, quaternions and Clifford Algebras.* PRELIMINARY REPORT.
128 **Leonardo Traversoni,** UNIVERSIDAD AUTÓNOMA METROPOLITANA-IZTAPALAPA.

Invited Address

19:15–20:15 AUDITORIUM

Title to be announced.
129✦ **Javier Bracho,** INSTITUTO DE MATEMÁTICAS, UNAM.

FRIDAY, DECEMBER 5

Special Session on Algebraic Geometry and Commutative Algebra, III

9:00–12:00 ROOM NO. 1

9:00 *Heissenberg-invariant Abelian and Kummer surfaces.* PRELIMINARY REPORT.
130 **Klaus Hulek, Isidro Nieto✦,** CIMAT, A.C., AND **Gregory K. Sankaran.**

9:30 $\mathbf{S}_4$*-Actions on Jacobians.* PRELIMINARY REPORT.
131 **Sevín Recillas✦,** INSTITUTO DE MATEMÁTICAS, UNAM, UNIDAD MORELIA, AND **Rubí Rodríguez,** PONTIFICIA UNIVERSIDAD CATÓLICA DE CHILE.

10:00 *Numerically effective divisors on blow-ups and fat points on* $\mathbf{P}^2$. PRELIMINARY REPORT.
132 **Stephanie Fitchett,** DUKE UNIVERSITY.

10:30 *An algorithm for fat points on* P^2.
133 **Brian Harbourne,** UNIVERSITY OF NEBRASKA-LINCOLN.

11:00 *On the variety of rank 4 quadrics containinig a projective curve.* PRELIMINARY REPORT.
134 **Sevín Recillas,** INSTITUTO DE MATEMÁTICAS, UNAM, **Alexis García-Zamora✦,** INSTITUTO DE MATEMÁTICAS, UNAM.

Special Session on Applied Nonlinear Analysis, III

9:00–12:00 ROOM NO. 2

9:00 *Geometric singular perturbation and Melnikov methods for PDEs: Part II.*
*135** **David W. McLaughlin✦ and Jalal Shatah✦,** COURANT INSTITUTE, NEW YORK UNIVERSITY.

10:00 *Phase transitions under confinement.*
*136** **Alberto Robledo,** INSTITUTO DE FÍSICA, UNAM.

11:00 *Wave propagation in liquid crystals.*
137 **Clara Garza-Hume✦, Catherine García-Reimbert, Antonmaría Minzoni, A. Reyes, and R. Rodríguez,** IIMAS-UNAM.

11:30 *Stable multi-pulse solutions along a phase-sensitive.*
138 **James C. Alexander✦, Manoussos G. Grillakis,** UNIVERSITY OF MARYLAND, **Christopher Jones,** BROWN UNIVERSITY, AND **Bjoern Sandstede,** OHIO STATE UNIVERSITY.

Special Session on Complex and Functional Analysis, III

9:00–12:00 ROOM NO. 3

9:00 *The Wold decomposition for tensor algebras.* PRELIMINARY REPORT.
139 **Paul S. Muhly✦,** UNIVERSITY OF IOWA, AND **Baruch Solel.**

9:30 *On the dual space of a topological vector space with basis.* PRELIMINARY REPORT.
140 **Angel Carrillo Hoyo, and Hugo Arizmendi Peimbert✦,** INSTITUTO DE MATEMÁTICAS, UNIVERSIDAD NACIONAL AUTÓNOMA DE MÉXICO.

10:00 *On spectral radius and power series in m-convex Algebras.* PRELIMINARY REPORT.

141 **María de Lourdes Palacios Fabila✦,** UNIVERSIDAD AUTÓNOMA METROPOLITANA- IZTAPALAPA, AND **Hugo Arizmendi Peimbert,** IMATE UNAM.

10:30 *The true measure of a matrix.* PRELIMINARY REPORT.

142 **Chandler Davis,** UNIVERSITY OF TORONTO.

11:00 *Ultradistributions as boundary values of analytic functions and.*

143 **Ioana Cioranescu,** UNIVERSITY OF PUERTO RICO AT RIO PIEDRAS.

11:30 *The spreading sequences in JH.* PRELIMINARY REPORT.

144 **Helga N. Fetter✦, and Berta Gamboa de Buen,** CENTRO DE INVESTIGACIÓN EN MATEMÁTICAS.

Special Session on Differential Geometry and Topology, III

9:00–12:00 ROOM NO. 4

9:00 *Title to be announced.*

*145** **Alberto Verjovsky,** UNIVERSITÉ DE LILLE.

10:00 *Hyperideal hyperbolic polyhedra.* PRELIMINARY REPORT.

146 **Xiliang Bao and Francis Bonahon✦,** UNIVERSITY OF SOUTHERN CALIFORNIA.

10:30 *Engagement condition and action of semisimple Lie groups.*

147 **Raúl Quiroga✦,** ESFM IPN, AND **Alberto Candel.**

11:00 *Two-bridge knots with property Q.* PRELIMINARY REPORT.

148 **Arturo Ramírez✦,** CIMAT, A.C., AND **Francisco J. Gonzalez-Acuña,** INSTITUTO DE MATEMÁTICAS, UNAM AND CIMAT A.C..

11:30 *Knots with few ideal tetrahedra.*

149 **John C. Dean✦,** UNIVERSITY OF MICHIGAN, **Patrick Callahan,** UNIVERSITY OF TEXAS, AND **Jeffrey Weeks.**

Special Session on General Topology, III

9:00–12:00 ROOM NO. 5

9:00 *Some recent results concerning submaximal spaces.*

*150** **Richard G. Wilson,** UAM-IZTAPALAPA.

10:00 *Dendrites with closed set of end ponts.* PRELIMINARY REPORT.

151 **Wlodzimierz J. Charatonik✦,** FACULTAD DE CIENCIAS, UNAM, **Daniel Arévalo Grajeda, Patricia Pellicer Covarrubias, and Likin C. Simón Romero,** INSTITUTO DE MATEMÁTICAS, UNAM.

10:30 *A return to homogeneous continua.*

152 **James T. Rogers,** TULANE UNIVERSITY.

11:00 *Cofinally Cech complete spaces.*

153 **Adalberto García-Maynez,** IMATE-UNAM, AND **Salvador Ronaguera.**

11:30 *Dugundji extenders on ordered spaces.*

154 **Gary Gruenhage✦,** AUBURN UNIVERSITY, **Yasunao Hattori,** SHIMANE UNIVERSITY, AND **Haruto Ohta,** SHIZUOKA UNIVERSITY.

Special Session on Graphs and Combinatorial Geometry, III

9:00–12:00 ROOM NO. 6

9:00 *Clique divergent graphs with unbounded sequence of diameters.*

155 **Francisco Larrión✦, and Víctor Neumann-Lara,** INSTITUTO DE MATEMÁTICAS, UNAM.

9:30 *Projections of cyclic polytopes and their fiber polytopes.* PRELIMINARY REPORT.

156 **Jesús A. De Loera,** UNIVERSITY OF MINNESOTA.

10:00 *Isoperimetric inequalities.*

157 **László Lovász,** YALE UNIVERSITY.

10:30 *On packings of circles of arbitrary radii.*

158 **Jiri Matousek✦, and Pavel Valtr,** CHARLES UNIVERSITY, PRAGUE.

11:00 *Geometric transversal theory and topology.*

159 **Luis Montejano Peimbert,** IMATE-UNAM.

11:30 *Dichromatic number and Zykov sums of digraphs.* PRELIMINARY REPORT.

160 **Víctor Neumann-Lara,** INSTITUTO DE MATEMÁTICAS, UNAM.

Special Session on Mathematical Physics, III

9:00–12:00 ROOM NO. 7

9:00 *Solution of systems of partial differential equations by means of potentials.*

161 **Gerardo F. Torres del Castillo,** INSTITUTO DE CIENCIAS, UNIVERSIDAD AUTÓNOMA DE PUEBLA.

9:30 *A geometric approach to the asymptotic of systems of evolution equations.*

162 **Juan H. Arredondo✦, and Peter Seibert,** UAM-IZTAPALAPA.

9:30 *On some classes of R-modules and congruences in R-tors.* PRELIMINARY REPORT.
185 **Carlos Signoret✦,** DEPARTAMENTO DE MATEMÁTICAS UAM-I, **Francisco Raggi,** INSTITUTO DE MATEMÁTICAS UNAM, AND **Hugo Rincón,** FACULTAD DE CIENCIAS UNAM.

10:00 *Linearization revisited.*
*186** **F. William Lawvere.**

11:00 *The Moeglin-Rentschler-Vonessen transitivity theorem.*
187 **Kenneth R. Goodearl✦,** UNIVERSITY OF CALIFORNIA, AND **Edward S. Letzter,** TEXAS A&M UNIVERSITY.

11:30 *Distributivity, from posets to categories.*
188 **Francisco Marmolejo,** DALHOUSIE UNIVERSITY.

Special Session on Stochastic Systems, II

9:00–12:00 ROOM NO. 12

9:00 *Markov chain approximations for deterministic control problems.*
*189** **Paul Dupuis,** BROWN UNIVERSITY.

10:00 *Computing mean exit times of diffusion processes using linear programming.*
190 **Kurt Helmes,** HUMBOLDT UNIVERSITY, BERLIN.

10:30 *Markov control processes with finite state space and compact action sets: The total-reward criterion.* PRELIMINARY REPORT.
191 **Raúl Montes-de-Oca✦,** UNIVERSIDAD AUTÓNOMA METROPOLITANA-IZTAPALAPA, AND **Rolando Cavazos-Cadena,** UNIVERSIDAD AUTÓNOMA AGRARIA ANTONIO NARRO.

11:00 *Sample path average optimality of Markov control processes with strictly unbounded cost.*
192 **Oscar Vega-Amaya,** UNIVERSIDAD DE SONORA.

11:30 *Risk sensitive controlled Markov processes.*
193 **Daniel Hernández,** DEPARTAMENTO DE MATEMÁTICAS, CINVESTAV.

General Session, II

9:00–12:00 ROOM NO. 13

9:00 *Cardinality of p-adic Fréchet spaces.*
194 **Jerzy Kakol✦,** UNIVERSITY OF NORTH DAKOTA, GRAND FORKS, AND **Nicole DeGrande-DeKimpe,** BRUSSELS,BELGIUM.

9:30 *On the p-adic weak basis theorem.* PRELIMINARY REPORT.
195 **Thomas E. Gilsdorf✦ and Jerzy Kakol,** UNIVERSITY OF NORTH DAKOTA, GRAND FORKS.

10:00 *Substitution lemma for G-spaces of 1-dimensional groups.*
196 **Juan Antonio Pérez,** UNIVERSIDAD AUTÓNOMA DE ZACATECAS.

10:30 *Finding optimal convex regions.*
197 **Alan P. Sprague,** UNIVERSITY OF ALABAMA AT BIRMINGHAM.

11:00 *The $*$-scalar curvature relationship on a quasi-Kähler submersion.* PRELIMINARY REPORT.
198 **Bill Watson,** ST. JOHN'S COLLEGE, JAMAICA NY.

Invited Address

12:15–13:15 AUDITORIUM

Title to be announced.
199✦ **Alberto Verjovsky,** UNIVERSITÉ DE LILLE AND IMATE, UNAM.

Special Session on Algebraic Geometry and Commutative Algebra, IV

16:00–19:00 ROOM NO. 1

16:00 *Chow motives of certain 3-folds and fiber spaces.*
200 **Stefan Müller-Stach,** UNIVERSITÄT GHS ESSEN, AND **Pedro Luis Del Angel-Rodríguez✦,** UNIVERSIDAD AUTÓNOMA METROPOLITANA-IZTAPALAPA.

16:30 *On the (almost) Cohen–Macaulayness of the associated graded ring of certain primary ideals.*
201 **Alberto Corso✦,** DEPARTMENT OF MATHEMATICS, PURDUE UNIVERSITY, **Claudia Polini,** DEPARTMENT OF MATHEMATICS, MICHIGAN STATE UNIVERSITY, AND **María Vaz Pinto,** CENTRO DE ALGEBRA DA UNIVERSIDADE DE LISBOA.

17:00 *Invariants from canonical bases.* PRELIMINARY REPORT.
202 **Joseph P. Brennan,** NORTH DAKOTA STATE UNIVERSITY.

17:30 *Chow quotients and projective bundle formulas for Euler-Chow series.*
203 **E. Javier Elizondo✦,** INSTITUTO DE MATEMÁTICAS, UNAM, AND **Paulo Lima-Filho,** TEXAS A&M UNIVERSITY.

18:00 *A simply connected surface with zero geometric genus and ample canonical class.*
204 **Caryn Werner✦, and Igor Dolgachev,** UNIVERSITY OF MICHIGAN.

Special Session on Applied Nonlinear Analysis, IV

16:00–19:00 ROOM NO. 2

16:00 *MHD instability in a complicated convective flow.*
205 **Antonmaría Minzoni✦, and Ignacio Bosch,** IIMAS-UNAM.

10:00 *Lifschitz tail in a magnetic field: The nonclassical regime.*
163 **Laszlo Erdos,** COURANT INSTITUTE, NEW YORK UNIVERSITY.

10:30 *Perfect spectra.* PRELIMINARY REPORT.
164 **Rafael René del Río,** INSTITUTO DE INVESTIGACIONES EN MATEMÁTICAS APLICADAS Y SISTEMAS.

11:00 *The spectrum of quadratic boson's operators.*
165 **Valeri Kucherenko,** CINVESTAV-IPN.

11:30 *Spherical means and the perturbed Dirac equation.* PRELIMINARY REPORT.
166 **Jesús Chargoy,** UNIVERSIDAD AUTÓNOMA METROPOLITANA-IZTAPALAPA.

Special Session on Nonlinear Models in Biology and Celestial Mechanics, III

9:00–12:00 ROOM NO. 8

9:00 *Continuation of KAM tori.*
167 **Kenneth R. Meyer,** UNIVERSITY OF CINCINNATI.

9:30 *Hamiltonian polynomial systems and cubic surfaces.*
168 **Manuel Falconi✦,** FACULTAD DE CIENCIAS, UNAM, AND **Ernesto Lacomba,** UAM-I.

10:00 *Recent results in the study of nonlinear resonances in parametrically excited pendula.*
169 **Steven P. Weibel✦,** NORTHEASTERN UNIVERSITY, AND **T. J. Kaper,** BOSTON UNIVERSITY.

10:30 *The braid group and periodic orbits for the planar N-body problem.*
170 **Richard Montgomery,** UNIVERSITY OF CALIFORNIA, SANTA CRUZ.

11:00 *Arnold diffusion near hyperbolic-elliptic periodic orbits.*
171 **Antonio García,** NORTHWESTERN UNIVERSITY.

11:30 *The isosceles restricted three-body problem.*
172 **Martha Alvarez✦, and Jaume Llibre,** UNIVERSITAT AUTÒNOMA DE BARCELONA.

Special Session on Numerical Analysis, III

9:00–12:00 ROOM NO. 9

9:00 *Trefftz-Herrera formulation of domain decomposition.*
*173** **Ismael Herrera,** IIMAS-UNAM.

10:00 *Application of a splitting method to Bingham fluid flow simulation.* PRELIMINARY REPORT.
174 **Francisco Javier Sánchez,** UNIVERSIDAD AUTÓNOMA METROPOLITANA-IZTAPALAPA.

10:30 *Numerical simulation of viscous flows in complex geometries.*
175 **Lorenzo H. Juárez✦,** UAM-I, **Ridgway Scott, Ralph Metcalfe, and Babak Bagheri,** UNIVERSITY OF HOUSTON.

11:00 *A logic approach to semicontinous variables formulation in.*
176 **María Auxilio Osorio Lama✦,** FACULTAD DE CIENCIAS DE LA COMPUTACIÓN, BUAP, AND **John N. Hooker,** GRADUATE SCHOOL OF INDUSTRIAL ADMINISTRATION, CARNEGIE MELLON.

11:30 *Nonnegative rank of nonnegative matrices.*
177 **Francisco J. Solís,** CIMAT.

Special Session on Representation Theory of Algebras and Groups, III

9:00–12:00 ROOM NO. 10

9:00 *Minimal projective resolutions.* PRELIMINARY REPORT.
178 **Edward L. Green✦,** VIRGINIA TECH, **Oyvind Solberg,** NTNU, AND **Dan Zacharia,** SYRACUSE UNIVERSITY.

9:30 *Algebras of tame uniserial type.* PRELIMINARY REPORT.
179 **Birge Huisgen-Zimmermann,** UNIVERSITY OF CALIFORNIA, SANTA BARBARA.

10:00 *Representations of Out(P) applied to stable splittings of some infinite groups.* PRELIMINARY REPORT.
180 **Daniel Juan Pineda,** IMUNAM-MORELIA.

10:30 *Properties of almost split sequences in subcategories.* PRELIMINARY REPORT.
181 **Mark Kleiner,** SYRACUSE UNIVERSITY.

11:00 *Strongly simply connected tilted algebras.*
182 **Ibrahim Assem, and Shiping Liu✦,** UNIVERSITÉ DE SHERBROOKE.

11:30 *Serre duality for a family of Auslander regular algebras.* PRELIMINARY REPORT.
183 **Roberto Martínez-Villa,** INSTITUTO DE MATEMÁTICAS, UNAM.

Special Session on Rings and Category Theory, III

9:00–12:00 ROOM NO. 11

9:00 *Radical endomorphisms of decomposable modules.*
184 **Julius M. Zelmanowitz,** UNIVERSITY OF CALIFORNIA, SANTA BARBARA.

16:30 *On the completeness of the singular eigenfunctions for the continuous spectrum of inviscid shear flow.*
206 **P. J. Morrison,** UNIVERSITY OF TEXAS AT AUSTIN.

17:00 *Singularity formation in 2D ideal, incompressible MHD.* PRELIMINARY REPORT.
207 **Isaac Klapper,** MONTANA STATE UNIVERSITY.

17:30 *Localized eigenstates for the hydrogen atom.*
208 **C. Villegas.**

18:00 *Perturbation problems in control of partial differential equations.*
209 **Miguel Angel Moreles,** CIMAT.

18:30 *Continuous descent methods for nonlinear problems.* PRELIMINARY REPORT.
210 **John W. Neuberger,** UNIVERSITY OF NORTH TEXAS.

Special Session on Complex and Functional Analysis, IV

16:00–19:00 ROOM NO. 3

16:00 *Qp-Functions and p-Carleson measures.* PRELIMINARY REPORT.
211 **Luis Manuel Tovar** ESFM-IPN.

16:30 *Quasiconformally expodable sets.*
212 **Lino F. Reséndis✦,** UNIVERSIDAD AUTÓNOMA METROPOLITANA-AZCAPOTZALCO, AND **R. Michael Porter,** CENTRO DE INVESTIGACIÓN Y DE ESTUDIOS AVANZADOS DEL I.P.N..

17:00 *Dynamical properties of certain meromorphic maps of P^2.* PRELIMINARY REPORT.
213 **Araceli Medina-Bonifant,** ESCUELA SUPERIOR DE FÍSICA Y MATEMÁTICAS, I.P.N..

17:30 *Projectors of spaces of harmonic functions in the ball with a Dini type weight.* PRELIMINARY REPORT.
214 **Oscar Blasco,** UNIVERSIDAD DE VALENCIA, AND **Salvador Pérez-Esteva✦,** UNIVERSIDAD NACIONAL AUTÓNOMA DE MÉXICO.

18:00 *The two-weight version of the representation for Hankel operators in Hardy spaces.*
215 **Mischa Cotlar,** UNIVERSIDAD CENTRAL DE VENEZUELA, AND **Cora Sadosky✦,** HOWARD UNIVERSITY.

18:30 *Multivariate cubatures and dilation theory.*
216 **Mihai Putinar,** UNIVERSITY OF CALIFORNIA, SANTA BARBARA.

Special Session on Differential Geometry and Topology, IV

16:00–19:00 ROOM NO. 4

16:00 *Four dimensional manifolds with recursive ends.* PRELIMINARY REPORT.
217 **Sa'ar Hersonsky,** CALIFORNIA INSTITUTE OF TECHNOLOGY.

16:30 *Envelopes of horospheres: Hypersurfaces and conformal metrics.* PRELIMINARY REPORT.
218 **Daniel Pollack✦,** UNIVERSITY OF WASHINGTON, AND **Michael Wolf,** RICE UNIVERSITY.

17:00 *A Whitehead algorithm for surface automorphisms.* PRELIMINARY REPORT.
219 **Karen Vogtmann✦, and** CORNELL UNIVERSITY, **Gilbert Levitt,** UNIVERSITÉ PAUL SABATIER.

17:30 *On a symplectic reduction of a cotangent superbundle.*
220 **Fausto Ongay,** CIMAT.

18:00 *Searching for universal links.* PRELIMINARY REPORT.
221 **Víctor Núñez,** CENTRO DE INVESTIGACIÓN EN MATEMÁTICAS, A. C..

18:30 *Completeness stability in the presence of Killing vector fields.* PRELIMINARY REPORT.
222 **C. T. J. Dodson✦,** UMIST, ENGLAND, AND **Lilia Del Riego,** UASLP, MÉXICO.

Special Session on General Topology, IV

16:00–19:00 ROOM NO. 5

16:00 *Inverse limits on intervals using unimodal bonding maps having only periodic points whose periods are powers of two.* PRELIMINARY REPORT.
223 **W. T. Ingram✦, and Robert Roe,** UNIVERSITY OF MISSOURI - ROLLA.

16:30 *Digraphs and dendroids.*
224 **Isabel Puga✦,** FACULTAD DE CIENCIAS, UNAM, AND **Víctor Neumann-Lara,** IMATE-UNAM.

17:00 *Title to be announced.*
225 **Oleg Okunev.**

17:30 *Thin generating sets in topological groups.*
226 **Mikhail G. Tkachenko✦, Vladimir V. Tkachuk,** UNIVERSIDAD AUTÓNOMA METROPOLITANA, IZTAPALAPA, AND **Dikranjan Dikran,** UNIVERSITÀ DE UDINE, ITALIA.

18:00 *Title to be announced.*
227 **Bykov.**

18:30 *Open sets in arcwise connected homogeneous continua.*
228 **David P. Bellamy,** UNIVERSITY OF DELAWARE.

Special Session on Graphs and Combinatorial Geometry, IV

16:00–19:00 ROOM NO. 6

16:00 *Operators with jumping nonlinearities and extremal problem on a hypercube.*
229 **Vojtech Rödl✦, Rudolf Svarc, and Beata Wysocka,** EMORY UNIVERSITY AND UNIVERSITY OF MELBOURNE.

16:30 *On tournaments free of large transitive subtournaments.*
230 **Adolfo Sánchez-Flores,** IIMAS-UNAM.

17:00 *Random walks and geometric algorithms.*
231 **Ravindran Kannan,** CARNEGIE-MELLON, **László Lovász,** YALE UNIVERSITY, AND **Miklós Simonovits✦,** MATHEMATICAL INSTITUTE OF THE HUNGARIAN ACADEMY OF SCIENCES.

17:30 *A midrange crossing constant.* PRELIMINARY REPORT.
232 **Joel H. Spencer,** COURANT INSTITUTE, NYU.

18:00 *Crossing numbers of graphs.*
233 **László A. Székely,** UNIVERSITY OF SOUTH CAROLINA.

18:30 *On the Bollobás-Eldridge conjecture for graph packings.*
234 **Endre Szemerédi,** RUTGERS UNIVERSITY.

Special Session on Mathematical Physics, IV

16:00–19:00 ROOM NO. 7

16:00 *Three levels in the theory of quantum groups.*
*235** **Stanislaw Lech Woronowicz.**

17:00 *Derivations of an algebra and of a bialgebra.*
236 **Zbigniew Oziewicz.**

17:30 *A C^*-algebraic approach to quantum classifying spaces and quantum characteristic classes.*
237 **Micho Durdevich,** IMATE-UNAM.

18:00 *On the geometry of quantum mechanics.*
238 **Miguel Socolovsky✦,** INSTITUTO DE CIENCIAS NUCLEARES UNAM, AND **Marcelo Aguilar,** IMATE UNAM.

18:30 *Extracting quantum Lie algebras.* PRELIMINARY REPORT.
239 **César Bautista,** BENEMÉRITA UNIVERSIDAD AUTÓNOMA DE PUEBLA.

Special Session on Rings and Category Theory, IV

16:00–19:00 ROOM NO. 11

16:00 *Local bijective Gabriel correspondence and finite annihilation of modules.* PRELIMINARY REPORT.
240 **Paul Kim, and Günter Krause✦,** UNIVERSITY OF MANITOBA.

16:30 *The closed subcategory generated by the μ-complemented modules.*
241 **Ana M. de Viola-Prioli, and Jorge E. Viola-Prioli✦,** UNIVERSIDAD SIMÓN BOLÍVAR, CARACAS, VENEZUELA.

17:00 *On rings with chain conditions.* PRELIMINARY REPORT.
242 **Dinh V. Huynh,** OHIO UNIVERSITY, ATHENS AND INSTITUTE OF MATHEMATICS, HANOI, AND **S. Tariq Rizvi✦,** THE OHIO STATE UNIVERSITY, LIMA.

17:30 *Global Krull dimension and global dual Krull dimension of Grothendieck categories.*
243 **Toma Albu,** UNIVERSITY OF WISCONSIN-MILWAUKEE.

18:00 *The localization of the enveloping algebra of $sl(2,k)$ at the finite dimensional representations.*
244 **Ivo Herzog.**

18:30 *On weak injectivity and weak projectivity.*
245 **Mohammad A. Saleh,** BIRZEIT UNIVERSITY.

General Session, III

16:00–19:00 ROOM NO. 12

16:00 *On Hamiltonian structures for first variational equations.* PRELIMINARY REPORT.
246 **Yuri M. Vorobjev✦,** MOSCOW INSTITUTE OF ELECTRONICS AND MATHEMATICS AND UNIVERSIDAD DE SONORA, AND **Rubén Flores-Espinoza,** UNIVERSIDAD DE SONORA.

16:30 *Tangle analysis of bacteriophage Mu Gin recombination.*
247 **Maria-Elena Vázquez✦, De Witt Sumners, and Javier Arsuaga,** FLORIDA STATE UNIVERSITY.

17:00 *Results on the integral geometry of knots.*
248 **David C. Miller✦,** WILLIAM PATERSON UNIVERSITY, AND **Craig Benham,** MOUNT SINAI MEDICAL SCHOOL.

17:30 *Integrability of constrained Hamiltonian systems in optimal control theory.* PRELIMINARY REPORT.
249 **Felipe R. Monroy-Perez,** UNIVERSIDAD AUTÓNOMA METROPOLITANA-AZCAPOTZALCO.

18:00 *Change of stability and bifurcation.* PRELIMINARY REPORT.
250 **Peter Seibert,** UAM IZTAPALAPA.

18:30 *On the existence of bifurcations arising from saddle sets.*
251 **José S. Florio,** UNAM.

Invited Address

19:15–20:15 AUDITORIUM

Are there too many smooth four-dimensional manifolds?.
252✦ **Ronald J. Stern,** UNIVERSITY OF CALIFORNIA AT IRVINE.

SATURDAY, DECEMBER 6

Special Session on Algebraic Geometry and Commutative Algebra, V

9:00–12:00 ROOM NO. 1

9:00 *The index of vector fields on singular varieties.*
*253** **Xavier A. Gómez-Mont,** CIMAT.

10:00 *Generic vanishing via hyperplane sections.* PRELIMINARY REPORT.
254 **Giuseppe Pareschi,** UNIVERSITÀ DI ROMA "LA SAPIENZA".

10:30 *Gauss-Manin connection arising from arrangements of hyperplanes.* PRELIMINARY REPORT.
255 **Herbert Kanarek,** INSTITUTO DE MATEMÁTICAS, UNAM.

11:00 *Algebraic foliations having several polynomial first integrals.*
256 **Jesús R. Muciño-Raymundo,** INSTITUTO DE MATEMÁTICAS UNAM, UNIDAD MORELIA.

Special Session on Applied Nonlinear Analysis, V

9:00–12:00 ROOM NO. 2

9:00 *Birkhoff normal form for problems of free surfaces and interfaces.*
257 **Walter Craig,** BROWN UNIVERSITY.

9:30 *Absence of caustics for nonlinear reflection laws and Minkowski billiards.*
258 **Eugene Gutkin,** UNIVERSITY OF SOUTHERN CALIFORNIA.

10:00 *Nonlinear dynamical problems for deformable solids.*
*259** **Stuart S. Antman,** UNIVERSITY OF MARYLAND.

11:00 *Stochasticity of a toroidal magnetic field separatrix due to periodic perturbations.*
260 **J. J. E. Herrera✦, D. Kh Morozov,** INSTITUTO DE CIENCIAS NUCLEARES, UNAM, AND **E. Chávez,** INSTITUTO NACIONAL DE INVESTIGACIONES NUCLEARES.

11:30 *On the existence of standing waves for the Davey-Stewartson system.*
261 **Marisela Guzmán,** UNIVERSIDAD AUTÓNOMA METROPOLITANA-AZCAPOTZALCO.

Special Session on Complex and Functional Analysis, V

9:00–12:00 ROOM NO. 3

9:00 *The energy sequence of a set of commuting operators.*
*262** **William B. Arveson,** UNIVERSITY OF CALIFORNIA AT BERKELEY.

10:00 *Minimal representing measures arising from rank-increasing moment.* PRELIMINARY REPORT.
263 **Lawrence A. Fialkow,** STATE UNIVERSITY OF NEW YORK, COLLEGE AT NEW PALTZ.

10:30 *Separability and compactness in the space of compact operators on a separable and reflexive Banach space.*
264 **Fernando Galaz,** CIMAT.

11:00 *Locally complete spaces and lp, q-summability.* PRELIMINARY REPORT.
265 **Carlos Bosch✦,** INSTITUTO TECNOLÓGICO AUTÓNOMO DE MÉXICO, AND **Armando García,** INSTITUTO DE MATEMÁTICAS UNAM AND ITESM CIUDAD DE MÉXICO.

11:30 *Singular integral operators on weighted distribution spaces.* PRELIMINARY REPORT.
266 **Josefina Alvarez,** NEW MEXICO STATE UNIVERSITY.

Special Session on Differential Geometry and Topology, V

9:00–12:00 ROOM NO. 4

9:00 *The effect of the topology on the number of positive symmetric solutions of a nonlinear elliptic equations on a symmetric domain.* PRELIMINARY REPORT.
267 **Mónica Clapp,** INSTITUTO DE MATEMÁTICAS, UNAM.

9:30 *Systoles of cusped hyperbolic 3-manifolds.* PRELIMINARY REPORT.
268 **Colin C. Adams, and W. Reid✦.**

10:00 *Quantum motion on manifolds of non-positive curvature.*
269 **Frederico Xavier,** UNIVERSITY OF NOTRE DAME.

10:30 *Knots in S^3 which admit a strong generalized tangle decomposition and a reducible surgery are cabled.* PRELIMINARY REPORT.
270 **Luis G. Valdez-Sánchez,** UNIVERSITY OF TEXAS AT EL PASO.

11:00 *Principal configurations of surfaces of codimension 2.*
271 **Federico Sánchez-Bringas,** FACULTAD DE CIENCIAS, UNAM.

11:30 *Title to be announced.*
272 **Santiago López de Medrano,** IMATE-UNAM.

Special Session on General Topology, V

9:00–12:00 ROOM NO. 5

9:00 *On feebly monotone mappings.*
273 **Janusz J. Charatonik,** UNIVERSITY OF WROCLAW AND UNAM.

9:30 *Local Siegel disks.* PRELIMINARY REPORT.
274 **Lex G. Oversteegen,** UAB.

10:00 *Asymmetric k-spaces and the k-dual.* PRELIMINARY REPORT.
275 **Ralph D. Kopperman✦,** CITY COLLEGE, CUNY, AND **Jimmie D. Lawson,** LOUISIANA STATE UNIVERSITY.

10:30 *On linking of cycles in Menger manifolds.*
276 **Rolando Jiménez✦,** IMATE MORELIA, AND **Evgeni Scepin,** STEKLOV INSTITUTE OF MATHEMATICS, MOSCOW.

11:00 *A solution of the O. Hajek problem.*
277 **Sergey Antonyan,** UNAM.

11:30 *Spaces with all real eigenvalues and asymmetric distance data.* PRELIMINARY REPORT.
278 **Stephen Watson,** YORK UNIVERSITY.

Special Session on Graphs and Combinatorial Geometry, V

9:00–12:00 ROOM NO. 6

9:00 *Unsolved problems in dimension theory.* PRELIMINARY REPORT.
279 **William T. Trotter.**

9:30 *On measuring areas and volumes.* PRELIMINARY REPORT.
280 **Felipe Contreras,** UNIVERSITY OF OTTAWA, **Jurek Czyzowicz,** UNIVERSITY OF QUEBEC, AND **Jorge Urrutia✦,** UNIVERSITY OF OTTAWA AND IMATE UNAM.

10:00 *Cycle pancyclism in tournaments.*
281 **Hortensia Galeana-Sánchez✦, and Sergio Rajsbaum,** INSTITUTO DE MATEMÁTICAS, UNAM.

10:30 *The graph of large distances among n points in the plane.*
282 **Katalin Vesztergombi,** YALE UNIVERSITY.

11:00 *Continous motion arguments for k-set bounds.* PRELIMINARY REPORT.
283 **Emo Welzl,** ETH ZURICH.

11:30 *The distribution of the maximum vertex degree in random eplanar maps.* PRELIMINARY REPORT.
284 **Zhicheng Gao,** CARLETON UNIVERSITY, AND **Nicholas C. Wormald✦,** UNIVERSITY OF MELBOURNE.

Special Session on Mathematical Physics, V

9:00–12:00 ROOM NO. 7

9:00 *Hamiltonian structure for degenerate AKNS systems.*
285 **Gulmaro Corona-Corona,** UAM-AZCAPOTZALCO.

9:30 *Completness of left invariant pseudo-Riemannian metrics on Lie groups.*
286 **Alberto Medina✦,** UNIVERSITÉ DE MONTPELLIER II, AND **Shirley T. Bromberg,** UNIVERSIDAD AUTÓNOMA METROPOLITANA – IZTAPALAPA.

10:00 *The Lie Transform Method for perturbations generated by deformations of Poisson Brackets.* PRELIMINARY REPORT.
287 **Rubén Flores-Espinoza✦,** UNIVERSIDAD DE SONORA, AND **Yuri M. Vorobjev,** MOSCOW INSTITUTE OF ELECTRONICS AND MATHEMATICS AND UNIVERSIDAD DE SONORA.

10:30 *On the Segal-Bargmann space reproducing kernel.*
288 **Stephen B. Sontz,** UNIVERSIDAD AUTÓNOMA METROPOLITANA-IZTAPALAPA.

11:00 *On Hausdorff dimension of attractive sets of viscous fluid under a fixed Grashof number.*
289 **Yuri N. Skiba,** CENTRO DE CIENCIAS DE LA ATMÓSFERA UNAM.

11:30 *Fredholm determinants as Tau functions for isomonodromic deformations.*
290 **John Harnad✦, and A. Its,** CRM, UNIVERSITÉ DE MONTRÉAL.

Special Session on Nonlinear Models in Biology and Celestial Mechanics, IV

9:00–12:00 ROOM NO. 8

9:00 *From individuals to ecosystems.*
*291** **Simon A. Levin,** PRINCETON UNIVERSITY.

10:00 *The impact of intermediate hosts on the disease dynamics of schistosomiasis.*
292 **Zhilan Feng,** PURDUE UNIVERSITY.

10:30 *Interaction between two virus serotypes in a dengue disease model.*

293 **Lourdes Esteva,** FACULTAD DE CIENCIAS-UNAM.

11:00 *Avoiding competition by improving resistence to changes in the environment.*

294 **Ignacio Barradas,** CIMAT.

11:30 *Models for the spread of tuberculosis.*

295 **Carlos Castillo-Chávez,** CORNELL UNIVERSITY.

Special Session on Representation Theory of Algebras and Groups, IV

9:00–12:00 ROOM NO. 10

9:00 *Combinatorics and representations.*

*296** **Arun Ram,** PRINCETON UNIVERSITY.

10:00 *Diagrams for 3-configurations with only dual affine planes.* PRELIMINARY REPORT.

297 **Alberto G. Raggi-Cárdenas✦, Humberto Cárdenas, Emilio Lluis,** INSTITUTO DE MATEMÁTICAS, UNAM, AND **Rodolfo San Agustín,** FACULTAD DE CIENCIAS, UNAM.

10:30 *Homogeneous wild matrix problems.* PRELIMINARY REPORT.

298 **Dieter Vossieck,** INSTITUTO DE MATEMÁTICAS UNAM.

11:00 *Total positivity and double Bruhat decomposition.* PRELIMINARY REPORT.

299 **Andrei V. Zelevinsky,** NORTHEASTERN UNIVERSITY.

Special Session on Stochastic Systems, III

9:00–12:00 ROOM NO. 12

9:00 *Exponential convergence for filtering problems.* PRELIMINARY REPORT.

*300** **Ofer Zeitouni,** TECHNION.

10:00 *Some recent advances in stochastic adaptive control.*

301 **Bozenna Pasik-Duncan,** UNIVERSITY OF KANSAS.

10:30 *Ergodic boundary/point control and filtering for boundary processes of semilinear stochastic systems.*

302 **T. E. Duncan,** UNIVERSITY OF KANSAS.

11:00 *Optimal stopping theory, taxes, and transaction costs.* PRELIMINARY REPORT.

303 **Abel Cadenillas✦,** UNIVERSITY OF ALBERTA, AND **Stanley Pliska,** UNIVERSITY OF ILLINOIS AT CHICAGO.

11:30 *Robustness of average cost optimal policies in Markov control processes. Quantitative estimations.*

304 **Evgueni Gordienko,** UNIVERSIDAD AUTÓNOMA METROPOLITANA-IZTAPALAPA.

General Session, IV

9:00–12:00 ROOM NO. 9

9:00 *Asymptotic models of orthotropic highly inhomogeneous layered structure.* PRELIMINARY REPORT.

305 **Orlando Avila-Pozos✦, Alexander B. Movchan,** BATH UNIVERSITY, AND **Andrew Klarbring,** LINKÖPING UNIVERSITY.

9:30 *Periodic movement and little theorem of Fermat.*

306 **José Ramón Guzmán✦,** INSTITUTO DE INVESTIGACIONES ECONÓMICAS, UNAM, **Humberto Carrillo,** FACULTAD DE CIENCIAS; UNAM.

10:00 *On the solvability of boundary value problems for parabolic equations in general Hölder spaces.*

307 **Martín López Morales,** ITESM-CEM.

10:30 *Existence of solutions to $\Delta u = 0$ with nonlinear boundary conditions $-\frac{\partial u}{\partial \vec{n}} + \rho|u|^{m-1}u = \Phi$ from dynamic programming.* PRELIMINARY REPORT.

308 **Angel Soriano,** IMATE, U.N.A.M.

11:00 *Schur functions and generalized Gram determinants.* PRELIMINARY REPORT.

309 **Luis Verde-Star,** UNIVERSIDAD AUTÓNOMA METROPOLITANA-IZTAPALAPA.

Invited Address

12:15–13:15 AUDITORIUM

Ten mathematics problems I will never solve.

310✦ **Gian-Carlo Rota,** MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

Meetings and Conferences of the AMS

Associate Secretaries of the AMS

Western Section: William A. Harris Jr., Department of Mathematics, University of Southern California, Los Angeles, CA 90089-1113; e-mail: wharris@math.usc.edu; telephone: 213-740-3794.

Central Section: Susan J. Friedlander, Department of Mathematics, University of Illinois at Chicago, 851 S. Morgan (M/C 249), Chicago, IL 60607-7045; e-mail: susan@math.nwu.edu; telephone: 312-996-3041.

Eastern Section: Lesley M. Sibner, Department of Mathematics, Polytechnic University, Brooklyn, NY 11201-2990; e-mail: lsibner@magnus.poly.edu; telephone: 718-260-3505.

Southeastern Section: Robert J. Daverman, Department of Mathematics, University of Tennessee, Knoxville, TN 37996-1300; e-mail: daverman@novell.math.utk.edu; telephone: 423-974-6577.

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 via the Internet at URL http://www.ams.org/.

Meetings:

Important Information Regarding AMS Meetings

Potential organizers, speakers, and hosts should refer to page 183 in the January 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 plain TeX, AMS-TeX, 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 Abstracts Coordinator, 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.)

1998:

January 5–6 : AMS Short Course on Singular perturbation concepts for differential equations. See pp. 1262–1265 for details.

June 21–July 23: Joint Summer Research Conferences in the Mathematical Sciences, South Hadley, MA. See pp. 1412–1416 for details.

Cosponsored Conference:

February 12–18: American Association for the Advancement of Science, Philadelphia, PA. See p. 1550 for details.

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 12.5% sales occupancy tax. **Guarantee requirements: First night deposit by check (add to payment on reverse of form) or a credit card guarantee.**

☐ Deposit enclosed ☐ Hold with my credit card Card Number_____ Exp. Date _____ Signature _____

Date and Time of Arrival _____ **Date and Time of Departure** _____

Name of Other Room Occupant _____ **Arrival Date**_____ **Departure Date**_____**Spouse** ☐ **Child** ____**(give age)**

Order of choice	Hotel	Single	Double 1 bed	Double 2 beds	Triple 2 beds	Triple 2 beds w/cot	Quad 2 beds	Quad 2 beds w/cot	Suites Starting rates
	Renaissance Harborplace (hdqtrs)	$102	$112	$112	$125	$125	$135	$135	$150
	Students	$82	$92	$92	$105	$105	$115	$115	N/A
	Hyatt Regency Baltimore	$102	$112	$112	$137	$137	$162	$162	$225
	Students	$95	$95	$95	$115	$140	$115	$140	N/A
	Marriott Inner Harbor	$96	$106	$106	$116	$136	$126	$146	$209
	Students	$86	$86	$86	$96	$116	$106	$126	N/A
	Sheraton Inner Harbor	$95	$95	$95	$110	$110*	$125	$125*	$425
	Students	$85	$85	$85	$100	$100	$100	$100	N/A
	Omni Inner Harbor Hotel	$92	$92	$92	$112	$132	$112	$132	$325
	Students	$86	$86	$86	$106	$126	$106	$126	N/A
	Baltimore Hilton & Towers	$86	$86	$86	$106	$116	$126	$136	$275
	Students	$77	$77	$77	$77	$87	$77	$87	N/A
	Clarion Hotel (Mt. Vernon Square)	$82	$82	$82*	$92	$92	$102	$102	N/A
	Students	$72	$72	$72	$82	$82	$92	$92	N/A
	Days Inn Inner Harbor	$80	$80*	$80	$90	$90	$100	$100	$100
	Students	$70	$70	$70	$70	$70	$70	$70	N/A
	Holiday Inn Inner Harbor	$79	$79	$79	$79	$94	$79	$94	$250
	Tremont Plaza (all suites)	$75	$75	$75	$95	$115	$95	$115	$155
	Students	$65	$65	$65	$85	$105	$85	$105	N/A
	Tremont Hotel (all suites)	$65	$65	$65	$85	$105	$85	$105	$155

*** Limited Availability**

Special Housing Requests:.

☐ I have disabilities as defined by the ADA that require a sleeping room that is handicap accessible.

My needs are: _____

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: _____

Other requests: _____

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.

Joint Mathematics Meetings

Baltimore, Maryland
January 7-10, 1998

Baltimore Advance Registration/Housing Form

Please complete this form and return it 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

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(please note charge below)

Membership
✓ all that apply

- ☐ AMS
- ☐ ASL
- ☐ AWM
- ☐ CMS
- ☐ MAA
- ☐ NAM
- ☐ SMM

If you do not wish your program and badge to be mailed to you on 12/10/97, check this box. ☐

Registration Fees

Joint Meetings	**by Dec 19**	**at mtg**
☐ Member AMS, ASL, CMS, MAA	$155	$202
☐ Nonmember	$240	$312
☐ Graduate Student	$ 35	$ 45
☐ Undergraduate	$ 20	$ 26
☐ High School Student	$ 2	$ 5
☐ Unemployed	$ 35	$ 45
☐ Temporarily Employed	$105	$125
☐ 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
☐ One-day Member	—	$121
☐ One-day Nonmember	—	$172

AMS Short Course on *Singular Perturbation Concepts for Differential Equations.*
Registration for the Joint Meetings is not required for the Short Course.

☐ Member, Nonmember	$75	$ 90
☐ Student, Unemployed, Emeritus	$35	$ 45

Employment Register
Registration for the Joint Meetings is required for participation. Applicant résumé forms and employer job listing forms will be on e-MATH in September and in the October issues of *Notices* and *Focus*.

☐ Employer—First Table ☐ Regular ☐ Self-scheduled	$200	$250
☐ Employer—Second Table ☐ Regular ☐ Self-scheduled	$ 50	$ 75
☐ Employer—Posting Only	$ 50	$ 50
☐ Applicant	$ 40	$ 75

Events

Events with Tickets				**Price Per**	**Total**
AMS Banquet	#___Regular	#___Veg	#___Kosher	$32	_____
MER Banquet	#___Regular	#___Veg	#___Kosher	$32	_____
NAM Banquet	#___Regular	#___Veg	#___Kosher	$32	_____
				Total	_____

Student Activities
- ☐ Mathchats (no charge)
- ☐ MAA Student Workshop (no charge)

Statistical/Other Information

Mathematical Reviews field of interest # _____
☐ I am a mathematics department chair.
How did you hear about this meeting? Check one:
☐ *Notices* ☐ *Focus* ☐ WWW ☐ Colleague(s) ☐ Special Mailing
☐ Please do not include my name on any mailing list used for promotional purposes.
☐ Please ✓ this box if you have a disability that requires special services.

Deadlines

Room lottery	**November 7, 1997**
Housing reservations, listing of résumés/job descriptions in the Winter Lists	**November 20, 1997**
Housing reservation changes/cancellations through MMSB	**December 8, 1997**
Advance registration, Employment Register, Short Course, banquets	**December 19, 1997**
50% Refund on banquets	**December 19, 1997***
50% Refund on advance registration	**January 2, 1998***

***no refunds after this date**

Payment

Category	**Total**
Joint Meetings fee(s)	_____
AMS Short Course	_____
Employment Register	_____
Event tickets	_____
Hotel deposit (only if paying by check)	_____
Total amount paid	**$** _____

(Please note that 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)

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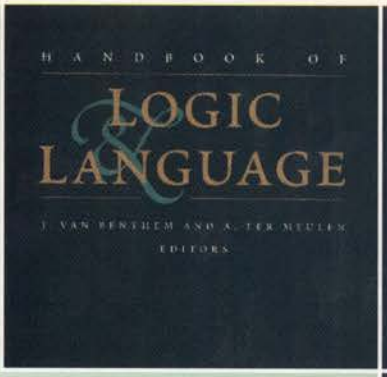

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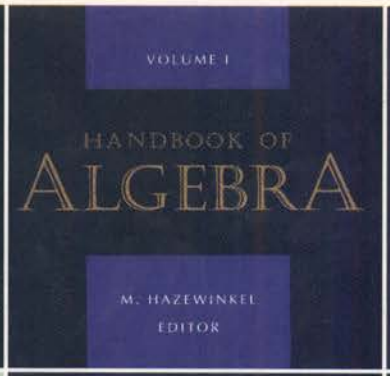

Handbook of Algebraic Topology

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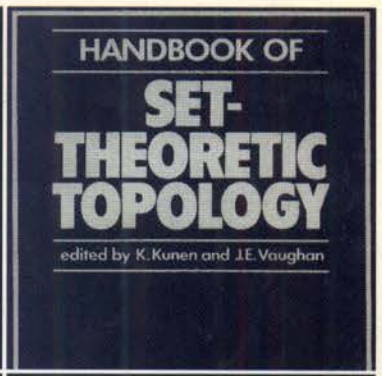

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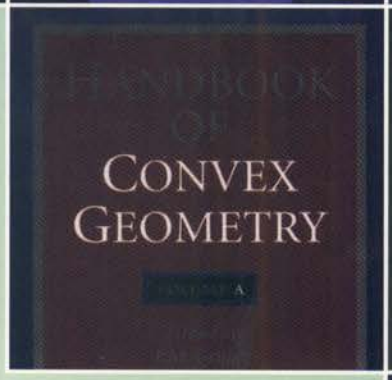

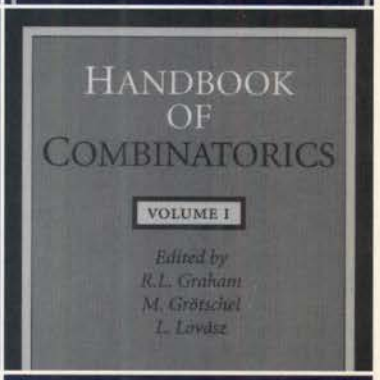

Handbook of Set-Theoretic Topology

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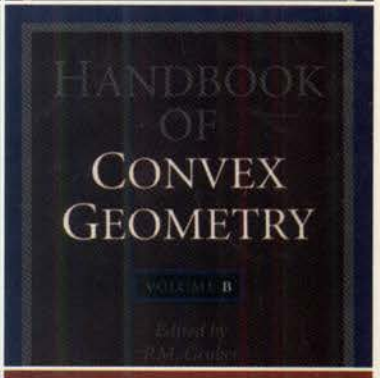

Handbook of Mathematical Logic

Edited by **J. Barwise**

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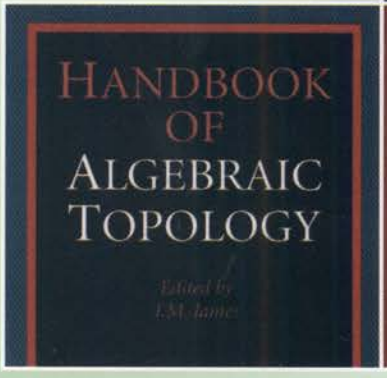

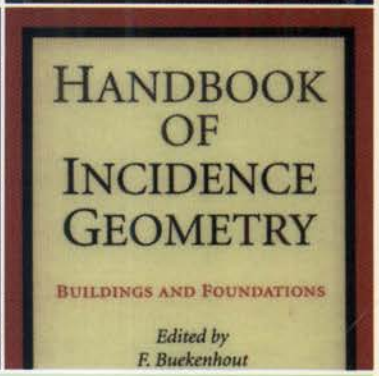

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