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Solomon Feferman, Stanford University, CA, Editor

This volume presents all the published works—spanning more than thirty years—of Julia Bowman Robinson. Outstanding among the latter are Robinson’s proof of the effective unsolvability of the decision problem for the rational number field (and, consequently of that for the first-order theory of all fields), and her work that provided the central step toward the negative solution of Hilbert’s Tenth Problem. Besides thematic unity, Robinson’s papers are distinguished by their clarity of purpose and accessibility to non-specialists as well as specialists.

The volume includes an extensive biographical memoir on the life and work of Robinson.

Collected Works, Volume 6; 1996; 338 pages; Hardcover; ISBN 0-8218-0375-4; List: $69; Individual member $41; Order code CWorks/6NA

Complex Algebraic Geometry
Janos Kollar, University of Utah, Salt Lake City, Editor

This volume contains the lectures presented at the third Regional Geometry Institute at Park City in 1993. The lectures provide an introduction to the subject, complex algebraic geometry, making the book suitable as a text for second- and third-year graduate students.

Members of the Mathematical Association of America (MAA) and the National Council of Teachers of Mathematics (NCTM) receive a 20% discount from list price.

IAS/Park City Mathematics Series; December 1996; approximately 336 pages; Hardcover; ISBN 0-8218-0432-4; List: $89; All AMS members $57; Order code PCMS-KOLLARNA

Lectures on the Mathematics of Finance
Ioannis Karatzas, Columbia University, New York

In this text, the author discusses the main aspects of mathematical finance. These include arbitrage, hedging and pricing of contingent claims, portfolio optimization, incomplete and/or constrained markets, equilibrium, and transaction costs. The book outlines advances made possible during the last fifteen years due to the methodologies of stochastic analysis and control. Readers are presented with current research, and open problems are suggested. The text makes significant use of students’ mathematical skills, but always in connection with interesting applied problems.

CRM Monograph Series, Volume 8; October 1996; 148 pages; Hardcover; ISBN 0-8218-0637-8; List: $39; Individual member $23; Order code CRM/8NA

Qualitative Topics in Integer Linear Programming
V. N. Shevchenko, Nizhnii Novgorod, Russia

Integer solutions for systems of linear inequalities, equations, and congruences are considered along with the construction and theoretical analysis of integer programming algorithms.

Translations of Mathematical Monographs, Volume 156; 1996; 146 pages; Hardcover; ISBN 0-8218-0395-5; List: $69; Individual member $41; Order code MA0209/156NA

A Primer of Mathematical Writing
Steven G. Krantz, Washington University, St. Louis, MO

This book is about writing in the professional mathematical environment. Those who are familiar with Krantz’s writing will recognize his lively, inimitable style.

In this volume, he addresses these nuts-and-bolts issues:
• Syntax, grammar, structure, and style
• Mathematical exposition
• Use of the computer and TeX
• E-mail etiquette
• All aspects of publishing a journal article

Krantz’s frank and straightforward approach makes this particularly suitable as a textbook. Readers will find in reading this text that Krantz has produced a quality work which makes evident the power and significance of writing in the mathematician’s profession.

November 1996; approximately 216 pages; Softcover; ISBN 0-8218-0635-1; List $15; All AMS members $10; Order code PMVNA

Symétrie Miroir
Claire Voisin

This volume describes recent work reflecting the discovery of the mirror symmetry phenomenon. The text is written in French.

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, 63-65, B.P. 67, 1324 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.

Panoramas et Synthèses, Volume 2; 1996; 148 pages; Softcover; List: $30; Individual AMS members $22; Order code PASY/2NA

Stable Marriage and Its Relation to Other Combinatorial Problems
Donald E. Knuth, Stanford University, CA

This is a very stimulating book!

—N. G. de Bruijn

This short book will provide extremely enjoyable reading to anyone with an interest in discrete mathematics and algorithm design.

Mathematical Reviews

This book is an excellent (and enjoyable) means of stretching a large area of computer science for specialists in other fields. It requires little previous knowledge, but exposes the reader to a degree of mathematical facility and a willingness to participate. It is really neither a survey nor an introduction; rather, it is a paradigm, a fairly complete treatment of a single example used as a synopsis of a larger subject.

—SIGACT News

Anyone would enjoy reading this book. If one had to learn French first, it would be worth the effort.

—Computing Reviews

The above citations are taken from reviews of the initial French version of this text—a series of seven expository lectures that were given at the University of Montreal in November of 1975. The book uses the appealing theory of stable marriage to introduce and illustrate a variety of important concepts and techniques of computer science and mathematics: data structures, control structures, combinatorics, probability, analysis, algebra, and especially the analysis of algorithms.

CRM Proceedings & Lecture Notes, Volume 10; October 1996; 74 pages; Softcover; ISBN 0-8218-0603-3; List: $19; All AMS members $15; Order code CRMP/10NA

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### Articles

**Review of Roland Omnès, The Interpretation of Quantum Mechanics**

*William Faris*

The success and universal applicability of quantum mechanics are now well-established at a level unequaled by any other theory in the history of science. However, serious questions arise when one tries to reconcile quantum theory with the familiar macroscopic world also described by Newtonian mechanics. Our reviewer considers whether or not the approach described in Omnès's book provides a satisfactory resolution.

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### Communications

1996 Steele Prizes

- Systems Administration: The Mathematician’s Perspective
- Mathematics *The Science of Patterns*: A Book Review
- Models That Work: Case Studies in Effective Undergraduate Mathematics Programs
- New Directions at the IAS
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### From the AMS

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About the Cover
It is possible to maintain threefold symmetry for the projections of the graph of the complex squaring function into a family of planes, starting at the unit disc (at the lower left) and ending at the conjugate of its square. Lifting those mappings into three-space gives a very symmetric sequence of projections of the Riemann surface of the squaring function. This image sequence was produced at the Geometry Center by Thomas Banchoff from Brown University and Davide Cervone from Union College. For more information on this deformation, see the prototype of “Communications in Visual Mathematics” at the location http://www.geom.umn.edu/locate/journal/.

Boycott Cut-Rate MathematicsInstruction!

In one of those strange ways that ethical concerns occasionally leap to center stage in American popular culture, in the spring of 1996 the working conditions under which their garments were manufactured became a concern among purchasers of mass market clothing. Suddenly consumers were paying attention to whether the workers sewing the garments were third world child laborers or workers trapped in domestic sweatshops, along with their usual consumer concerns about whether the clothes fit, lasted, were stylish, and had a celebrity label. Indeed, it seems as though the celebrity label may have been the key factor, and it was the supermarket tabloid media which first exposed the problem to the public. Be that as it may, a perfectly good shirt produced by exploited workers came to be seen as not so good after all.

We have been struggling with the problem of exploiting workers in the mathematical world also. The AMS took a strong stand on one-year appointments. But this is hardly the only threat. Mathematicians have quipped that only technology has kept their administrations from having calculi taught by South American teenagers at subminimum wages. Hyperbole of course, but, nonetheless, a disturbing trend to "outsourcing" the teaching of entry-level core mathematics to adjuncts or underutilized faculty outside of mathematics, which was a notorious part of the now-modified Rochester Renaissance Plan, has been proposed and sometimes implemented in a number of institutions.

Mathematicians know that mathematics, including entry-level college mathematics, is best taught by mathematicians, where we define the latter as having experience and commitment to mathematics scholarship. (And if the empirical studies demonstrating this do not exist, then we should conduct them immediately.) Regardless of background, adjuncts or faculty whose primary orientation is to another discipline will not have this experience and commitment to mathematics scholarship, and institutions that entrust their mathematics teaching to them are cheating their students.

Supermarket tabloids are unlikely to take up this story, and anyway the analogy is not complete: unlike the clothing issue, the mathematics courses taught by substitute faculty are defective products as well as being produced under improper working conditions. Nor should we realistically expect a consumer boycott, from either the cheated students or their subsequent employers.

Can we do anything except deplore these developments? For example, could graduate programs refuse to accept students who had not been taught mathematics by bona fide mathematicians? As unworkable as such a suggestion might be, perhaps it is time for the American Mathematical Society to consider some sort of collective action on accreditation or certification aimed at keeping inferior (outsourced) mathematics instruction off the market by embarrassing those institutions that try it. While we may never capture the public attention that Kathie Lee Gifford's Honduran sweatshops did, by exposing perpetrators, we may stop the trend. And mathematics will be the better for it.

—Andy Magid
On Zucker's "Teaching at the University Level"

Steven Zucker (Notices 43 (1996), 863) is correct in his assessment that most students are not prepared for college courses when they enter college and that the student is ultimately responsible for learning the course material. It would be a mistake, however, for an instructor to use the above observations as a rationale for not improving his/her teaching skills; a mistake that seems implicit in his dictum "We should be ... reforming the students, not the calculus." Reforming the students may require reforming the course.

There is a growing body of research showing that some instructional practices are more effective than others. (See, for example, the National Research Council's series "Enhancing Human Performance"). For instance, as Zucker recommends, defining the role of the instructor, being clear about the amount of outside work expected, having the text read before class, etc., help the student by providing some guidelines. But why stop there? If a further change in teaching method would improve the students' ability to learn the material, why not go further?

Instructors should be willing to work at teaching just as they expect their students to work at learning. This includes applying research in learning and instruction to mathematics courses.

Jeff Connor
Ohio University
(Received July 25, 1996)

I read Steve Zucker's "Teaching at the University Level" in the August 1996 issue with great interest. We have always had a large number of students in our classes with little knowledge of what it means to learn the content of a college-level course. Now we are lucky to have any that do. This is due not to any lack of intelligence, at least on the part of those attending elite private colleges, but rather to having been taught that "learning" consists of taking careful notes in class; doing routine homework problems with clean, definite answers; and doing well on examinations in which they are expected only to get the "correct" answers to problems almost identical to those worked by their instructor in class. Demanding that work on examinations be presented coherently or examining students on material not "covered" in class is almost certain to guarantee poor student evaluations—a sure way to commit academic suicide by untenured faculty.

I value highly Zucker's recommendations on how to explain to freshmen the difference between high school and university-level courses and will incorporate them into my own teaching. They can only help students to realize the importance of learning how to be independent, that they cannot apply mathematics they do not understand, and that almost all important questions are open-ended and do not have definite answers that can be put on a multiple-choice exam. Yet I cannot be optimistic that carrying out his excellent recommendations is nearly enough. By making student evaluation forms (that are usually read only long enough to associate numerical values to the responses) the principal way of deciding what constitutes good teaching, we end up by punishing those who try to teach students how to learn while rewarding those who make them feel content with old bad habits that turn a college "education" into an amusing game of little value.

Melvin Henriksen
Harvey Mudd College
(Received August 15, 1996)

The article "Teaching at the University Level" by Steven Zucker in the
August Notices really hit the mark. He clearly identifies a problem that has bothered us all, namely, that many, if not most, of our students have no idea of what it means to truly know something well or what it means to learn. He correctly locates the problem as being in the students’ expectations and perceptions of what learning is as shaped by their high school experience. The solution he offers is simple, direct, and elegant. Because of Zucker’s article, our department has prepared an “Academic Orientation” sheet for use by instructors of freshman classes this fall, and this sheet is based on Zucker’s article. There is an ongoing series of discussions on our campus about improving undergraduate education. I alerted our academic VP to Zucker’s article. The VP liked its emphasis on student expectations and readiness. The VP had the deans read it and discuss it. In the fall the article will also be used as a starting point in another of those continuing series of discussions.

It is too early to tell what impact the article will ultimately have, but it has stimulated a lot of discussion. Thank you for publishing a useful article.

William Lampe
University of Hawaii
(Received July 31, 1996)

Steven Zucker’s article “Teaching at the University Level” in the August Notices was right on the mark. It should be republished in the Chronicles of Higher Education, where college administrators can read it.

The single statement “A high school is a place where knowledge is taught, while a university is a place where knowledge is sought” best describes the philosophical difference between the approaches of these two types of institutions to learning.

Unfortunately, the notion that a university is a place where all (student as well as professor) are to be actively engaged in the pursuit of knowledge is rapidly being replaced by a new, pernicious philosophical notion. The guiding principle of this new philosophy states that the student is a customer and has as its (unspoken) corollary that professors are really sales clerks whose main goal is to protect the university’s revenue stream in the face of declining enrollments by seeing that the customer is properly served. (Other expressions of the same desires by administrators to protect and even enhance revenue streams are embodied in the notions that we must “retain at-risk students” and “move toward a policy of open enrollment”. At least this is the kind of nonsense I hear on my campus.)

The unfortunate consequence of this view of the student as customer is that the student need play only a passive role in the learning process. Thus as professionals we are driven to activities such as “calculus reform” instead of “student attitude reform”. It is not calculus that needs reforming; it is the attitudes of students toward learning and the attitudes of administrators toward scholarship.

The student is, of course, not a customer, and the professor is most assuredly not a sales clerk. However, there is perhaps one business analogy which, while not perfect, does make at least some sense. That is the idea of the student as franchisee and the professor as franchisor. This analogy at least has the advantage of requiring some considerable responsibility for learning on the part of the student. In order to obtain a business franchise, the franchisee must first be trained in the management and operations practices of the franchisor. Should he or she fail to meet the standards of the franchisor, the time and money invested in the pursuit of the franchise is lost and no tears are shed by the rest of society over that particular outcome.

When universities attempt to protect their revenue streams by admitting weak students and watering down the curriculum in order to accommodate them, they defraud these students and their parents of valuable time and money that could be better spent on technical college and vocational college training while at the same time cheapening the value of the university degree. Turning our universities into glorified high schools or forcing them to compete with junior colleges and vocational schools for students will cause far more harm to them and to the students they serve than will be caused by gradually downsizing these institutions and permitting them to serve only those students with sufficient intellectual interest, motivation, and ability to make the most of a university experience.

Howard A. Levine
Iowa State University
(Received August 19, 1996)

On the Continuation of the Summer Mathfests

In my role as the Mathematical Association of America’s (MAA) associate secretary, I have the responsibility to schedule the MAA scientific program at its two national meetings. So I was interested, perhaps more than the average AMS member, in what the secretary of the Society, Robert Fossum, had to say in his piece “Adieu to the Mathfest” (Notices 43 (1996), 836).

I object to bidding “Adieu to the Mathfest”. It is curious that Fossum doesn’t even mention the MAA at all, since it is a fact that up to and including this year the MAA and the Society have cosponsored the Mathfests. Starting next year, after a unilateral decision by the AMS to not hold any more summer meetings this decade, the MAA will sponsor the Mathfests by itself because it believes the meetings serve a very real and valuable function in the mathematics community.

It seems to me that one of Fossum’s goals is to explain why the Society is acting in the best interests of its members in not continuing its participation in the traditional summer Mathfest. He lists activities “...attractive to the modern specialized mathematician” that all seem to stress mathematics research. I agree that research is a major interest of AMS members, but it is far from our only professional interest. Unfortunately, the overall effect of Fossum’s column is to encourage the belief that AMS members will not attend a meeting in the summer unless it is a pure “research” meeting.

I am not convinced. I believe that AMS members—whether we consider ourselves researchers, practitioners, teachers, or even one of “The gurus of a subject...”—will be interested in
organizing and attending sessions at the MAA's 1997 Mathfest in Atlanta (August 2-4). Already we know that Elliott Lieb will deliver the three Hedrick lectures. I believe the Program Committee for the 1997 Mathfest will develop a strong mathematical program, including short course(s), lectures that introduce the non-specialist to new research results throughout the discipline, a lively program by and about students (undergraduate and graduate) of mathematics, and general sessions of interest to mathematicians in areas covering research, teaching, and the general state of the mathematics profession. In this regard, if you have an idea you would like to pursue relative to the Mathfest program, please contact the chair of this committee, Barbara Osofsky.

The Society as an organization will not be supporting the MAA's 1997 Mathfest in Atlanta directly, but I expect and hope that many of my fellow AMS members will be involved in an integral way. In any event, the Mathfest does not qualify to be bid adieu to: the rumors of its death were greatly exaggerated in Fossum's well-intentioned piece!

Donovan H. Van Osdol
University of New Hampshire
(Received August 20, 1996)

The Vanishing Regular Position
Susan Friedlander discusses the trend people are calling the "vanishing regular position" in her second page editorial (Notices 43 (1996), 956). She focuses on the perception of many that replacing regular positions with "free-way flyers" may lead to "marginalization of the mathematics departments".

She suggests a key danger in the trend; it drops the appeal of a long-range mathematics research career to young people. I agree. Still, I would like to clarify the following comment she made: "...some departments (e.g., the University of California, Irvine, and the University of Michigan) have been able to counter the trend to a certain extent by converting graduate student positions to junior faculty positions, one consequence of which is that more courses are taught by Ph.D. mathematicians."

That may be the operating position of the U. of Michigan under the chair of Donald J. Lewis. While we believe the Irvine department was sensitive to the issue, we believe other departments are, too. Our method, however, started with an observation on who filled Visiting Positions. For considerable time, the department had a few senior visitors, who returned to appointments regularly. Starting with chair Ronald Stern and continuing with chair Peter Li, the department consciously discouraged repeats of senior visitors. Instead, it encouraged faculty to create mentoring situations for younger mathematicians.

Further, UCI actually increased its graduate support during this time, and is still doing so. In particular, the department increased the fraction of graduate students holding summer instructorships. This gave them opportunities to improve their teaching skills (and money). Now fewer courses have freeway flyers and senior visitors as instructors, and many more are taught by visiting assistant professors (academic year) and graduate students (summer).

The department benefited with a rejuvenation for having these talented young people around. Yet, there is no simple guarantee this model will continue. It depends on the chair (and sometimes the dean) and his or her consultants. That is why it is so important that someone like Professor Friedlander put this issue out for discussion. There are many models that might work if a conscious effort is made by chairs of departments. The mathematics community needs young Ph.D.s (although that is not the subject of this letter). Still, it cannot keep producing them and then prefer employing non-U.S. trained Ph.D.s. If we train them, then we must share responsibility for their employment.

Michael D. Fried
University of California, Irvine
(Received August 27, 1996)
Review of Roland Omnèes, *The Interpretation of Quantum Mechanics*  

William Faris

**The Quantum World**

The first chapter of the *Feynman Lectures on Physics* contains the following proud claim on behalf of the scientific enterprise:

> If, in some cataclysm, all of scientific knowledge were to be destroyed, and only one sentence passed on to the next generations of creatures, what statement would contain the most information in the fewest words? I believe it is the atomic hypothesis (or the atomic fact, or whatever you wish to call it) that all things are made of atoms—little particles that move around in perpetual motion, attracting each other when they are a little distance apart, but repelling upon being squeezed into one another. In that one sentence, you will see, there is an enormous amount of information about the world, if just a little imagination and thinking are applied.

Contrast Feynman's confidence with the following phrase from Wittgenstein's *Philosophical...* 

*Remarks:* "The table I see is not made of electrons."

Those familiar with the successes of modern physics might scoff at such a statement. However, the author of the book under review, a physicist who is evidently as familiar with Feynman as with Wittgenstein, quotes it approvingly. In his words: "This agrees well with the impossibility of identifying in quantum logic a classically meaningful property with a more complete set of elementary properties referring to each constituent particle in the object."

In the view of quantum mechanics that he presents, the particles are there, they have properties, but the properties are typically neither true nor false. In his terminology, facts are true properties, but they are restricted to the macroscopic world. As for other properties: "One must distinguish between the facts, the microscopic properties that may be said to be true, and also the vast number of microscopic properties that cannot even be said to be true or false." This raises the issue of just how well we understand the world on the atomic scale.

According to the current picture, the world consists of particles; these include electrons.

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According to the current picture, the world consists of particles; these include electrons.
protons, and neutrons. Protons and neutrons are themselves made of constituent particles, quarks. Particles move under the influence of forces. There are short-range forces (strong and weak interactions), and there are also long-range forces (electric and gravitational interactions). The electric, weak, and strong forces dominate on the atomic and subatomic scales; there is considerable progress toward a unified theory of these forces. The description of all these particles and forces is via quantum mechanics.

Quantum mechanics is not just another physical theory; it is supposed to be the framework for all physical theories. Its structure is independent of the details of what kind of particles exist and what kind of forces make them interact. In the words of the author of the book, this theory "has known a progress with no analogue in the history of science, finally reaching a status of universal applicability."

Quantum mechanical calculations pervade the description of the world. The numerical factor that enters into such calculations is Planck's constant $\hbar$. Consider, for instance, the size of an atom. The Bohr formula for the radius of an atom is

$$a_0 = \frac{\hbar^2}{me^2}.$$  

This involves not only the mass $m$ and charge $e$ of the electron, but also Planck's constant. When the numerical values are inserted, this gives the familiar fact that atoms have a diameter of the order of $10^{-8}$ cm.

The mystery of quantum mechanics begins when one looks more closely at its foundations. It seems reasonable that properties of the atomic world may not be the ones that we are used to. For example, an atom is much smaller than the wavelength of visible light, and so it is meaningless to speak of the color of an atom. However, one might expect that properties of particles such as being located in a certain region or having a certain energy would be meaningful. It turns out that such properties have a peculiar structure.

For each property the state of the system determines the probability that the property is true when an appropriate measurement is made. However, quantum mechanics does not fit comfortably into the ordinary framework of probability theory. The reason is that in general there is no natural way to combine properties. One can ask for the probability that the electron is in a certain region in space. One can also ask for the probability that its momentum is in a certain range. But one cannot ask for the probability that the electron is in the region and the momentum is in the range. It is sometimes said that a measurement that will decide about one property interferes with or precludes a measurement that will decide about the other property. However, the usual analysis says that the combined property is simply meaningless. Furthermore, the truth or falsity of the individual properties are not defined until the point at which the measurement that will establish one of the properties is performed. At that point the selected property becomes true or false.

Is this a satisfactory picture of the world, or is it merely a description of the results of experiments? This sort of question is a source of unease among physicists. One of the earliest and most influential answers was the Copenhagen interpretation, a circle of ideas associated with Bohr and other pioneers of the quantum theory. According to this view, the interpretation of quantum mechanics must refer to our experience in the macroscopic world of everyday experience that is described by classical mechanics. The classical world is thus in opposition to or at least complementary to the quantum world. Such a view is congenial to a physicist who takes the view that the job of physics is only to predict experimental results.

Heisenberg, von Neumann, and other scientists contributed their own perspectives to the interpretation of quantum mechanics. Textbook accounts often give an uneasy review of the opinions of these masters and then move on to the mathematics, where there is no doubt about what to do. The more careful authors attempt to give a quantum mechanical account of the measurement process, usually following von Neumann. The typical conclusion is that the result of an experiment on a system must be described in terms external to the system. However, this leads to puzzling questions. Can the universe be described by quantum mechanics? There are many atoms in the universe; why should they not form an aggregate that obeys the laws of physics? Yet here there is no external system.

This and other questions have led some physicists to a reevaluation of the interpretation of quantum mechanics. Roughly speaking, there are two camps. One camp would like a conceptual revolution that sweeps away the orthodox way of thinking of quantum mechanics. The other camp would like to keep quantum mechanics much as it is but seeks an interpretation that does not depend on having an external system. This camp is willing to question the dogmas of Bohr and the other masters. However, its goal is conservative: to find a reformulation that maintains the spirit of the orthodox framework. The book *The Interpretation of Quantum Mechanics* by Roland Omnès represents the conservative camp. It builds on various newer ideas, including decoherence and the notion of consistent histories. The author refers in particular...
Properties and States
The mathematical framework is standard quantum mechanics. There is a Hilbert space $\mathcal{H}$. This is a complex vector space with an inner product; with its norm it is a complete metric space. Every closed subspace is itself a Hilbert space; we shall refer to it simply as a subspace. Each subspace $M$ of $\mathcal{H}$ specifies a property of the quantum system. The entire space is the sure property, and the zero subspace is the impossible property. If $M$ is a subspace specifying a property, then the orthogonal complement $M^\perp$ specifies the negation of the property. If $M$ and $N$ are two subspaces with orthogonal complements $M^\perp$ and $N^\perp$, then the four intersections $M \cap N$, $M \cap N^\perp$, $M^\perp \cap N$, and $M^\perp \cap N^\perp$ are each subspaces. If the direct sum of these four subspaces is the entire Hilbert space, then $M$ and $N$ are compatible. If $M$ and $N$ are compatible, then the conjunction of each pair of properties is defined to be the corresponding intersection. Otherwise the conjunction is not defined. When $M$ and $N$ are compatible, the disjunction of $M$ and $N$ is also defined and is the direct sum of the first three of the four subspaces.

When $M$ and $N$ are compatible and their conjunction is impossible, then the properties are mutually exclusive. In this case the disjunction of $M$ and $N$ is just the direct sum of orthogonal subspaces $M$ and $N$. The logic of quantum mechanics is thus much like ordinary logic, except that conjunction and disjunction are defined only for compatible properties.

This logical structure is often formulated in another language. An operator is a linear transformation of $\mathcal{H}$ to itself. There is a one-to-one correspondence between subspaces of $\mathcal{H}$ and orthogonal projection operators; the subspace is the range of the operator. Call such an operator a projection; it is a self-adjoint operator $E$ with $E^2 = E$. In this language the projections $I$ and $0$ correspond to the sure property and the impossible property, and the projection $E' = I - E$ corresponds to the negation of the property specified by $E$. The properties associated with $E$ and $F$ are compatible if $E$ and $F$ commute (Figure 1). In general the projections do not commute, and the properties are not compatible (Figure 2). In the case when the projections $E$ and $F$ commute, the projection $EF = FE$ represents the conjunction, and the projection $EF + EF' + E'F = E + F - EF$ represents the disjunction. When $EF = 0$, the properties are compatible—in fact, they are mutually exclusive—and the disjunction is represented by the sum $E + F$. From now on we identify properties with projections.

A state provides a specification of a probability $p(E)$ for each property $E$. This specification must be additive. This refers to the situa-

to related work of Griffiths (on consistent histories) and by Zurek (on decoherence) and by Gell-Mann and Hartle (another synthesis). The importance of the book is that it represents a self-contained statement of one variant of what may become the new orthodox position. Does this position carry conviction? The following more detailed description may suggest an answer.
tion where there are projections $E_1, \ldots, E_n$ onto orthogonal subspaces with $E_1 + \cdots + E_n = I$. The additivity requirement is that

$$p(E_1) + \cdots + p(E_n) = 1.$$  

This says that the probabilities of a set of mutually exclusive properties whose disjunction is sure add up to one. It is not necessarily assumed that every property can be measured or that all these probabilities are empirically meaningful. The state is a mathematical specification of probabilities for all properties, whether they have physical meaning or not.

In quantum mechanics states are determined by vectors in the Hilbert space in the following way. A pure state is determined by a unit vector $\psi$ in the Hilbert space. The probability of a property $E$ when the system is in a pure state is given by the inner product

$$p(E) = \langle \psi, E\psi \rangle.$$  

Since $\langle \psi, E\psi \rangle = \|E\psi\|^2$, this number is between 0 and 1 (Figure 3). In general a state is defined as a pure state or as a randomized family of pure states.

Two unit vectors determine the same pure state if and only if they belong to the same one-dimensional subspace. Therefore, the space of pure states is really the complex projective space consisting of all these one-dimensional subspaces. This suggests a representation of pure states as projections on one-dimensional subspaces. In this review I follow the physicist's convention that inner products are conjugate linear on the left and linear on the right. Thus the projection on the one-dimensional subspace spanned by $\psi$ is

$$P = \psi\langle \psi, \cdot \rangle.$$  

This leads to a particularly elegant expression for the probability as a trace of a product of a state projection $P$ with a property projection $E$:

$$p(E) = \text{tr}(P E).$$  

This expression follows immediately from $\text{tr}(PE) = \text{tr}(PEP)$ and $PEP = \langle \psi, E\psi \rangle P$. This trace can be thought of geometrically as the square of the cosine of the angle between the two subspaces.

The physical interpretation of properties is also reflected in the geometry of the corresponding projections. Let $E$ and $F$ be projections representing properties. The geometrical relation between the two corresponding subspaces [1] is expressed by certain angles $\theta$ that lie in the range from 0 to $\pi/2$. They are defined so that the spectrum of the self-adjoint operator $E + F$ consists of the numbers $1 \pm \cos(\theta)$, with the same angles $\theta$. Let $\vartheta$ be the infimum of the angles. The norm of $E + F$ is $1 + \cos(\vartheta)$. In the quantum mechanical interpretation this says that, for every state $\rho$, the sum of the probabilities of $E$ and $F$ satisfies the inequality (Figure 4)

$$p(E) + p(F) \leq 1 + \cos(\vartheta).$$  

This is a special case of a characterization [2] of all points with coordinates $p(E)$ and $p(F)$. It is convenient to estimate the right-hand side in terms of a trace, since it is easier to compute. The trace of $EFE$ is the sum of all the $\cos^2(\theta)$, so

$$\cos(\vartheta) \leq \sqrt{\text{tr}(EFE)}.$$  

Suppose that $E$ corresponds to the position of a particle being in a particular interval of length $\ell$. The uncertainty principle then asserts that the sum of the squares of the uncertainties in the positions of $E$ and $F$ is less than or equal to $\ell^2$.
\(\Delta q\) and that \(F\) corresponds to the momentum of the particle being in another interval of length \(\Delta p\). Then the trace is given explicitly by

\[
\text{tr}(EFE) = \frac{\Delta q \Delta p}{2\pi \hbar}.
\]

If the product \(\Delta q \Delta p\) is much smaller than \(\hbar\), then the trace is close to zero, the minimum uncertainty principle: it is impossible to simultaneously specify position and momentum to a greater precision than given by Planck’s constant \(\hbar\).

There are two ways of combining pure states to give new states, superposition, and mixture. A superposition is obtained by taking linear combinations of the vectors. Thus if \(\psi_a\) is an orthonormal family of unit vectors and \(c_a\) are complex coefficients with \(\sum |c_a|^2 = 1\), then the superposition is the pure state given by the vector \(\sum c_a \psi_a\). The corresponding one-dimensional state projection \(P\) is

\[
P = \sum_b \sum_a \bar{c}_a c_b \psi_b \langle \psi_a, \cdot \rangle,
\]

and the probability of a property \(E\) is

\[
p(E) = \sum_b \sum_a \bar{c}_a c_b \langle \psi_a, E \psi_b \rangle.
\]

The terms \(\bar{c}_a c_b\) with \(a \neq b\) are called interference terms. If one thinks of the pure state as points in a complex projective space, then the superposition of states is given by a geometrical construction in this space. For example, the possible superpositions of two states lie on the projective line (Riemann sphere) containing the two states (see [3] for an elementary discussion).

The other way of combining pure states is as a mixture obtained by taking linear combinations of the corresponding one-dimensional projections. The coefficients are probabilistic weights \(w_a \geq 0\) with \(\sum_a w_a = 1\). The mixture is the state obtained by randomization with these weights, so the probability of a property \(E\) is

\[
p(E) = \sum_a w_a \langle \psi_a, E \psi_a \rangle.
\]

There are no interference terms. Let \(\rho\) be the density operator defined by combining the projections with these weights, so

\[
\rho = \sum_a w_a \psi_a \psi_a^\dagger.
\]

This is a positive self-adjoint operator with trace equal to one. The probability of the property in the mixed state is the trace of the product of the state operator \(\rho\) with the property projection \(E\):

\[
p(E) = \text{tr}(\rho E).
\]

Superposition has characteristically quantum mechanical features (interference terms), while mixture is just an ordinary probabilistic process.

**Decoherence**

The most famous puzzles of quantum mechanics have to do with the notion of superposition. These arise when the classical world of macroscopic properties is coupled to the quantum world of atomic properties. The conventional account of this refers to an experimenter who couples an atomic system to the fate of a cat. However, it is convenient conceptually to dispense with the experimenter, and present practice is to substitute a less attractive life form, perhaps from another phylum [4]. For instance, the decay of a single radioactive atom might trigger a volcanic eruption that kills a passing cockroach. The collective variables describing the fate of the cockroach are coupled to the environment that consists of the world on the atomic scale. The state determining the health of the cockroach might well turn out to be a superposition of two states, one where the cockroach is alive and the other where it is dead. This involves more than just uncertainty about the fate of the cockroach; the two possible states are entangled in a more profound sense.

Such a situation has its formulation in the framework of quantum mechanics. Consider two quantum mechanical systems described by Hilbert spaces \(\mathcal{H}_C\) and \(\mathcal{H}_E\). We can think of the first system as a collective system (describing a cockroach or perhaps a counter in some physics laboratory). The second system is the environment. These two systems determine a combined system determined by the tensor product Hilbert space \(\mathcal{H} = \mathcal{H}_C \otimes \mathcal{H}_E\). For each pair of vectors \(\psi\) in \(\mathcal{H}_C\) and \(\chi\) in \(\mathcal{H}_E\) there is a tensor product vector \(\psi \otimes \chi\) in \(\mathcal{H}\). Such a tensor product vector represents a pure state in which the two systems are independent. Let \(\phi_i\) and \(\psi_j\) be orthonormal bases for \(\mathcal{H}_C\) and \(\mathcal{H}_E\). The tensor product vectors \(\phi_i \otimes \psi_j\) form an orthonormal basis for \(\mathcal{H}\). The general vector in \(\mathcal{H}\) is a doubly indexed linear combination of tensor product basis vectors

\[
\Psi = \sum_i \sum_j c_{ij} \phi_i \otimes \psi_j.
\]

This may be partially factored as

\[
\Psi = \sum_i \phi_i \otimes \left( \sum_j d_{ij} \phi_j \right) = \sum_i c_i \phi_i \otimes \chi_i,
\]
The change of a quantum system over a time interval is given in conventional quantum dynamics by a unitary operator. An operator $U$ from $\mathcal{H}$ onto itself is unitary if it preserves the inner product. In the Schrödinger picture this is regarded as changing state vectors $\psi$ to state vectors $U\psi$. In the Heisenberg picture this is regarded as changing properties $F$ to corresponding properties $F^U$ defined by $F^U = U^{-1}FU$. Since

$$\langle U\psi, FU\psi \rangle = \langle \psi, U^{-1}FU\psi \rangle,$$

these two pictures give the same predictions for the probabilities. Theoretical physicists spend much effort computing the unitary dynamics for a given situation.

In some variants of the Copenhagen interpretation there is another kind of change, a so-called reduction, or collapse, of the state vector. In the simplest circumstance it takes the following form. With the state $p$ given by $\psi$ the probability of property $E$ is

$$p(E) = \langle \psi, E\psi \rangle = \|E\psi\|^2.\tag{1}$$

If, after a measurement, $E$ turns out to be true, then the state vector changes to $E\psi/\|E\psi\|$. With this new state $\hat{p}$ the probability of another property $F$ would be $p(E') = \langle E'\psi, E\psi \rangle / \|E\psi\|^2 = \|F\psi\|^2 / \|E\psi\|^2$. Since reduction provides a new kind of dynamics, it seems that one should either explain its relation to the unitary dynamics or eliminate it from the theory.

The book under review has a proposal in this direction. The idea is that it is useful to assign probabilities to ordered conjunctions of properties. These properties need not be compatible. Let $E$ and $F$ be projections representing properties. Consider the operator $EFE$, representing an ordered conjunction of $E$ and $F$. Regard the state $p$ as a linear function defined on operators, and define the probability of the ordered conjunction of $E$ and $F$ to be $p(EFE)$. For a pure state this probability is $\langle \psi, EFE\psi \rangle = \|F\psi\|^2$ (Figure 5). Similarly, the probability of $E' = I - E$ and $F$ is $p(E'FE')$. These should add up to the probability of $F$. The additivity condition

$$p(EFE) + p(E'FE') = p(F)$$

is equivalent to

$$p(EFE') + p(E'FE) = 0.$$
When this is satisfied, the properties are said to be consistent with respect to the state \( p \). More generally, let \( E_1, \ldots, E_m \) be a family of exclusive properties such that \( E_1 + \ldots + E_m = I \). Let \( F_1, \ldots, F_n \) be another such family. Define the probability of the ordered conjunction of \( E_i \) and \( F_j \) as \( p(E_i F_j E_i) \). The consistency condition for additivity is now

\[
p(E_i F_j E_k) + p(E_k F_j E_i) = 0
\]

for \( i \neq k \).

If properties are compatible, then they are consistent with respect to every state. However, for special states there may be properties that are consistent but not compatible. A simple example of consistency is when the state is a probabilistic mixture of pure states given by orthogonal unit vectors \( \phi_i \) with weights \( w_i \). If the projections \( E_i \) project onto the vectors \( \phi_i \) and the projections \( F_j \) are arbitrary, then the properties are consistent, and the probabilities of the conjunctions taken in order are

\[
p(E_i F_j E_i) = w_i \langle \phi_i, F_j \phi_i \rangle.
\]

This example provides a possible framework for discussion of the decoherence effect.

Omnes, following Griffiths [5], is motivated by examples where \( E_i \) and \( F_j \) are properties associated with two different times \( s < t \). When the properties are consistent, this is an example of what is called consistent histories. This notion may be generalized to any finite number of reference times. Consistent families of histories are rare objects, but they are central to the proposed theory.

One appeal of consistent histories is that they might replace reduction of the state vector. In the state \( p \) given by \( \psi \) the probability of \( E_i \) is \( p(E_i) = \langle \psi, E_i \psi \rangle = \|E_i \psi\|^2 \), and the probability of \( E_i \) and then \( F_j \) is \( p(E_i F_j E_i) = \langle \psi, E_i F_j E_i \psi \rangle = \|F_j E_i \psi\|^2 \). The conditional probability of \( F_j \) given \( E_i \) is the quotient \( p(E_i F_j E_i)/p(E_i) = \|F_j E_i \psi\|^2 / \|E_i \psi\|^2 \). This is the probability of \( F_j \) that would have been given by reduction if the previous measurement had made \( E_i \) true.

A consistent family of histories has no more quantum mystery; it defines an ordinary stochastic process. A stochastic process is a probability measure \( P \) on a space of functions of time. If there are only two instants of time \( s < t \), then an element of this space is a function \( \omega \) defined on \( (s, t) \) such that \( 1 \leq \omega(s) \leq m \) and \( 1 \leq \omega(t) \leq n \). Such a function is an outcome of the probability experiment. An event is a set of outcomes; it is usually defined by a condition involving an arbitrary outcome \( \omega \). The probability measure \( P \) assigns a probability to each event. It is characterized by

\[
P(\omega(s) = i, \omega(t) = j) = p(E_i F_j E_i).
\]

For each \( i \) there is a new probability measure \( \hat{P}_i \) defined by

\[
\hat{P}_i(\omega(s) = i, \omega(t) = j) = \frac{p(\omega(s) = i, \omega(t) = j)}{p(\omega(s) = i)} = \frac{p(E_i F_j E_i)}{p(E_i)}.
\]

This is the conditional probability given the event \( \omega(s) = i \). The calculation above shows that it coincides with the probability measure given by reduction of the quantum state.

We are accustomed to the fact that probabilities do not determine the actual outcome of an experiment. No amount of mathematics can foretell the conclusion of an evening at the roulette tables. On the other hand, partway through the evening we know how we are doing. Our stochastic process is like any other probability model; the probabilities given by \( P \) do not determine the outcome \( \omega \). This is only known when the experiment has been completely performed. If the experiment has been conducted only up to time \( s \), then it may be known only that \( \omega(s) = i \), for some particular \( i \). This partial knowledge of the outcome of the experiment is equivalent to a knowledge of the probability measure \( \hat{P}_i \), since \( \hat{P}_i \) determines \( i \). In fact, \( \hat{P}_i \) assigns probability one to the event that \( \omega(s) = i \). If one keeps a fixed quantum state, the probability measure is fixed, and the partial outcome is new information. On the other hand, if a reduction of the quantum state is specified, then this determines the new measure and hence the partial outcome. Thus there are two different mechanisms that can describe evolving reality for a consistent family of histories: a direct description of the evolving outcome or an evolving reduction of the state vector. The next issue is whether one or the other of these mechanisms is appropriate to the interpretation of quantum mechanics.

**Actualization**

The bedrock of the Omnes theory is Rule 1: The theory of an individual isolated physical system is entirely formulated in terms of a specific Hilbert space and a specific algebra of operators, together with the mathematical notions associated with them. Omnes emphasizes: "The word 'entirely' that occurs in it will be taken in its strongest sense, to mean that not only dynamics, but also the logical structure of the theory and the language one uses when applying it to observations and experiments will be cast into the mold of Hilbert space." Again: "What is important about the first rule is that it assumes that
everything that might be said about the physical system should take place in its mathematical framework. This includes in particular the understanding of empirical properties and the whole of interpretation.” He shows no enthusiasm for the notion that “other significant data could exist, completing or replacing the wave function.”

Rule 2 requires unitary dynamics, and Rule 3 deals with the description of composite systems by tensor product Hilbert spaces. Everything must fit into this structure, including the world of our familiar experience. One must make the most of the Hilbert space structure, and this is where consistent histories are to be put to use.

Omnès elevates their role to a “universal role of interpretation,” given as Rule 4: Every description of a physical system should be expressed in terms of properties belonging to a common consistent logic. A valid reasoning relating these properties should consist of implications holding in that logic. Such a logic is defined by the probabilities associated with the histories; a property implies another property if the conditional probability of the second property given the first property is equal to one.

The first task of consistent histories in the Omnès theory is to explain classical properties. These are properties defined by requiring that collective variables belong to cells in classical phase space of a size that is large with respect to Planck’s constant $\hbar$. For systems in which there is no significant interaction of the collective variables with variables on the atomic scale, and for initial states that specify a single cell, these classical properties are at least approximately consistent and obey deterministic dynamics. So the classical world has its familiar properties while being part of the quantum world. In particular we can talk about the usual trajectories given by classical mechanics. In more general situations there is the possibility of interaction between the collective system and the atomic-level environment. Then decoherence eliminates interference effects and allows the collective system to be described by ordinary probability.

Omnès refers to classical properties of macroscopic objects that arise from this theory as phenomena. Phenomena are described by probabilistic laws. Classical properties are called facts when they actually occur in reality. The passage from phenomena to facts does not emerge from the internal structure of quantum mechanics; Omnès postulates it as an additional rule, analogous to the reduction rule of the Copenhagen interpretation. The postulated passage from phenomena to facts is called actualization. Obviously this is an important transition, especially for the cockroach. It also is important for the theoretical structure of the book. The statement is the following Rule 5: Physical reality is unique. It evolves in time in such a way that, when actual facts arise from identical antecedents, they occur randomly and their probabilities are those given by the theory.

This statement by itself does not give a clear picture of the mathematical formulation of actualization. The intent may be that the notion of “fact” is external to the theory, so that the rule of actualization is merely a license to use consistent logic to reason from present brute experience. This is supported by the assertion: “The existence of actual facts can be added to the theory from outside as a supplementary condition issued from empirical observation.” A dead cockroach is a fact; there is no more to it. This is a long way from the ambitious goal of basing everything on Hilbert space.

However, in another passage Omnès describes a change in the state given by what appears to be continuous reduction on the classical level. “Let $\{F_k(t_k)\}$ denote the quasi-projectors representing all the facts having occurred everywhere in the ‘universe’ at some time $t_k$ earlier than the time $t$. One can then consider that the state of the universe at time $t$ is the result of all these facts combined with the assumed knowledge of the initial state of the ‘universe’ at some initial time.” The state is expressed in terms of an initial state and an operator $G(t)$ that “recapitulates all the facts occurring between an initial time $t_0$ and the time $t$. More explicitly, one has

$$G(t) = T \left\{ \prod_{t_k \leq t_0} F_k(t_k) \right\}.$$  

This is a time-ordered product [later times to left of earlier times], as indicated by the symbol $T$.

In this new state certain classical properties have probability one and thus can be said to be factual or true. There are obvious questions. Does Rule 5 prescribing actualization require the new dynamics that recapitulates facts? What is the relation between the unitary dynamics given by Rule 2 and the new dynamics? Are Rule 1, Rule 2, and Rule 5 (however interpreted) consistent?

The actualization postulate thoroughly undermines any program of basing the theory on orthodox quantum dynamics alone. Omnès nevertheless wants to think of actualization in a positive way; he bravely remarks that “the inability of quantum mechanics to offer an explanation, a mechanism, or a cause for actualization is in some sense a mark of its achievement. This is because it would otherwise reduce reality to bare mathematics and would correspondingly suppress the existence of time.”
The postulate of actualization is designed to forestall an interpretation of quantum mechanics in which the various histories that are predicted with nonzero probability all have a claim to current physical reality. This variant would "rely on Everett's approach and to consider 'our' actual present as a branch of the histories of the universe separated from all the other ones." Omnès finds this alternative "difficult to accept."

Perhaps one could interpret the Rule 5 of actualization in another way, as introducing a particular history that is a new element of reality. Is this consistent with Rule 1? Perhaps not, since Rule 1 seems to require that the state vector and its relation to the various quantum properties provide a complete description of the current physical situation. If Rule 1 is relaxed, then certainly something like actualization can take place without a corresponding change in the state vector. This is the usual situation with a stochastic process, where, as we have seen, the outcome of the experiment is not predicted by the probability model. It is possible that the outcome can be explained by a more elaborate model, but the search for such a model is a new scientific endeavor, perhaps quite difficult. (It might be a considerable challenge to find a mechanical explanation for the sorry results of the evening of roulette.) In any case, if the outcome has been observed up to a certain time, then this provides an account of the current situation. There is no need to discard the original probabilities, though it is quite natural to consider the conditional probabilities given the outcome up to the present as a prediction of the future. In the context of a stochastic process given by a consistent family of histories, the state vector determines the probabilities of various histories, but the outcome would be a particular history. The particular history that occurs is extra information not specified by the state vector, so such an interpretation admits data outside the Hilbert space framework as part of the current physical situation.

**Measurement**

Up to this point this version of quantum theory seems to be a theory of properties of macroscopic objects. How about the properties of objects on the atomic scale; are they ever definitely true or false? The answer to this is to be given by the theory of measurement. For this purpose we decompose our system in a somewhat different way, into an atomic system and a larger system that is to act as a measuring device. The classical properties of the measuring device will be called data, while the corresponding properties of the atomic system will be called results. The results precede the data. In appropriate circumstances results and data fit into consistent histories, and furthermore the results and data are equivalent. This constitutes a measurement.

We can again think of the decay of the radioactive atom and the resulting condition of the cockroach. Suppose that the only immediate menace to the cockroach is the decay of the radioactive atom and the subsequent volcanic eruption. The health of the cockroach may be thought of as an experimental datum. The corresponding result is a statement of what happened to the atom.

A factual property is always regarded as being true. According to Omnès, in the context of a measurement, if the property expressing the datum is a fact, then the property expressing the result should also be considered as true. Thus one is allowed to speak, at least in special circumstances, of the truth of properties of systems on the atomic level. The death of the cockroach is equivalent to the decay of the atom. If in fact the cockroach is dead, then the atom must have decayed. The measurement situation is exceptional; in most other cases a radioactive decay cannot be said to have happened or not to have happened.

The following more detailed sketch of the measurement process illustrates how one works with these concepts. The picture presented by Omnès follows the general pattern of the classic von Neumann account. The Hilbert space is a tensor product \( \mathcal{H} = \mathcal{H}_C \otimes \mathcal{H}_E \) describing the combination of the collective system that describes the data with the atomic system describing the radioactive emission for which one wants to obtain results. There are orthonormal state vectors \( \chi_i \) of the atomic system \( \mathcal{H}_E \) with corresponding projection operators \( E_i \). These operators represent the results. The general pure state of the atomic system is a superposition \( \sum a_i \chi_i \).

There are also corresponding orthonormal state vectors \( \phi_j \) of the collective system \( \mathcal{H}_C \) with projection operators \( F_j \). Their role is to represent the data. The initial state of the collective system is taken to be some \( \phi_0 \). The initial pure state of the combined system is a tensor product state, and the two systems are independent:

\[
\Psi = \phi_0 \otimes \sum a_i \chi_i.
\]

A measurement is a special kind of dynamical process given by a unitary operator \( U \). In the Schrödinger picture \( U \) acts so that

\[
U(\phi_0 \otimes \chi_i) = \phi_i \otimes \psi_i,
\]

where the \( \psi_i \) are some other unit vectors whose nature is irrelevant. The important part is that \( U \) relates the state vector \( \chi_i \) of the atomic sys-
tem at the beginning of the process (the eventual result of the measurement) to the state vector $\phi_i$ of the collective system describing the data at the end of the process. The resulting state vector for the combined system is a superposition that specifies a strong dependence between the constituent systems:

$$U\Psi = \sum_a c_a \phi_a \otimes \psi_a.$$ 

Let $\hat{E}_i$ and $\hat{F}_j$ be the projections for the combined system corresponding to the results and the data at time zero. In the Heisenberg picture the state vector remains the initial $\Psi$, while the projections for the data at the later time of the measurement are $\hat{F}_j = U^{-1} \hat{F}_j U$. In the state determined by $\Psi$ we can use the fact that $\hat{E}_i$ projects on $\chi_i$ and the form of the unitary time evolution operator $U$ to compute that

$$p(\hat{E}_i \hat{F}_j \hat{E}_k) = \hat{c}_i \hat{c}_k (\phi_0 \otimes \chi_i, U^{-1} \hat{F}_j U \phi_0 \otimes \chi_k))$$

$$= \hat{c}_i \hat{c}_k (\phi_i \otimes \psi_i, \hat{F}_j \phi_k \otimes \psi_k).$$

However, $\hat{F}_j$ projects on $\phi_j$, and the $\phi_j$ are orthonormal. So this is just

$$p(\hat{E}_i \hat{F}_j \hat{E}_k) = |c_i|^2 \delta_{ij} \delta_{jk}.$$ 

Since this is zero for $i \neq k$, the logic is consistent. In particular the probability for the ordered conjunction of result and datum is

$$p(\hat{E}_i \hat{F}_j \hat{E}_i) = |c_i|^2 \delta_{jj}.$$ 

This says that each result is equivalent to the corresponding datum. In particular they have the same probability $p(\hat{E}_i) = p(\hat{F}_j) = |c_i|^2$. As Omnes remarks, "When one thinks of how complicated a measuring apparatus can be and how different two experimental devices purporting to measure the same quantity may be, it is remarkable that there exists such a simple universal correspondence between them."

**Experiments**

Some of the peculiar features of quantum mechanics may be artifacts of theoretical interpretation, but there are experiments that more or less directly test the fundamental principles. Omnes briefly describes Leggett’s experiment with superconducting quantum interference devices. The magnetic flux through a superconducting ring plays a role analogous to that of the position of a particle undergoing radioactive decay. By this means one can observe the analog of a radioactive decay, but with a macroscopic device. According to Omnes, this means that there is "no Heisenberg frontier between the microscopic and macroscopic domains, nor is Bohr’s point of view useful because one cannot tell here what is a phenomenon and what is not."

The relation of laboratory experiments to the mathematical apparatus of quantum mechanics is subtle. For instance, it is often held that the uncertainty principle relating position and momentum is a fundamental principle of quantum mechanics. On the other hand, it can be argued that momentum is measured in practice by measuring particle location in a scattering experiment. There are only position measurements, and so there is no independent empirical content to the momentum properties that play such a fundamental role in the mathematical formulation. This point of view is vigorously defended by some proponents of such alternative theories as Bohmian mechanics and stochastic mechanics.

One remarkable effect has a rather direct experimental test. Omnes discusses the famous example of a system prepared in a state in which two particles are widely separated in space but intimately related in their behavior. This manifests itself in strong correlations between experimental results at the two locations. The analysis of the implications of such experiments involves concepts of *locality*. Although the treatment in the book is not explicit on this point, it is helpful to distinguish two types of locality. The condition of *active locality* is that there is no instantaneous influence over long distances. This seems to be satisfied in nature. The condition of *passive locality* is more subtle; it says that simultaneous random events at widely separated locations that are correlated must be correlated only through events in their common past. Bell showed that any deterministic or probabilistic theory that purports to be an alternative to quantum mechanics and that satisfies both the active locality and passive locality conditions must have correlations that satisfy certain inequalities [6]. The experimental results agree with quantum mechanics; the correlations are so strong that Bell’s inequalities are violated. From this, one can conclude that in any alternative theory one of the locality conditions must be violated. However, this is no worse than the situation in quantum mechanics, which also seems far from satisfying any condition like passive locality. There is a more complete discussion of this issue in the appendix to reference [7]. The conclusion seems to be that we live in a world generously furnished with unexplained and unexplainable coincidences.

**Interpretations**

In his final summary, Omnes compares three possible outlooks on quantum mechanics. There is the radical view that the theory is not yet in final form and that there should be a deeper de-
scription of reality at the atomic level than that given by the quantum state. There is the Everett many-world interpretation and such theories as that of Gell-Mann and Hartle; these maintain conventional quantum dynamics. Finally, there are views such as the Copenhagen interpretation, and the view of Omnès himself, where the quantum state is to provide the complete description of the physical situation; these require either an external interpretation or a new kind of quantum dynamics to make reality unique.

The radical view is provoked by the puzzle over whether we understand a world in which properties on the atomic scale are typically neither true nor false. Various people have attempted to provide a more satisfying picture; Wick’s recent book [7] has a lively discussion of this history. Omnès describes the Ghirardi, Rimini, and Weber [8] proposal of spontaneous random wave packet reduction. He also mentions Bohm’s theory [9, 10, 11] and stochastic mechanics [12, 13]. In both these theories particles have trajectories, and statements about their positions are perfectly meaningful at all times. The particle trajectory is extra information not given by the state vector. However, the probability predictions for position at fixed time agree with those of quantum mechanics. The theories are rather similar, except that in Bohm’s theory the particle moves deterministically, while in stochastic mechanics there is an extra diffusive component. Neither of the theories is as well developed in the relativistic domain as orthodox quantum mechanics. Furthermore, Bohm’s theory and stochastic mechanics both violate the active locality condition on the level of the particle trajectories [14], and this is troubling. On the other hand, a study of these theories has a liberating effect that may point the way to new directions.

The Everett many-world interpretation accepts the fact that the conventional quantum dynamics applies in all cases and interprets it as a theory of multiple reality. However, conventional quantum dynamics is compatible with a single reality. A specified consistent family of histories defines a stochastic process; the experimental outcome can be a particular history. More recently Gell-Mann and Hartle have presented another attempt to maintain quantum dynamics. They use many of the same technical ingredients as in the Omnès theory, including decoherence and consistent histories. According to Omnès, they “attribute completely to decoherence the dynamical origin of phenomena...as well as the selection of the significant collective observables and...the occurrence of the histories making physical sense.” These authors want a consistent family of histories to represent a “quasiclassical domain” of familiar experience. The specification of the family is an important issue. They say in one of their articles [15] that, “We have posed the question as to whether there could be various kinds of essentially inequivalent quasiclassical domains or whether any quasiclassical domain is more or less equivalent to any other. The former case poses some challenging intellectual puzzles, especially if we imagine [information gathering and utilizing systems] evolving in relation to each of the essentially inequivalent classical worlds.”

Finally, there is the version offered by Omnès. In the end this new synthesis of quantum mechanics turns out to be fairly close to the old Copenhagen account. There are differences; in the Copenhagen version the classical world is complementary to the quantum world, while in the Omnès picture it emerges from the quantum world. According to Omnès, quantum mechanics is divided into parts concerned with dynamics and with logic, and “contrary to dynamics, the logical structure of quantum mechanics must select a definite direction of time.” The underlying problem is the same in the two interpretations. In the Copenhagen interpretation there is the external notion of measurement, and in some versions there is a “reduction of the wave packet” that takes place in the quantum world as a consequence of measurement. In the Omnès account the corresponding process is the spontaneous classical actualization of facts. This concept is never clearly explained. However, it appears that in both accounts one has to rely on external elements or violate quantum dynamics in order to salvage the interpretation.

The most important ingredient in the current attempts to maintain orthodox quantum mechanics is the notion of decoherence. This idea has been around for some time; Omnès gives several references. (The reviewer first encountered it in mathematically rigorous form in papers of Hepp and Lieb [16] in the mid-seventies.) It explains to some extent why it is so difficult to make the paradoxical-seeming statements of quantum mechanics expose their own weakness in some crucial experiment. The fact that this is a dynamical effect makes it a tempting subject for further research by mathematicians, whatever their views on the underlying philosophy.

Decoherence makes possible the existence of a family of consistent histories, at least on the level of classical properties. Such a family defines a stochastic process. If this process can be specified in some natural and precise way, then an experimental outcome is a history in some huge space of classical properties. If this outcome is regarded as part of the description of the actual physical situation, then this gives a strange role
for the atomic world: to define a reality that exists only on the level of the classical world. Furthermore, such a description puts the theory on the same ground as theories that define a stochastic process on the atomic level, where again the state vector is not the complete description of reality. This direction could lead far from quantum orthodoxy.

What can we conclude from such a book? Some physicists regard quantum mechanics as a totally successful theoretical framework; they consider any attempt to raise questions about its foundations as an irritating distraction. Omnes, to his credit, recognizes that the puzzles are profound and that the traditional resolutions do not achieve the level of clarity appropriate to a completed science. Furthermore, he embarks on the task of providing a resolution within the framework of orthodox quantum mechanics. If he or anyone else succeeds in this task, then the questions should be settled, once and for all. In the present case the book is energetic and lively and full of examples and ideas. But the core resolution is merely a desperate bluff. The resolution is to "add to the whole logical construction an assumption according to which present phenomena are unique (and therefore facts)." The bluff lies in such statements as: "the actuality of facts is something that need not be explained by a theory," and "when one finds a gap between theory and reality only at their common extremities, this is not a failure but the mark of an unprecedented success for quantum mechanics, as compared with all the theories before it." The fact that an obviously competent physicist is driven to such assertions is evidence that the quantum theory remains in conceptual murk. The challenge remains: interpret quantum mechanics on its own terms, without appeal to authority, in a way that makes sense to reasonable people. This challenge has not yet met an adequate response.

References

Three Leroy P. Steele Prizes were awarded at the Summer Mathfest held at the University of Washington in Seattle in early August. These prizes were established in 1970 in honor of George David Birkhoff, William Fogg Osgood, and William Caspar Graustein and are endowed under the terms of a bequest from Leroy P. Steele.

The Steele Prizes are awarded in three categories: for expository writing, for a research paper of fundamental and lasting importance, and for cumulative influence extending over a career, including the education of doctoral students. The current award is $4,000 in each category.

The recipients of the 1996 Steele Prizes are BRUCE C. BERNDT and WILLIAM FULTON for Mathematical Exposition, DANIEL STROOCK and S. R. S. VARADHAN for Seminal Contribution to Research, and GORO SHIMURA for Lifetime Achievement.

The Steele Prizes are awarded by the AMS Council acting through a selection committee whose members at the time of these selections were Richard Askey, Ingrid Daubechies, Eugene Dynkin, H. Blaine Lawson, Andrew J. Majda, Barry Mazur, Marina Ratner, Gary M. Seitz, and William P. Thurston.

The text that follows contains, for each award, the committee's citation, the recipient's response, and a brief biographical sketch of the recipient.

Steele Prize for Mathematical Exposition: Bruce C. Berndt

Citation
To Bruce C. Berndt for the four volumes *Ramanujan's Notebooks*, Parts I, II, III, and IV, Springer, 1985, 1989, 1991, and 1994. In recognition of Berndt's heroic and extraordinary achievement in exposing to the general mathematical researcher a trove of results that were utterly inaccessible before, the AMS decided this year, exceptionally, to broaden the standard interpretation of "exposition". In an impressive scholarly accomplishment spread out over 20 years, Berndt has provided a readable and complete account of the notebooks, making them accessible to other mathematicians. Ramanujan's enigmatic, unproved formulas are now readily available, together with context and explication, often after the most intense and clever research efforts on Berndt's part.

Response
I owe my first debt of gratitude to the late Emil Grosswald. It was on a cold winter day in early February 1974, while on leave at the Institute for Advanced Study, that I was reading two papers of Grosswald in which he proved some formulas from Ramanujan's notebooks. I suddenly realized that I could also prove these formulas by using some transformation formulas for Eisenstein series that I had proved about two years earlier. I was naturally curious to determine if...
there were other formulas in the notebooks that I could prove using my theorems. Fortunately, the library at Princeton University had a copy of the Tata Institute's photostat edition of Ramanujan's Notebooks. I found a few more formulas which I could prove, but I also found a few thousand others which I could not prove.

In the spring of 1977, I set myself the task of attempting to prove all the results in Chapter 14 (87 altogether) of the second notebook, where the formulas which Grosswald had proved can be found. After I had been working on this project for nearly a year, George Andrews informed me that the library at Trinity College, Cambridge, possessed the notes that B. M. Wilson and G. N. Watson had accumulated in their efforts to edit the notebooks in the 1930s. I decided that, with these notes, I could possibly further chapters, and so wrote Trinity for a copy. To make a long story short, since May 1977, I have devoted all of my research efforts to establishing the 3,000–4,000 unproved claims made by Ramanujan in his notebooks. In particular, Watson's notes were extremely helpful in the massive amount of material on modular equations.

During this time I have been stymied numerous times by Ramanujan's formulas, and after months or years of frustration I often turned to other mathematicians for help. At the University of Illinois, we have been blessed with a large number of very gifted graduate students in number theory, and several of them have made important contributions to my work, both while at Illinois and more frequently in the years that followed. I particularly owe a huge debt of gratitude to my first Ph.D. student, Ron Evans, at UCSD, and to my most recent Ph.D. student, Heng Huat Chan, on his way from the Institute for Advanced Study to National Chung Cheng University. I also express my thanks to the following mathematicians (including former students), without whose help the task of editing the notebooks would not have been completed: George Andrews, Richard Askey, Gennady Bachman, S. Bhargava, Tony Bhagiolli, D. Bradley, Henri Cohen, Frank Garvan, Jim Hafner, Lisa Lorentzen, Kenneth Williams, Don Zagier, and Liang-Cheng Zhang. A more complete list can be found in Ramanujan's Notebooks. Part V, which will be submitted to Springer-Verlag early this fall.

I also am grateful to my colleagues in number theory at the University of Illinois for their many suggestions and support. In particular, my association with Springer began in the early 1980s when Heini Halberstam called me to his office to meet Walter Kaufmann-Bühler, who suggested that I compile my work into volumes for Springer. Thanks for the completeness of the bibliographies goes to Nancy Anderson, mathematics librarian at the University of Illinois, for helping me dig up many obscure references. The early years of my work were supported by the Vaughn Foundation, and I extend my sincere gratefulness to James Vaughn for this support. Most of all, I express my thanks (and my continual amazement) to Ramanujan for leaving so many beautiful theorems and formulas to mathematics.

Biographical Sketch
Professor Berndt has his bachelor's degree from Albion College and received his Ph.D. in 1966 from the University of Wisconsin, Madison. His first position after receiving his Ph.D. was at the University of Glasgow (1966–67). While most of his academic life has been spent at the University of Illinois, Urbana-Champaign, he was a member of the Institute for Advanced Study (1973–74). Since 1986 he has served as associate editor of the Journal of Mathematical Analysis and Applications. Berndt is one of two coordinating editors for The Ramanujan Journal, the first issue of which is scheduled to be published in January 1997 by Kluwer. He has been the recipient of the Young College Educator Award (University of Illinois, 1972), two Lester R. Ford Awards (1989 and 1994), and the Carl B. Allendoerfer Award.

A fifth and final volume of the notebooks, Part V, will be submitted this October. His book Ramanujan: Letters and Commentary (coauthored with Robert A. Rankin) was published by the AMS last year.

Steele Prize for Mathematical Exposition: William Fulton

Citation
To William Fulton for his book Intersection Theory, Springer-Verlag, "Ergebnisse series", 1984. It introduced a new order into a field that had been in disarray, by introducing a new and simpler approach that gave all the old results and more. Moreover it gave clarifying expositions of many classical computations in intersection theory, often reducing lengthy old arguments to a few lucid paragraphs. By its very clear exposi-
to be discovered in the classical literature related to intersection theory.

Another reason for my appreciation of this award is the hope that it may spur Springer-Verlag to print a new edition, so that the corrections that readers have generously sent to me since 1984 can be incorporated!

Biographical Sketch
William Fulton received his B.A. from Brown University (1961) and his Ph.D. from Princeton University (1966). He held junior positions at Princeton University (1965-66, 1969-70) and at Brandeis University (1966-69). At Brown University Professor Fulton served as associate professor (1970-75), professor (1975-87), and chair (1985-86). He moved to the University of Chicago in 1987, where since 1995 he has been the Charles L. Hutchinson Distinguished Service Professor.


Professor Fulton was a Guggenheim Fellow during 1980-81. The Swedish Natural Science Research Council has appointed him the Tage Erlander Guest Professor for 1996-97.

Steele Prize for Seminal Contribution to Research: Daniel Stroock and S. R. S. Varadhan
Citation
To Daniel Stroock and Srinivasa Varadhan for their four papers


in which they introduced the new concept of a martingale solution to a stochastic differential equation, enabling them to prove existence, uniqueness, and other important properties of solutions to equations which could not be treated before by purely analytic methods; their formulation has been widely used to prove convergence of various processes to diffusions.

Response from Professor Stroock
I am honored to share the Steele Prize with my old friend and colleague, S. R. S. Varadhan. I am also amused to realize that the articles cited might never have been written had \\TeX been available to our teacher, H. P. McKean, Jr. Indeed, Varadhan's and my collaboration grew out of a seminar on stochastic integration which McKean was conducting at Rockefeller University in 1967. The seminar was based on the preliminary, typewriter-produced manuscript of what would become McKean's famous little treatise on the topic. Using the Springer-Verlag color-coding scheme, McKean had scrupulously marked the original to distinguish between various typefaces. Unfortunately, his efforts were obliterated by xerography. As I recall, there was one page on which the letter "e" was to be typeset in five different fonts. On the Xerox copies, four of the five appeared with indistinguishable grey underlines. As a result, even K. Itô, the father of stochastic integration theory, would have found McKean's handouts a challenging exercise in cryptography. Thus, it should be no surprise that a couple of novices such as Varadhan and I would have been confused sufficiently to seek an alternative formulation of the whole subject. What is surprising is that, nearly thirty years later, our alternative has been deemed worthy of the Steele Prize.

Biographical Sketch of Daniel Stroock
Daniel Stroock received his A.B. from Harvard College in 1962 and did his doctoral research at Rockefeller University under the direction of Mark Kac, receiving his Ph.D. in 1966. From 1966 to 1972, he was at the Courant Institute of Mathematical Sciences at New York University, first as a postdoc and then as an assistant professor. In the fall of 1972 he decamped to the University of Colorado at Boulder, where he rose to the rank of professor before departing in the fall of 1984 for his present position at the Massachusetts Institute of Technology. Aside from the work with Varadhan which has been cited by the Steele Prize Committee, the accomplishment for which he is best known is the popularization of the name (if not the topic) that he called Malliavin's Calculus.

Response from Professor Varadhan
I want to thank the American Mathematical Society as well as the members of the Steele Prize committee for selecting me as a recipient this year. I am very pleased that my colleagues have chosen to single out some of my work with Dan Stroock in the late sixties as important. The Courant Institute, where most of the work was done, provided us with an ideal intellectual environment. We had the active encouragement and support of our senior colleagues, particularly Louis Nirenberg and Monroe Donsker. With the presence of Henry McKean and Mark Kac at Rockefeller, New York was indeed a very exciting place to be for an aspiring probabilist. Dan and I worked closely during this period, and to me it was very exciting and fruitful. I thank him, not just because he was a great person to work with, but for the years of close friendship as well. I am particularly pleased to be sharing this prize with him.

I was fortunate to have been a graduate student at the Indian Statistical Institute in Calcutta, which provided a very stimulating environment for my education. I want to express my appreciation to my advisor, C. R. Rao, and my colleagues V. S. Varadarajan, K. R. Parthasarathy, and R. Ranga Rao, from whom I learned a lot. Finally, I wish to express my thanks to my wife, Vasu, whose love and understanding have always been a source of strength to me.

Biographical Sketch of S. R. S. Varadhan
Srinivasa R. S. Varadhan received his B.Sc. degree from Presidency College, Madras (1959), and his Ph.D. from the Indian Statistical Institute (1963). Professor Varadhan began his academic career at the Courant Institute of Mathematical Sciences at New York University as a postdoctoral visitor (1963–66). At Courant he served as assistant professor (1966–68), associate professor (1968–72), and professor (1972–). He has twice served as director of the Institute (1980–84 and 1992–94). He has held visiting positions at Stanford University (1976–77), the Mittag-Leffler Institute (1972), and the Institute for Advanced Study (1991–92).

Professor Varadhan has been elected a member of the American Academy of Arts and Sciences (1988), the Third World Academy of Sciences (1988), and the National Academy of Sciences (1995), and was elected as Fellow of the Institute of Mathematical Statistics (1991). Professor Varadhan was an Alfred P. Sloan Fellow (1970–72) and a Guggenheim Fellow (1984–85). His awards and honors include the Birkhoff Prize (1994) and the Margaret and Herman Sokol Award of the Faculty of Arts and Sciences, New York University (1995).

Steele Prize for Lifetime Achievement: Goro Shimura

Citation
To Goro Shimura for his important and extensive work on arithmetical geometry and auto-
morphic forms; concepts introduced by him were often seminal, and fertile ground for new developments, as witnessed by the many notions in number theory that carry his name and that have long been familiar to workers in the field.

Response

I always thought this prize was for an old person, certainly someone older than I, and so it was a surprise to me, if a pleasant one, to learn that I was chosen as a recipient. Though I am not so young, I am not so old either, and besides, I have been successful in making every newly appointed junior member of my department think that I was also a fellow new appointee. This time I failed, and I should be grateful to the selection committee for discovering that I am a person at least old enough to have his lifetime work spoken of.

There are many prizes conferred by various kinds of institutions, but in the present case, I view it as something from my friends, which makes me really happy. So let me just say thank you, my friends!

I would like to take this opportunity to give a historical perspective of a topic on which I worked in the 1950s and 1960s, intermingled with some of my personal recollections. It concerns arithmetic Fuchsian groups which can be obtained from an indefinite quaternion algebra $B$ over a totally real algebraic number field $F$. For such a $B$ one has

$$B \otimes_Q R = M_2(R)^r \times H^{d-r},$$

where $d = [F : Q]$, $0 \leq r \leq d$, $M_2(R)$ is the matrix algebra over $R$ of size 2, and $H$ is the Hamilton quaternions. Assuming $r > 0$ and taking a subring $R$ of $B$ that contains $Z$ and spans $B$ over $Q$, denote by $\Gamma$ the group of invertible elements of $R$ whose projection to any factor $M_2(R)$ has determinant 1. Then we can view $\Gamma$ as a subgroup of $SL_2(R)^r$ through the projection map to $M_2(R)^r$, and so we can let $\Gamma$ act on the product $H^r$ of $r$ copies of the upper half plane $H$. In this way we obtain an algebraic variety $\Gamma \backslash H^r$, which is an algebraic curve if $r = 1$. It is known that $\Gamma \backslash H^r$ is compact if and only if $B$ is a division algebra. In particular, we can take $B$ to be the matrix algebra $M_2(F)$ over $F$ of size 2, in which case $r = d$ and the meromorphic functions on $\Gamma \backslash H^d$ are called Hilbert modular functions.

If $F = Q$, the group $\Gamma$ was first discovered by Poincaré [7] "when he was walking on a cliff," apparently in 1886, as he reminisced in his Science et Méthode. One interesting aspect of this work is that the quotient $\Gamma \backslash H$ is compact if $B$ is a division algebra. Until then the only Fuchsian groups he or anybody else knew were those obtained from hypergeometric series, among which the arithmetically defined ones were the classical modular groups; in all those cases the quotient is not compact. (Uniformization of an arbitrary compact Riemann surface was proved independently by Koebe and Poincaré only in 1907.) Poincaré’s group was generalized to the case $1 = r \leq d$ with an arbitrary $F$ by Fricke [3] in 1893. It is also discussed in the last chapter of the thick volume [4] of Fricke and Klein published in 1897. These mathematicians employed an indefinite ternary quadratic form instead of a quaternion algebra. Since $SO(2, 1)$ is covered by $SL_2(R)$, the unit group of the given ternary form produces a discrete subgroup of $SL_2(R)$.

After Fricke’s investigations, which showed that the action of the groups on $H$ is properly discontinuous, no significant progress was made in this area for the next fifty years. In 1912 Hecke published his thesis work [5] concerning Hilbert modular functions in the case of $M_2(F)$ with $d = 2$. In its introduction he said that the results of Fricke on the Fuchsian groups of the above type seemed to be “without specific meaning in number theory”. Later developments proved that he was wrong. Taking his tender age of 25 into consideration, we may forgive him and may even justify his comment, allowing him a 30-year warranty, since it could apply to all papers on this subject in that period—one by Heegner [6] for example, which I cite here in order to show that the topic was not forgotten, but was being treated without any new ideas. It should also be pointed out that Hecke’s own work was critically flawed, though generally speaking he was headed in the right direction, except for that comment.

Eichler may have been the first person who was seriously interested in this group. He wrote his dissertation with Brandt on quaternion algebras and later worked on more general types of simple algebras. He once told me that Brandt did not think much of nonquaternion algebras and was unhappy with Eichler’s turning to them. In reality, there was no need for him to be unhappy, since the fact that Eichler started with quaternion algebras determined his course thereafter, which was vastly successful. In a lecture he gave in Tokyo he drew a hexagon on the blackboard and called its vertices clockwise as follows: automorphic forms, modular forms, quadratic forms, quaternion algebras, Riemann surfaces, and algebraic functions. Anyway, in the mid-1950s Eichler was developing the theory of Hecke operators for the Fuchsian groups of Poincaré’s type (see [1], for example). He also gave a formula for the genus of $\Gamma \backslash H$ somewhat earlier. However, there were no other number-theoretical investigations on these algebraic curves by that time.
In 1957 while in Paris I became interested in this class of groups. I had just finished my first work on the zeta functions of elliptic modular curves. Though I knew that it needed elaboration, I was more interested in finding other curves whose zeta functions could be determined. I was also trying to formulate the theory of complex multiplication in higher dimension in terms of the values of automorphic functions of several variables—Siegel modular functions, for example. It turned out that these two problems were inseparably connected to each other. Also, nobody else was working on such questions. I can assure the reader that I had no intention of humiliating Hecke posthumously.

So I took up the group of the above type. My aim was to find an algebraic curve $C$ defined over an algebraic number field $k$ that is complex analytically isomorphic to $\Gamma \backslash \mathcal{H}$ and to determine the zeta function of $C$. Such a $C$ is called a model of $\Gamma \backslash \mathcal{H}$ over $k$. Naturally I started with the simplest case, $F = \mathbb{Q}$. Since it was relatively easy to see that $\Gamma \backslash \mathcal{H}$ in this case parametrizes a family of certain two-dimensional abelian varieties, I was soon able to prove that the curve had a $\mathbb{Q}$-rational model. The proof required a theory of the field of moduli of a polarized abelian variety, but luckily I had it at my disposal, since I had been forced to develop such a theory in order to get a better formulation of complex multiplication, as mentioned above. In June 1958 I visited three schools in Germany: Münster, Göttingen, and Marburg. I gave a talk at each place, but remember only that at Göttingen I interrupted me and simply wanted to know whether I really had the proof. I decided to investigate more general families of abelian varieties. By specifying the types of endomorphism algebra and polarization of abelian varieties, one obtains a quotient $\Delta \backslash S$ that parametrizes abelian varieties of a prescribed type, where $S$ is a hermitian symmetric domain of non-compact type, and $\Delta$ is an arithmetic subgroup of a certain algebraic group. The above $\Gamma \backslash \mathcal{H}$ for Poincaré's $\Gamma$ is the easiest example of $\Delta \backslash S$; one simply takes $B$ to be the endomorphism algebra. For certain reasons, however, the algebra $B$ with $0 < r < d$ never appears as the endomorphism algebra of an abelian variety, which was the main difficulty. Then I realized that by choosing an algebra different from $B$, one obtains $\Delta \backslash S$ that is essentially the same as $\Gamma \backslash \mathcal{H}$ for an arbitrary $B$ of the above type. I think that was sometime in

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The curves with $F \not= \mathbb{Q}$ were more difficult. After going back to Tokyo in the spring of 1959, I decided to investigate more general families of abelian varieties. By specifying the types of endomorphism algebra and polarization of abelian varieties, one obtains a quotient $\Delta \backslash S$ that parametrizes abelian varieties of a prescribed type, where $S$ is a hermitian symmetric domain of non-compact type, and $\Delta$ is an arithmetic subgroup of a certain algebraic group. The above $\Gamma \backslash \mathcal{H}$ for Poincaré's $\Gamma$ is the easiest example of $\Delta \backslash S$; one simply takes $B$ to be the endomorphism algebra. For certain reasons, however, the algebra $B$ with $0 < r < d$ never appears as the endomorphism algebra of an abelian variety, which was the main difficulty. Then I realized that by choosing an algebra different from $B$, one obtains $\Delta \backslash S$ that is essentially the same as $\Gamma \backslash \mathcal{H}$ for an arbitrary $B$ of the above type. I think that was sometime in

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the fall of 1960. I knew at that point that the problem was approachable, and even knew that the curves had models over a number field, but did not know how to state the theorems in the best possible form, not to mention how to prove them.

In a series of papers published in 1963-65 I investigated the number fields over which the varieties $\Delta \setminus S$ can be defined. In many higher-dimensional cases, the results were best possible, but in the one-dimensional case that was the main question, I was not satisfied. So I turned to a higher-dimensional case of a different nature. In a famous paper on symplectic geometry [12] Siegel defined a certain arithmetic subgroup $\Gamma'$ of $Sp(n, R)$ which was a generalization of Fricke's group and which was also defined relative to $F$. If $n > 1$ and $F \neq \mathbb{Q}$, this group does not appear as the above group $\Delta$ associated with a family of abelian varieties. But in the summer of 1963, while in Boulder, Colorado, I found that there was an injection $\Gamma'' \to \Delta$ with some $\Delta$, which produced a holomorphic embedding $\Gamma'' \setminus S' \to \Delta \setminus S$, where $\Delta$ is the Siegel upper half space of degree $n$. If $n = 1$, $\Gamma' \setminus S'$ is exactly the algebraic curve $\Gamma \setminus H$ in question, and, moreover, the embedding is essentially birational over $\mathbb{C}$. Anyway, employing this embedding, I was able to find a number field over which $\Gamma'' \setminus S'$ is defined for an arbitrary $n$. When I was asked to contribute a paper to the volume in honor of Siegel's 70th birthday, I naturally took this as the topic and sent the manuscript to the editor in the fall of 1965.

Around the same time, perhaps in early September that year, I finally had a definite idea of settling the original question in the one-dimensional case: to employ many different $\Delta \setminus S$ for a given $\Gamma \setminus H$. By means of this idea together with a finer theory of variety of moduli of polarized abelian varieties, by June 1966 I was able to finish the paper [9] in which I determined the zeta function of the curve $\Gamma \setminus H$ with any totally real $F$. At the same time I determined the class fields generated by the values of automorphic functions, not only in the one-dimensional case, but also in the case where $B$ is totally indefinite, including the Hilbert modular case. By doing so I showed that similar theories could be developed in a parallel way in both Fricke's and Hecke's cases. In fact, those are the two extreme cases of a more general class of arithmetic quotients for which one can do number-theoretical investigations Hecke wished to do in his case, a fact Hecke never realized.

I dedicated the paper to Weil. At some point I said to him jokingly that he became sufficiently old that I could now dedicate a paper to him, to which he replied, "I can't stop it." Meanwhile my paper dedicated to Siegel appeared in the *Mathematische Annalen* [10]; I also sent a reprint of my *Annals* article to him, as I had been doing regularly with my earlier papers. Here is what he wrote me about these:

**Göttingen, 15 May 1967**

Dear Professor Shimura:

After a long trip around the world I returned to Göttingen and I found your last paper from the *Annals of Mathematics* together with the work which you kindly dedicated on the occasion of my 70th birthday.

I am sending you my most cordial thanks for your kindness. I have now begun to study these two papers, and both of them seem to be of great interest, from the arithmetical and the analytical point of view.

During many years I have regretted that Hecke's earlier work on Hilbert's modular function and class field theory had not been continued by later mathematicians. I am glad to see in your last paper how much you have already achieved in this direction.

I was very pleased to see from your other paper that you have obtained decisive results concerning those groups which I introduced in my paper on symplectic geometry.

Best congratulations for the success of your previous work, and best wishes for the future!

Yours sincerely

Carl Ludwig Siegel
however, for his good-naturedness. Around 1980 I sat next to Natasha Brunswick at a dinner table, when she proclaimed, "Siegel is mean!" I don't remember how our conversation led to that statement, but many of those who knew him would agree with her opinion. Hel Braun, one of his few students, apparently disliked him. He was indisputably original, and even original in his verseness. Once at a party he played a piano piece and challenged the audience to tell who the composer was. Hearing no answer, he said it was a sonata by Mozart, Köchel number such and such, played backward. On the other hand, he had a certain sense of humor. When Weil asked him which work of his he thought best, he replied, "Oh, I think a few watercolors I made in Greece some years ago are pretty good."

In any case, it would be wrong to presume him to be a mathematician who did what he wanted to do, unconcerned about what other people might think of his work. I believe he was not that aloof. He must have known who he was, but at the same time he must have felt unappreciated by the younger generation. That was Eichler's opinion, and I am inclined to agree with him. After his retirement Siegel took a long trip around the world, as he mentions in his letter. On coming back to Göttingen, one day he went into his office in the university and found on his desk a copy of the volume of the Mathematische Annalen dedicated to him, which pleased him greatly. And here was a man 34 years younger than he, completely outside of his German influence, who took up the topic on which he expended considerable effort many years ago, with genuine appreciation of his work.

Perhaps he was not so crabbed as many people had imagined, and it is possible that he wrote a few more letters like the above one. At any rate, when he wrote that letter, he knew that at least one of his papers was really understood, and at that moment he was capable of appreciating the progress made by the new generation, of which he had often been contemptuous. I am indeed glad to be the recipient of the letter which showed this great mathematician as a warm-hearted man with no trace of ill-temperedness, nor any cynicism.

References

Biographical Sketch
Goro Shimura was born on February 23, 1930, in Hamamatsu, Japan. He received his B.S. (1952) and D.Sc. (1958) from the University of Tokyo. During his academic career, Professor Shimura served as lecturer at the University of Tokyo (1954), as professor at Osaka University (1961), and as professor at Princeton University (1964-). He was a Guggenheim Fellow (1970-71).
Virtually all American mathematics departments have computer systems and cannot live without them. Running these systems is often a problem for lack of money, expertise, or vision. I argue here that we need to become better educated about computer administration, savvier in getting financial support for the task, and more competitive in acquiring and retaining good staff.

Workshops that focus on systems administration can be a powerful tool in achieving these goals. The Geometry Center has held the first such workshops for the mathematical community; I discuss their contents and some of their consequences.

Nowadays a large majority of mathematicians in the United States have access to computers at their institutions. But when the typical mathematician has occasion to think about the process by which computers and software are made to run, it is usually because something is not working. Arguably, this is as it should be: most people want to get on with their lives and to think as little as possible about tools. They do not often fuss over the innards of their car and telephone either.

Yet the analogy breaks down in this respect: cars and telephones have had a century and more to mature, and the pace of their evolution has been far more sedate. Today's computers and software are tremendously complicated creations, expected to perform an astounding variety of tasks at a rate utterly inconceivable a few decades ago. If I risk slipping into banality here, it is because this fact, easy to lose sight of, is crucial to an understanding of why computers will not, for a long time to come, be as "transparent" as some of our other technologies.

Computers demand attention, nurturing, and periodic renovation if they are to be as useful as they can be, especially because so much of their usefulness depends on their talking with one another quickly and reliably. In short, they demand competent administration. A lot of mathematics departments are understaffed in this respect; in many cases everything is in the hands of faculty members or graduate students.

The Need for Stable Systems Administration

There is evidence that leaving systems administration in the hands of faculty members or graduate students is a false savings and a misallocation of resources. It leads to frustration, waste of time, and fragmentation that outweigh the cost of adequate systems administration staff. My own experience and comments from many sources—both systems administrators and end-users at a variety of institutions—have persuaded me of this point.

At a professionally run site, the administrator performs many time-consuming and not always obvious tasks: keeping abreast of new technology, writing purchasing specs and shopping around, advising faculty on the best use of grant money, installing new software and hardware, running the local network or interfacing with central campus networking, coming in on weekends to handle emergencies or catch up with work, helping users make their programs run. This is as true for a Macintosh or PC site as for a Unix network, despite claims that personal computers require little or no administration. (It is true, however, that a homogeneous site requires less maintenance; the drawback is that users have fewer choices.)
Faculty are no cheaper than systems administrators and do a poorer job. It is unreasonable to expect a faculty member to devote a lot of time to build up and keep a good environment for the whole department, and with very few exceptions they do not do it. To the extent that they do, they are employing their time suboptimally, even from the point of view of the university, which logically should prefer them to do what they are best at and what they are paid for—research and teaching. Certainly, having a committee made up of computer-literate faculty to direct and oversee the computer administration process is a good thing: as end-users, faculty should retain control of the big picture. But beyond that, it is a waste of time.

Students have a high turnover rate. A computer environment administrated primarily by students will have no continuity over a period of several years. Moreover, students often lack a certain healthy conservatism: they are eager to experiment with new technologies, install new versions of software, and so on (which is good), but often stop supporting or delete too fast the old versions to which many users are wedded (which is bad). Because they pick up new things fast, they assume that all other users will too. Career systems administrators, whether or not they started as students, learn after a few years to be more tolerant; but if a site has new students in charge all the time, this never happens.

Neither faculty nor students are likely to maintain the level of commitment necessary to avoid annoying disruptions. During my Princeton years, there were two times when many computer users lost several days’ worth of work: in each case there was a disk crash and it was then discovered that no backups had been made for a week, even though they were supposed to be done every day. On the first occasion the backups were the responsibility of three students; on the second, we had just hired an inexperienced systems administrator. Nightly backups are much more likely to be done reliably by someone whose performance evaluation depends on it than by students or faculty. The same goes for the many other boring, mechanical tasks that are necessary to maintain a computer system.

Without a central vision, the system is at the mercy of short-term constraints. It is important that the system should survive without strain personnel changes and temporary budget cuts, that it should expand without disruption as the number of users grow, and that it should make it easy for users to gain a variety of competencies and enlarge their horizons. This is not easily achieved by a committee, and even dedicated and knowledgeable faculty members may not succeed in doing it unless one or two of them choose to devote most of their time to the task for a period of years. The result of failure is a rocky system and frequent frustrations and/or a pathetically low level of expectations. By contrast, a good, experienced systems administrator will set up a model that will serve users well long after his/her departure.

Why Workshops on Systems Administration

Most departments are more or less aware of the arguments just given; and if they still treat systems administration as a haphazard issue and leave it in the hands of faculty and students, it is sometimes not through their own choice, but because they cannot get the necessary resources to do otherwise. Good professionals are a scarce resource and command salaries that are high for academia, so not every department will be able to afford one. But more departments would be able to afford one if they pursued this as a clear and consistent goal.

Therefore the mathematical community as a whole needs to become better informed about computer administration issues, find ways to secure greater financial support for systems administration staff, and whether or not professional staff can be hired, make it easier for systems administrators to grow in their jobs and keep abreast of current developments.

Creating opportunities for systems administrators (professional or casual) and interested faculty to come together can go a long way in helping address these problems. There is an annual conference (LISA) for UNIX systems administrators and similar conferences for PCs and Macs, not to mention trade shows. If systems administrators can go to these events, so much the better, but it is unlikely that the administrator at a department that has all three types of computers would want to attend three such conferences a year or that the department would pay the often steep registration fees. There are also subjects of specific interest to mathematicians that are addressed tangentially, if at all, at these conferences: symbolic manipulation systems, the use of computers in teaching, and so on. Chances that systems administrators will go to the specialized conferences on those topics are infinitesimal.

Given this background, a workshop focusing on the systems administration of mathematics sites, especially one with no registration fee, would seem like a winner. This has indeed proved to be so. Prompted by a suggestion made by Al Thaler of the NSF, the Geometry Center held in December 1994 the first such workshop, called SAMP, for “Systems Administration: The Mathematician’s Perspective”. SAMP brought together...
about sixty academics and career systems administrators. In addition to general issues, such as user education, software updates, security, networking, and funding, there were talks and discussions on subjects of particular interest to mathematicians, including the role of computers in math instruction and communication, preparation of mathematical documents, computer algebra systems and other mathematical software, and MathSciNet.

SAMP was very well received (see a later section on evaluation), so the Center hosted SAMP2 in December 1995. Among the new topics discussed were technical advances such as better security, tools for electronic documents, and the explosive use of the Java programming language for interactive Web applications. I will return to them in the next section.

Not all lessons learned were technical. It was particularly useful for people from big and small universities to mix. Systems administrators at small universities are often the most resourceful and have a lot of good ideas to share. As an example, David Marshall, a graduate student at Humboldt State University in California, gave a talk on how he was able to procure funding to upgrade and maintain a lab intended for undergraduate mathematics instruction by allowing it to be used as a university-wide resource at times when it would be otherwise idle. Big and small institutions alike have much to learn in the matter of cooperation.

There was ample discussion of how math departments can obtain funds for staffing. If lobbying the university administration using the arguments enumerated in the preceding section is insufficient (and indeed no amount of rational argumentation will change the minds of some university officials), a department can use a variety of tactics such as levying a percentage of faculty grants; applying to outside sources for funding, especially for educational labs; and so on.

I regret to say, however, that no magic bullet was found that will work in every situation. Even the Geometry Center has been without an official systems administrator since the old one quit for another job, eight months ago as I am writing this; for various reasons the search for a replacement could not be initiated until recently. Fortunately, because of the Center's character, other staff members know the system very well and have not allowed it to deteriorate.

**Why All the Excitement?**

Here is a nontechnical overview of some of the technical topics that attracted most interest at SAMP2. I include Web addresses for readers who are interested in details; most of these addresses are collected as links at the Web page http://www.geom.umn.edu/locate/workshop/SAMP2/.

Java is a computer language specifically designed for networking whose introduction greatly increased the power of the World Wide Web. Ages ago (around 1992) the Web was an essentially static tool: you would see static text, static figures, and static links to other pages. Later came fill-up forms and other methods designed to allow greater interactivity; the Geometry Center, thanks largely to postdoc Paul Burchard (now at Utah), was a pioneer in interfaces to mathematical programs. Users could now send input to a remote program and obtain results over the Web. However, installing such interfaces was complicated and cumbersome; it was not something that a casual writer of Web documents would attempt. Moreover, a program running on the server can deal with only so many requests at a time. Java has changed the situation dramatically for the better by making it easy to write programs that are downloaded on demand by the browser and run on the local machine. The Web user can now solve a differential equation, manipulate a three-dimensional scene, run a spreadsheet, play a game, or get continuously updated data, provided she is running a browser (such as the current version of Netscape) that understands Java. A good Java introduction and tutorial can be found at http://www.cs.ust.hk/~cheungkh/java/javatutorial.html.

Electronic mathematical documents and WebEQ. WebEQ is a Java-based system that allows Web authors to include mathematics in their pages; it is in advanced stages of development at the Geometry Center by a team led by Robert Miner. If you have attempted to translate a TeX document into HTML, you know that doing any but the simplest formulas is essentially impossible in pure HTML. Automatic translation (using \\LaTeX to HTML) is possible, but each formula is replaced by a bitmap, which looks different from the surrounding text, is completely unstructured, and takes much longer than text to download. In the 3.0 specification of the HTML language there is provision for mathematics and scientific notation, but it does not appear that browser manufacturers are in any rush to implement this new standard; obviously the market for sound and fancy backgrounds is much larger, so that is where all the commercial effort is being put. WebEQ is an attempt to implement the HTML 3.0 specification for mathematics notation and is an important step toward making the Web more valuable for scientific research. For details, see http://www.geom.umn.edu/locate/WebEQ/.

Network Security is a hot subject and was extensively debated at both workshops. The dis-
Discussions and recommendations were much too technical to detail here, but interested readers may profit from looking at the URL http://www.math.ubc.ca/~djun/samp2/security.html, which contains the writeup of a talk and discussion led by Djun Kim (University of British Columbia).

**ISDN.** With a great increase in the number of people who have computers at home and expect to access their work accounts and the Web from there, the traditional modem-dialing setup has become inadequate. Paulo Ney de Souza of UC Berkeley gave a talk on ISDN (Integrated Services Digital Network), an international telephone standard now available in many areas. Because it uses digital rather than analog signals, ISDN can carry much more information (in the form of voice, data, or video) than the old system over the same existing copper wiring. ISDN is fast enough to allow the remote site to become a fully integrated part of the university network, mounting file systems, accessing software and other resources transparently, and so on. See http://math.berkeley.edu/~desouza/isdn-crash.html.

**Why the Geometry Center?**

The Geometry Center was uniquely placed to hold these workshops, being a leading institution in the use of computers in mathematics and in the communication of mathematics. The Center has an excellent computing and visualization lab with a variety of equipment, including SGI graphics workstations, other UNIX workstations, PCs, Macintoshes, and video production facilities. The Center's resources are used both locally and across the Internet for research, development, and education. The lab serves a diverse group of students, high school teachers, professors, and the Center's own staff; it is used regularly as the site for workshops with national and international participation. Center staff gave several talks at the workshops, sharing its experience in setting up and maintaining this environment.

There certainly exist other places where a similar mix of hardware and people are present. I believe that the reason a workshop like SAMP has not taken place elsewhere, before or since, is not that other sites have not understood the potential usefulness of such a meeting, but rather that their mission is different from the Geometry Center's. Cornell and Utah are examples of universities where mathematicians have a good computing environment, but their goal is research and education in math proper; I doubt that they will become the site of the next SAMP workshop. (Of course, I would love to be proved wrong.) By contrast, the mission of the Geometry Center is in part to promote computational tools for mathematicians and to facilitate communication among mathematicians and between mathematicians and the public at large.

**Composition, Evaluation, and Consequences**

The composition of participants at SAMP and SAMP2 is probably close to being a representative cross-section of bigger four-year colleges and universities in the U.S., with an admixture of other sites like the MSRI and the AMS. Among the participants of SAMP were two from Britain, two from Canada, and one from Israel. Women and minorities were particularly encouraged to apply; women were relatively well represented. About half the participants received total or partial support from the Geometry Center. Others had support from their home institution.

An evaluation sheet was passed out after each workshop. Over 95 percent of respondents chose a 5 or a 4 (out of 5) for an overall rating, and many praised particularly the helpfulness of the administrative and technical staff. The most common criticism of SAMP (apart from the cold, which was even worse the second year) was that there was too little time for informal interaction; this problem was addressed in SAMP2 by having fewer lectures each day and more time for discussion groups and informal conversation. Discussions were usually quite lively.

Some comments and criticisms from the SAMP2 evaluation forms:

Because of the huge increase in use of the Web, this year the conference focused much more on cross-platform issues. This made the conference this year much more valuable to me. Almost all of the talks this year contained aspects of interest to me. Last year as a Mac user in a largely Unix-oriented group, I had little to relate to in perhaps 30–40% of the talks. It's amazing how much the Web has changed things!

I now see Java as more important [than before], and plan to update Web pages with info learned here.

There were a lot of talks which were interesting but many didn't relate to my field. It was very slanted towards the educational arena, so getting more vendors would be a good idea.

Get a few people from industry to give an alternate perspective to the academic environment.
Great conference! I hope to be back next year!

What lasting benefits did the workshops bring? First of all, participants found them useful as opportunities to get acquainted with many topics that they did not know or knew only slightly. Almost everyone had heard about Java, for example, but few mathematicians and math-site administrators had done anything with it, so the tutorials and talks on the language were very well attended. In the months after the workshop some of these participants started using Java to provide services at their sites.

Another example: Someone mentioned in passing during SAMP2 an indexing and query program called Glimpse, through which users can search through a large collection of files very quickly; it allows approximate matching of misspelled words, Boolean queries, and even some regular expressions. I find it invaluable. In spite of being free and requiring little setup time (though it does require disk space for the index files), Glimpse was familiar to less than a third of participants. After the workshop I set up a Web page of pointers to interesting software, including Glimpse; I’ve had reports of administrators picking it up and recommending it enthusiastically to their users.

I will mention two more ways in which SAMP and SAMP2 left their mark. Late in 1994 the mathsys mailing list had been established at the MSRI, with the purpose of networking together the same people for whom SAMP was designed. As a consequence of SAMP, its membership increased fivefold. It continues to increase, and currently stands at about 120. (To subscribe, send e-mail to majordomo@msri.org with the subject “subscribe mathsys”.) The mailing list is used for consultations, job postings, and so on. It was extremely useful on the occasion of a major security break not long after the first workshop: the more knowledgeable subscribers were able to explain to the others what action to take, direct them to sites where they could obtain patches for faulty programs, etc.

The Survey of Math Computing Environments

The second initiative originated with Joe Stone, then of the School of Mathematics, University of Minnesota. It is a survey of the computer environment—demands and resources—of participating institutions. It has now been extended from the original audience of SAMP attendees to other members of the mathsys mailing list. The results are available on the Web (see last paragraph). Here I mention only two questions.

“How would you classify the hardware resources at your site?” Choices “somewhat insufficient” and “adequate” got almost 50% each; the other two choices, “grossly insufficient” and “more than adequate”, got a sprinkling. So the situation regarding hardware seems to be fair to middling.

By contrast, the question

“How would you classify the human resources, as far as systems administration is concerned?” got 50% “somewhat insufficient”, another 30% “grossly insufficient”, 20% “adequate”, and 0% “more than adequate”. A related observation is that about half of the respondents report a greater de facto workload than expected from their job descriptions.

Conclusion

Computers are here to stay, and running them will remain a complicated affair for the foreseeable future. The mathematical community can only profit by learning more about the issues involved and by supporting its systems administrators as much as possible.

Workshops such as SAMP can be a powerful agent in helping the mathematical community make informed decisions, in spreading familiarity with new computer tools, and in helping systems administrators do their job better. We must bring together, on a regular basis, the people involved with the administration of our systems—be they career systems administrators or academics—to teach each other more about a subject that is essentially unbounded. The ultimate goal, stressed by the title of the Geometry Center workshops (and of this article) is to help fulfill the needs of the mathematicians who use the computers.

More information about SAMP and SAMP2 is available on the Web at http://www.geom.umn.edu/locate/workshop/SAMP2/. It includes schedules of talks and discussions, many of the talks presented, comments from the evaluation sheets, pointers to interesting software and Web addresses, and more results from the surveys. If you are interested in attending a SAMP workshop in the future or think your systems administrator may be interested, send e-mail to orgsamp@geom.umn.edu.

Acknowledgments

I would like to thank the editors, Hugo Rossi and Steve Krantz, whose suggestions greatly improved this article, and Geometry Center director Dick McGehee, who provided the initial impetus for the writing of it.
Among the variety of activities which constitute the career of the professional mathematician, communicating the nature of mathematics to those not in the profession is surely one of the most frustrating; so frustrating, in fact, that many of us are unwilling even to try it. Where do the difficulties come from? First of all, for many people, their relationship to mathematics has been defined by their educational experience. They take mathematics only as long as it is required, and neither the experience itself nor its recollection tends to be happy. Try to tell them about mathematics? They will simply shut you out. Admittedly, the same distaste is often characteristic of science as well. Science, however, is more in the habit of making its case for research in terms of usefulness than is mathematics. The applicability of mathematics is very real but often hard to see in specific areas; the topics on which we actually work may not easily lend themselves to communication. So a second major difficulty in explaining what we do is to find a way to begin, to make a connection with some previous experience or human need. Our standards for communication are yet another problem: It is our professional habit to be as precise as we can, and if we gloss over some fine points in the interest of clarity, we will criticize ourselves severely if our colleagues have not done it for us already. All in all, a classic no-win situation.

Nevertheless, the mathematical community's concern with popular communication is on the rise. The first international conference on popularization was held in 1989 under the auspices of the International Commission on Mathematical Instruction, and the subject continues to be represented in national and international meetings. Television, museum exhibits, and to a growing extent, software, can be used to reach a mass audience, but the more traditional media of books and periodicals continue to dominate communication with the amateur mathematician and the educated lay public, two favorite targets of opportunity.

There have, over the years, been many "popular" books for these audiences, and the nature of such books is interesting. As a typical example, look at one of the most successful, *The Enjoyment of Mathematics*, by Hans Rademacher and Otto Toeplitz. Its subtitle is *Selections from Mathematics for the Amateur*. It was originally published in 1933 (in German), and the English version dates from 1957.

It contains a series of developments, averaging about eight pages in length, of separate topics in mainly geometry, combinatorics, number
theory, and topology. They presuppose a first-rate high school education, and each example is self-contained, reaches closure, and is elegant, a term whose meaning we all recognize but do not find easy to explain.

The problems were not chosen to be current, or applicable, or especially important: they are beautiful problems and embody beautiful mathematical thought.

Keith Devlin’s *Mathematics: The New Golden Age*, published in 1988, serves as a second example. It is intended for the interested layperson. Each development is perhaps three times as long as in Rademacher and Toeplitz, and there is much less actual proof and much more informal description, exposition, and history. The intent is to make it possible to appreciate eleven separate newsworthy developments in mathematics during the twenty or so years preceding the book’s publication.

These two books are excellent examples of their genres and are typical of popularization for the amateur mathematician and the educated layperson respectively. What is missing in both books, and in the many other popular books I have seen, is the feeling for the connectedness and the continuity of mathematics, the way in which mathematics develops and progresses. This is not a complaint about those two truly excellent books; that is not what they were trying to do. But if you really want to get across where mathematics has been and where it is now, this continuity of thought is fundamental. The first book I know which truly attempts to convey the logic behind the development of mathematics is Keith Devlin’s *Mathematics: The Science of Patterns*.

The six chapters of the book are entitled “Counting”, “Reasoning and Communicating”, “Motion and Change”, “Shape”, “Symmetry and Regularity”, and “Position”. Each chapter takes the reader from the beginnings of the subject, be they ancient times or the eighteenth century, up to the present time. The continuity in each chapter is truly remarkable and exemplifies not only a command of the subject matter but a style of writing of which a mystery writer could be proud. Take the chapter on position, for example. The lead-in to the notion of topology is the familiar map of the London underground. The history of the subject begins with Euler and the Bridges of Königsberg and is followed by a transition to networks and the Euler formula in the plane and on the sphere. Möbius’s definition of a topological transformation leads to surfaces and naturally to their orientability and nonorientability. The Euler characteristic is identified as an invariant which together with a number of crosscaps is used to classify surfaces. Then surfaces are generalized to manifolds, and homotopy is defined and illustrated. Do homotopy groups distinguish manifolds that are not topologically equivalent? What follows is a history of the Poincaré conjecture up to the present time.

The continuity in the chapter so far is evident, but the style is also marvelous. Here is the paragraph which ends the discussion of the Poincaré conjecture:

It should be said that the expectation that the one remaining case of the Poincaré conjecture will turn out to be true is certainly not based on the fact that all the other cases have been proved. If ever topologists had thought that all dimensions behaved in more or less the same way, they were forced to change their views radically by an unexpected, and dramatic, discovery made in 1983, by a young English mathematician named Simon Donaldson.

Devlin then reminds us of differential calculus and of the definition of a manifold and goes on to ask about differentiation structures on Euclidean $n$-space. This is then followed by the story of knots and their invariants, the significance of the Alexander and Jones polynomials, and the connection with the work of Atiyah and Witten.

At this point Devlin is ready to return to Fermat’s Last Theorem, which had naturally come up in Chapter 1, “Counting”. There is discussion of the associated curves and surfaces, of Mordell’s Conjecture, and the outline story of the sequence of discoveries which led to the proof by Wiles (which was not complete at the time the book was finished). This ends the chapter on topology and the book as a whole. It may seem surprising that the discussion of Fermat’s Last Theorem comes in a chapter on topology, but both the chapter and the theorem reflect the book’s overall theme of the unity of mathematics.

The continuous flow of exposition which is so characteristic of this book is achieved by rigorous control of not only what is put in but also what is left out. Enormous self-control is evident in its resistance to mathematical and pedagogic temptations. For example, in the presentation of the method of generating primitive Pythagorean triples, the conditions are $s > t$, $s$ and $t$ have no common factor, and one of $s$, $t$ is even, the other odd. The temptation to ask what happens if both $s$ and $t$ are odd would be overwhelming to me: It would be so nice for the readers to see that in that case the solution would not be primitive—and why not. But that would interrupt the
flow, and it is not done. Devlin does not even suggest this as an exercise for the reader—that is not the point of the book.

As I said, there is bound to be some sniping from mathematical colleagues, and I will try to fulfill this obligation. The constant in the formula for the volume of a truncated pyramid on page 14 is 1/3, not 1/2. There is the usual demonstration that the harmonic series diverges, but then the completeness axiom on page 98 reads as if the partial sums of that series had to have a real number as a limit. The discussion of the differential and integral calculus in Chapter 3 comes close at several points to leading the reader to infer that a function is a formula. In Chapter 2, it is not clear (p. 39) whether the predicate includes the verb itself. We are told that S denotes Socrates and P denotes the predicate “is a man”, but in the next paragraph the proposition is restated as “S is P”, which strictly speaking would have “is” in it twice. Might a second distributive law be mentioned for a Boolean algebra (p. 43)? The discussion of the meaning of $i^2$ on page 101 omits the possibility that it could have an infinity of values.

Not having Devlin’s self-control, I have allowed these last comments to interrupt the flow of this review. Mathematics: the Science of Patterns is a wonderful book for the layperson about the development and structure of mathematics. Devlin succeeds in keeping the reader enthralled with this story by taking the patterns of mathematics as they are, neither neglecting the applications of the subject nor relying on them to hold his audience. Physics and cryptography and codes for communication and wallpaper design have their place but are not the glue that keeps the story going. It is a great story.

Mathematics education is not the subject of this book, but one cannot help bringing it to mind as one reads and marvels at the story of mathematics as the science of patterns. The traditional memorization of formulas and tricks does not come very close to communicating the spirit of mathematics. Has anyone tried to develop the big ideas, as Devlin has done so successfully? One example comes to mind, namely, On the Shoulders of Giants from the Mathematical Sciences Education Board and edited by Lynn Steen, who has done much to get people to think of mathematics as the science of patterns. Several of the main themes in the two books coincide. Devlin’s book is hugely successful in introducing the lay reader to the real spirit of mathematics and in bringing that reader to some appreciation of the research frontier. Let us hope that in the future mathematics education will lay a good foundation for this appreciation.
Success in undergraduate mathematics depends on more than the curriculum. With NSF support, the Mathematical Association of America (MAA) created a committee to study a small group of successful undergraduate mathematics programs and to identify features and practices of those programs that might serve as the starting point for program improvements elsewhere. This report complements recent undergraduate curricular recommendations from the MAA with a discussion of other aspects of the undergraduate enterprise.

The heart of this study is a set of site visits to ten mathematics departments. The institutions visited spanned the spectrum from two-year colleges to research universities and were chosen because they were seen as having undergraduate mathematics programs that are particularly successful in several of the following areas: (i) attracting and preparing large numbers of mathematics majors, (ii) preparing students to pursue advanced study in mathematics, (iii) preparing future school mathematics teachers, and/or (iv) attracting and preparing members of underrepresented groups in mathematics.

The report describes general attitudes and strategies as well as particular activities that are effective. Based on the site visits, the report provides suggestions for other institutions to consider as they try to create and sustain an environment that will foster such attitudes and activities.

1. General Attributes. The following features, found at most of the programs visited (and at many institutions), seem to underlie these programs’ success. Note: This is not to imply that such features are either necessary or sufficient for success.

- No matter how successful their current programs are, faculty members in the visited departments are not yet satisfied with the programs. Experimentation is continuous.
- There is a great diversity of instructional and curricular approaches, varying from one visited department to another, and even varying within a single department.
- Faculty members believe in the value of their work as collegiate educators, enjoy teaching, and care about their students.
- Faculty members communicate explicitly and implicitly that the material studied by their students is important and that they expect their students to be successful in mathematical studies. Courses are designed to meet the needs of the program’s students, not the program’s faculty.
- Extensive student-faculty interaction characterizes both the teaching and learning of mathematics, both inside and outside of the classroom.

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1 “In this report, the terms ‘mathematics’ and ‘mathematical sciences’ are used synonymously.”
2. Attracting Students to Study Mathematics: In-Class Experiences. Most faculty in the programs visited approach all courses with a primary focus on the general mathematical experience rather than the particulars of the individual subject. In every class they try to motivate their students to learn and to be interested in mathematics. The particular course syllabus is a context for achieving these broad goals. All programs visited gave considerable attention to the teaching of first-year calculus. Many faculty considered it the most important teaching assignment they had. They believed the best inducement for beginning students to take another mathematics course is to have an excellent teacher in their current course. As a consequence, the departments were more selective about who was allowed to teach in beginning calculus than in higher-level courses.

Despite teaching classes with a variety of student abilities and a mixture of those eager to learn more mathematics and those required to be there, faculty in programs visited seemed to be effective reaching virtually all students in their classes. Faculty were seen by all students to be setting high but achievable standards and then helping them meet these standards. Almost all the programs visited put a large amount of effort into developing and validating good placement tests, whose results students tended to follow closely. This heightened the faculty's confidence that in introductory courses all students could master the material. It also contributed to lower failure rates in these courses.

While most programs visited had an honors calculus course for more mathematically talented students, faculty generally viewed the regular calculus course rather than the honors calculus as the prime source for recruiting mathematics majors. Graphing calculators were widely used in introductory mathematics courses at the programs visited, but most programs visited made little use of computers.

Many of the programs visited were experimenting with new approaches to precalculus, often using a combined two-semester precalculus/calculus course. Several students interviewed said that their precalculus course convinced them to become mathematics majors. Two programs visited had innovative alternatives to freshman calculus that led into post-calculus courses at the sophomore and higher levels. An innovative sophomore "laboratory" course consisting of a set of mathematical explorations which students wrote up in 12-page papers seemed worthy of consideration by other institutions.

Few faculty at the programs visited consciously try to recruit mathematics majors in their courses, but their good instruction and their personal interest in their students' mathematical and personal growth prove to be very effective indirect recruiting strategies.

3. Attracting Students to Study Mathematics: Out-of-Class Experiences. The faculty in most departments visited were generally available to students anytime they were in their offices. Office hours were a two-way street, where faculty got valuable feedback to help them be more effective in class at the same time that faculty helped students with their problems. At two- and four-year colleges visited, all mathematics faculty participate in advising mathematics majors. At universities visited, the advisors are a subset of the faculty chosen for their record of good rapport with students. Upper-division mathematics students at most programs visited played a major role in formal recruitment activities, whether it was organizing informational sessions and social events or helping to prepare written materials about the major.

4. Attracting High School Students to Study Mathematics. Most programs visited have an above average number of entering students expressing an interest in mathematics. This interest is a result of praise for the program that current students have communicated to their high school teachers and of the goodwill of graduates from the programs who are now high school teachers. All the programs visited had activities for teachers or students: continuing education programs, student competitions, and special programs for disadvantaged students or talented students. Mathematics majors often played a significant role in assisting in or organizing these efforts.

5. Organization of the Mathematics Major and Supporting Activities. Most of the effective mathematics major programs visited have an inclusive view of trying to serve a broad range of student objectives with general training in the modes of reasoning and techniques of mathematical sciences. Some effective programs have a very focused goal, such as the preparation for doctoral study. The prime objective of the mathematics courses at programs studied was to train their majors to think mathematically. Help-
ing students master a particular list of concepts and techniques was less important.

A very successful style of mathematics major used at one institution is a contract major in which a student and faculty advisor negotiate the courses in the mathematics major. As well as giving students a sense of ownership of their major, this format forces faculty to justify the value of their vision for a mathematics major. A highly successful approach used at a few universities (not visited) has been to design a professional (terminal) B.S. program with an applied flavor and little theory, geared to be a double major with engineering or business.

At two- and four-year colleges visited, many or most faculty have played a significant role in the development and maintenance of the successful mathematics program. The mathematics department chair at these institutions typically focuses on maintaining a friendly, supportive atmosphere around the department for faculty and students. At universities, a few faculty, frequently including the chair, are responsible for the success of the undergraduate program in mathematics.

Most of the programs visited had active student organizations. Students ran these activities with little faculty help. A monthly student-oriented colloquium was common, including talks by alumni about how they used their mathematical training in their careers. Most of the programs visited had a significant number of students participating in special individual or small-group learning experiences, such as independent study during summers or the academic year, an internship, senior thesis, or a (small-group) directed reading course.

While most of the programs visited have received external funding for instructional innovation, the most important support typically came from local campus administrators in the form of additional faculty positions and favorable treatment in other budgetary and administrative decisions.

6. Effective Programs for Preparing Students for Advanced Study. Two very different strategies were observed for increasing the number of students continuing on to advanced study in mathematics: (i) develop a major with an inclusive goal of preparing students for a wide variety of careers to attract a large number of students, and then motivate some of this large cohort to pursue graduate study, and (ii) have a major focused primarily on preparation for graduate study; this approach requires a selective student body and excellent instruction to avoid scaring most potential mathematics majors away.

An environment similar to that found in graduate school was a common theme at programs effective in preparing students for graduate study. Such an environment typically included frequent mathematical discussions outside of class among students and faculty (often in a departmental commons room), independent research opportunities, and seminar-type courses.

7. Effective Programs for Preservice Preparation of School Teachers. The syllabi and viewpoint of postcalculus courses enrolling substantial numbers of preservice secondary school mathematics teachers give consideration to the special needs of these students. Instructors of these courses should have a basic familiarity with the NCTM Standards. The instructional style in the mathematics program serves as a model for good teaching practices. The mathematics methods courses develop more than the mathematical foundations of school mathematics. They take a broad view of contemporary mathematics education issues. There are out-of-class activities and interactions with mathematical education faculty that enhance the in-class education and foster an intellectually active atmosphere of inquiry about new educational trends.

8. Effective Programs for Underrepresented Groups in Mathematics. Effective instruction and extensive student-faculty interactions in the mathematics programs visited appears to "disproportionately benefit" women, but not minorities. Special additional efforts seem to be required to obtain fuller participation of underrepresented minorities in mathematics. The mathematics programs at historically Black colleges and universities (HBCUs) visited had especially nurturing atmospheres for students. Mathematics majors at HBCUs showed a heightened degree of interest in professional career opportunities. Minority students with mathematics aptitude seem to be more numerous at non-HBCU institutions with engineering schools.

The institutions visited in this project were: Lebanon Valley College, Miami University of Ohio, Mount Holyoke College, Saint Olaf College, Seattle Central Community College, Southern University, Spelman College, University of Chicago, University of Michigan, and University of New Hampshire. For further details about the case study findings, readers are referred to the project report, "Models That Work: Case Studies in Effective Undergraduate Mathematics Programs", available from the Mathematical Association of America.
The Institute for Advanced Study (IAS), with its serene, sloping lawns and dignified buildings, is a shrine to intellectual achievement. Some universities—like the one across town in Princeton—might rival the Institute in the distinction of their faculties, but for sheer focus on higher intellectual pursuits the IAS wins out. The Institute has no degree programs, no courses, and very little bureaucracy to distract its thinkers from their thoughts. Long known as the ultimate ivory tower, the Institute, under the directorship of Phillip Griffiths, is applying its high standards to a broader range of goals. Nowhere is this more evident than in the programs of the IAS School of Mathematics and in the IAS/Park City Mathematics Institute, for which the IAS served as the host site this summer.

Applications a New Focus

For many years the the School of Mathematics at the Institute was known primarily as a center for research in pure mathematics, especially areas such as representation theory and number theory. More recently the school has broadened its agenda to include what Griffiths calls "theoretical applied mathematics". The shift began about ten years ago, when the Institute hired Luis Caffarelli and Thomas Spencer. Caffarelli is an expert in partial differential equations and is well known for his work on free boundary problems and fluids (he recently moved to Courant Institute). Spencer, a mathematical physicist specializing in statistical mechanics and random media, has recently become interested in the statistical description of solutions to partial differential equations. For the past few years the Alfred P. Sloan Foundation has provided crucial financial support to support the Institute's initiatives in several aspects of applied mathematics.

This past year, the research program focused on wave (or weak) turbulence, such as one might find on the surface of a calm ocean. The problem "sounds simple, but it's not," Spencer notes. While there are relations to the problem of full turbulence and the usual descriptions given by the Navier-Stokes equations, the mathematics is very different. In particular, the conventional methods of equilibrium statistical mechanics do not work, and one needs to develop new approaches.

The previous year the Institute hosted a research program that examined properties of semiconductors and lubricants, substances that have some fluidity but are not well described by fluid mechanics. The main tools are kinetic equations, the best known among them being the Boltzmann equations. "Kinetic theory is an area where American mathematicians are not so active, but there is a lot of activity in Europe," Spencer notes, "so we had a lot of participants from Europe." Although the researchers worked on some problems coming from industrial applications, the thrust was nevertheless theoretical. The work contrasts with that of, say, the Institute for Mathematics and its Applications at the University of Minnesota, where there are direct contacts with people from industry and the work is much closer to the specifics of given applications.

Another major push in applied directions, headed by IAS faculty member Enrico Bombieri, has centered on combinatorics and theoretical computer science. Many of the activities in this area have been organized in conjunction with DIMACS, the NSF-sponsored center on discrete mathematics and computer science which is a consortium of Rutgers and Princeton Universities and AT&T Research, Bellcore, and Lucent Technologies. This coming year there will be a program on those areas of discrete mathematics that are close to statistical mechanics, and efforts will be made to connect people who work in combinatorics with those working in mathematical physics.

Robert MacPherson, who joined the IAS mathematics faculty two years ago, has become interested in some problems in theoretical computer science and combinatorics since his contacts with the researchers in these areas. In fact, last year he solved a combinatorics conjecture posed by Gil Kalai, who was visiting the IAS from the Hebrew University of Jerusalem, and they ran a seminar on the solution. "Some would worry if this would fit into the Institute because we're very theoretical," says MacPherson. "But these people have talked to others in
almost every area of mathematics about the problems that are growing out of computer science."

This year the IAS is launching an ambitious, three-year program in mathematical physics, headed by IAS faculty members Pierre Deligne, from the School of Mathematics, and Edward Witten, from the School of Natural Sciences. The goal of the program is to familiarize mathematicians with the latest ideas in theoretical physics, such as string theory and mirror symmetry. Over the years Witten's intuition about physics has allowed him to come up with bold conjectures that mathematicians seized upon to prove some spectacular theorems. The most recent example came in late 1994, when Witten and his colleague Nathan Seiberg of Rutgers University proposed that certain equations contained much of the information of Donaldson theory. Now known as the Seiberg-Witten equations, they have sparked a revolution in low-dimensional topology.

The IAS program will not try to mine the Seiberg-Witten equations for more mathematical theorems. Rather, the program’s focus will be on developing mathematicians’ knowledge of physics so that they too can tap into physical intuition and eventually gain insight into mathematical problems. "Mathematicians will learn about path integrals, renormalization, gauge theory—some physics, basically," Spencer explains. "What they can get out of it is a new way of thinking about mathematics—and it won’t be a rigorous way of thinking." For this reason, the participants will be people "who will not insist on proving theorems at every step," says Spencer. MacPherson calls it "unlike anything anyone has ever tried before."

This less rigorous approach has been the cause of some controversy in the mathematical community. In the article "Theoretical Mathematics", which appeared in the Bulletin of the AMS in 1993, Arthur Jaffe and Frank Quinn laid out the concerns that many have to taking such a nonrigorous approach in mathematics research. In setting up the new program, the Institute seems to be taking to heart the views of Sir Michael Atiyah, who, in a rebuttal to the Jaffe-Quinn article, advocated a "more buccaneering style" in mathematical research.

**Linking Research and Education**

The late Hassler Whitney, who was a professor at the IAS from 1952 until his retirement in 1977, worked hard on problems of mathematics education for the last twenty years of his life. Following in Whitney’s tradition, the IAS this summer played host to thirty-seven high school teachers as part of the IAS/Park City Mathematics Institute (PCMI). Whitney occasionally brought teachers to the IAS, but, according to MacPherson, the PCMI constitutes the largest organized contingent of high school teachers ever brought to the Institute.

The PCMI grew out of the Regional Geometry Institute that started six years ago in Park City, with funding from the NSF. This is the third year that the IAS has served as institutional sponsor, and the first year that the PCMI has met in Princeton rather than in Park City. The PCMI brings together high school teachers, undergraduates, graduate students, and researchers, with parallel sessions for each group and informal discussions and social events for everyone. The unifying theme of the program is the spirit of research and discovery. For example, Gregory Lawler of Duke University and Emily Puckette of Occidental College, who served as instructors in the PCMI program for undergraduates, say they covered material that is off the beaten track of usual undergraduate courses in probability and that is closer to the frontier of research. The courses combined lectures and informal group discussions with the students. In computer laboratory sessions, students got to explore some open problems in random walks.

The idea of integrating research and education has become a hot topic, particularly with the NSF. In fact NSF Director Neal Lane has made it a theme of his tenure. Lane visited the Institute during the PCMI and was the keynote speaker at a special event there entitled "A Celebration of Mathematics: Teachers and Researchers Working Toward Excellence in Mathematics Education". In an interview, Lane said that the idea of integrating research and education is based on the assumption students benefit by learning in an environment in which research is going on. "In the classroom is a person who in other hours of the day is probing fundamental, difficult, challenging questions" in science or mathematics, he said. "This creates a certain attitude toward inquiry and discovery, a frame of mind, a different take on the world. It’s a combination of enthusiasm, openness, and creative thought processes." Sometimes professors can bring into the classroom things they have been doing in their research. Said Lane, "There’s an element of romance about it."

In higher education, such integration can happen fairly easily. The PCMI tries to siphon some of the excitement off to the high schools by linking teachers and researchers. But do the various groups at the PCMI really mix? According to John Polking of Rice University, who serves as convener of the PCMI Steering Committee, the mixing of the groups is "the overriding purpose" of the program. "Everyone in mathematics has their own job, things they are good at, things they have to do," he explained, so it is not
possible that all of the groups will be interested in the same things. However, "they gain mutual respect because they are all doing what they do as well as possible." A random sampling of PCMI participants report that the amount of mixing is variable. There was plenty of interaction between the graduate students and researchers and some between the graduate students and the undergraduates, but less between the high school teachers and the other groups.

One reason the teachers are more isolated is that their program is more structured than the programs for the other groups, so they become a more cohesive clan. Groups of teachers are drawn from specific geographic sites and attend the program for two consecutive summers. Each site has a director, usually a mathematician in a local university or college. During the academic year, the teachers meet as a group and with site directors. By contrast, the topic for the PCMI research program, and hence the participants, changes each year; this year the topic was probability and next year it will be symplectic geometry. The graduate and undergraduate programs follow suit and therefore attract a different group of students each year.

In addition, the teachers' activities in the PCMI provide a sharper contrast with their day-to-day work than those of the other groups. For many of the teachers, the PCMI is an oasis from the pressures of teaching high school. Jo Vaccaro, a teacher at Stafford High School in Houston and a participant in the Rice University PCMI Site, said that at least twice during the school year ambulances visited her school to rescue students who had overdosed on drugs or attempted suicide, and several other students had suicidal tendencies or severe behavioral problems. "Many of the students have terrible home lives," she noted. "Many have little motivation to put a lot of effort into their schoolwork." For the teachers, "It is sometimes difficult to keep ourselves motivated." Programs like the PCMI "help me recharge my enthusiasm and refocus my love for teaching," she said.

What the PCMI teachers' program tries to do is get the teachers thinking deeply about and exploring mathematics. Polking taught a course on geometry which included such things as Girard's theorem about the sum of the angles of a spherical triangle. After the teachers had experimented with drawing triangles on inflatable beach balls, they took a crack at discovering the formula in Girard's theorem, which says that the sum of the angles is $\pi + \text{area of triangle}/r^2$. As Polking was planning to discuss the generalization to the Gauss-Bonnet theorem (in which the triangle is a geodesic triangle on a more general surface, and the term (area of triangle)/$r^2$ is replaced by the integral of the curvature over the triangle), he was clearly enthusiastic: "This is such a winner. How could anybody not like this?" In the class, the teachers enjoyed the discussion even when a few giggles indicated that the presentation was sailing over some heads. Questions about the mathematics mingled easily with suggestions about how to use models to demonstrate notions of curvature in the classroom.

The program also includes sessions that focus more exclusively on classroom practice; these are led by Naomi Fisher of the University of Illinois at Chicago and Cindy Hays of McCallum High School in Austin, Texas. As Fisher points out, these sessions are very different from the usual "in-service" program for training teachers in the use of a new kind of teaching module or technique. Indeed, much of what they do in the PCMI program is not immediately transferrable to the high school classroom. "What we are aiming for is to encourage teachers to take a fresh look at familiar mathematics and standard high school topics in order to consider ways to rearrange their own curricula, and introduce new ways to present standard topics to make their teaching more coherent and absorbing for their students," Fisher explained. In particular, they try to get the teachers to make connections between separate parts of the mathematics curriculum, especially between geometry and other areas. She observes that some of the teachers make slow, evolutionary changes shifts, while others make bold, radical changes. Said Fisher, "What is exciting to me is to see teachers gain the confidence to make these decisions for themselves and carry them out successfully."

Clashing Views

One thing that comes out in some of the PCMI activities is that often the researchers and the teachers have very different views on high school mathematics education. In a lunchtime conversation with Elton Pei Hsu of Northwestern University, who led a graduate course at the PCMI, Michael Cranston of the University of Rochester, who was in the research program, and undergraduate instructors Gregory Lawler and Emily Puckette, there was general agreement that it is essential that high school students have a solid grasp of basic techniques such as factoring polynomials. There was also considerable wariness of student dependence on calculators and sympathy for the notion that calculators should not be allowed on exams. (And it's easy to see why: Lawler said that he had seen on an e-mail discussion group the comment that now that one has calculators there is no longer a need for such formulas as $\sin 2x = 2 \sin x \cos x$.)

Notes from this class may be found at the web site http://math.rice.edu/~pcmi/sphere.
Such views make many teachers shake their heads and cluck their tongues. Having tasted a richer and more exciting menu of mathematics than the one they were accustomed to, they are skeptical of views that smack of "back to basics". To those wary of the trend toward nontraditional approaches to teaching mathematics, Shirley Hill has this to say: "We certainly didn't do it awfully well the other way." Hill is a retired mathematics professor from the University of Missouri at Kansas City who serves on the PCMI Oversight Board. If the goal is to produce a few top-notch mathematicians, perhaps no changes are needed in the teaching of mathematics, she said. "But I think you've got to look at a broader population that's got to understand a lot more mathematics. And now you have to ask, Would the past programs produce that? I don't think so. What's happening now may not be fully evolved, but we don't have a great record of success to fall back on."

Tim Giesbrecht is a teacher in Franklin Junior High School in Pocatello who is a member of the Idaho State University PCMI site. He said that in order to capture the attention of his students he has to present mathematics in such a way that it relates to their lives in some fashion. Visualization helps a great deal, he said. For example, he worked with his students on the mathematics behind a simple harmonic oscillator. Being able to model the motion on a graphing calculator helped to spark the students' interest. Giesbrecht compared students' interest in mathematics to their interest in cars. "It's difficult to get students interested in the details of learning how to fix cars," he said. "What they want to do is drive cars. In the same way, we want to show them how to 'drive' mathematics, not 'fix' it."

For teachers to be able to take that kind of exploratory approach, they need to be confident about their mathematical knowledge—and to be comfortable knowing that they don't have all the answers. Cindy Hays from McCallum High School in Austin, Texas, was on a panel, held in conjunction with "A Celebration of Mathematics", which focused on connecting mathematics researchers and teachers. One of the best things about the PCMI, Hays noted, was that it "got me in touch with how fun it is not to know the answers." In talking to the research mathematicians attending the PCMI, she found that they don't know all the answers either. "I have much more freedom to talk about different topics with the students," she declared. "I won't necessarily understand all of hyperbolic geometry or spherical geometry, but I can give my kids a glimpse of the magic and the power of mathematics without knowing all the answers."

—Allyn Jackson
The Seattle Mathfest, held August 10-12, 1996, on the campus of the University of Washington, provided an occasion to sample some fine mathematics while taking in spectacular views of Mount Rainier. And if three days of talks and panel discussions were not enough, there was a symposium immediately after the Mathfest, entitled “In Celebration of the Centenary of the Prime Number Theorem: A Symposium on the Riemann Hypothesis”. The symposium, sponsored by the American Institute of Mathematics (AIM), featured a rare public lecture by Fields Medalist Atle Selberg, one of the major figures in the field. (An article about AIM and the symposium is planned for an upcoming issue of the Notices.)

The AMS has decided to get out of the business of this kind of summer meeting, at least till the year 2000; starting in 1997, the Mathematical Association of America will be the sole sponsor of the Summer Mathfest. The Society will continue to offer specialized summer seminars and institutes, but has ended its participation in this kind of general summer mathematics meeting. The fact that the Seattle Mathfest was quite successful, attracting about 1,200 attendees, must have left a few AMS hearts wistful. What follows is a small sampler of the offerings in Seattle.

A Bit of Bubbly
The Seattle meeting featured a number of sessions that broke with traditional formats. A talk on the “double-bubble conjecture” by Joel Hass of the University of California, Davis, included a panel that kibitzed on the lecture as it proceeded. Frank Morgan of Williams College moderated the panel consisting of Jenny Kelley and Jean Taylor of Rutgers University and Helen Moore of Bowdoin College. The program said that the panel would add their “two cents’ worth” after Hass spoke, but in fact the panel spoke before the lecture, during a break midway through, and also at the end. Such a panel could be disruptive, but as it turned out the different viewpoints and the questions of the panelists helped to illuminate the topic.

The topic of Hass’s lecture was a variant on the isoperimetric problem, which goes back to the time of the ancient Greeks. As Virgil recounts in the Aeneid, Queen Dido cut a deal with chieftains in North Africa in which she would be allowed to keep as much land as she could enclose inside a fence of a given length. That her choice of a circular fence was the one that gave her the most land was not established mathematically until the nineteenth century, when it was proven by Weierstrass. The 3-dimensional isoperimetric problem poses an analogous question: Among all shapes of a given surface area, which encloses the maximum volume? Or, said differently, given a certain volume, what is the smallest-area surface enclosing the volume? In 1882 Schwarz proved it is a sphere.

The question Hass explored is, What is the smallest-area surface enclosing two given volumes? Intuitively, it seems it would be a double-bubble: two identical spheres that meet at an angle of 120 degrees, with a flat disk separating their interiors. That this is the case was proven last year by Hass and Roger Schlafly of Real Software of Santa Cruz. Their proof relied on a panel consisting of Jenny Kelley and Jean Taylor of Rutgers University and Helen Moore of Bowdoin College. The program said that the panel would add their “two cents’ worth” after Hass spoke, but in fact the panel spoke before the lecture, during a break midway through, and also at the end. Such a panel could be disruptive, but as it turned out the different viewpoints and the questions of the panelists helped to illuminate the topic.

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on work of Michael Hutchings, a graduate student at Harvard who participated in the Research Experiences for Undergraduates program at Williams. Hutchings showed that each of the two pieces of the bubble have to be connected. Another important piece of information came from joint work of Frank Morgan of Williams and Brian White of Stanford, who proved that whatever the most efficient surface was, it had to be a surface of revolution. The field of solution candidates was then reduced to two: the double-bubble or one of a family of “torus bubbles”—a torus bubble is a sphere with a torus around its middle.

The Hass-Schlafly proof was unusual in that a computer carried out some of the critical steps. The torus bubbles can be classified according to two parameters, an angle and a mean curvature. Using geometric and other arguments, they were able to reduce the possible values of each parameter to a closed interval, so that the parameter space became a rectangle. All that is left to do is to check the areas and volumes of all of the candidates to see if any of them is more efficient than the double-bubble. The problem is, of course, that there are infinitely many candidates. How can the computer handle such a calculation?

Hass explained that their program used what is known as “interval arithmetic”, in which the computer performs calculations not on floating-point numbers but on intervals with endpoints that are floating-point numbers. For each 2-dimensional interval in the parameter space, the program produces an interval of values of the volumes of the torus bubbles represented by that interval. If the range of the volumes of each component are unequal, the program tosses out that interval, since only equal volume solutions are being sought. Other tests are used if volume comparison does not apply. The remaining intervals are then subdivided again, and the same elimination is carried out. This process produces strict upper and lower bounds on the volumes of each component of the torus bubble. From these and similar bounds, the proof follows. (For an expository presentation of this result, see “Bubbles and Double Bubbles”, by Joel Hass and Roger Schlafly, American Scientist, September-October 1996, pages 462–467. This and related papers may be found on the World Wide Web at http://www.math.ucdavis.edu/hass/bubbles.html.)

The Hass-Schlafly proof was adaptable to this problem. But he did mention that this result should apply to spaces with metrics that are “close to” the Euclidean metric. Hass, Hutchings, and Schlafly are working to generalize their result to bubbles enclosing unequal volumes and bubbles in manifolds.

The Ghost of Rochester

Although the crisis at the University of Rochester has been resolved, its ghost still haunts the mathematical community. Last fall the Rochester administration announced it would cut its mathematics department faculty by half and eliminate the mathematics graduate program. The move produced a strong outpouring of protest, a good deal of it generated by the AMS Task Force on Rochester, and by March the administration and the mathematics department reached an agreement in which the graduate program would be reinstated and the cuts in faculty made less severe. Despite the relatively happy ending, the fact that a highly regarded research university was seriously questioning the value of having a mathematics graduate program left a deep impression on the mathematical community.

“How Can You Defend Your Graduate Program In Mathematics?” was the title of a panel discussion sponsored by the AMS Committee on Education and organized by committee member Harvey Keynes of the University of Minnesota. The three panelists took rather different tacks on the question. John B. Conway, head of the mathematics department at the University of Tennessee at Knoxville, said he is not convinced that graduate programs are under attack. “If Rochester is n = 1, then what is n = 2?” he asked. He pointed out that it is very difficult to ferret out why the Rochester crisis occurred; one would have to examine the situation two, three, or even ten years earlier to understand how it came to pass. Nevertheless, he had a number of suggestions to offer to protect one’s graduate program: teach calculus better, examine precalculus, improve the undergraduate major program, and, finally, connect to engineering and science departments. “If the crunch comes and darkness is at your door,” he said, “these are the only allies you can have.”

Bus Jako of Oklahoma State University saw a number of threats to mathematics graduate programs. One of them is the mathematical community itself: overproduction of mathematics Ph.D.s has fueled comments that the lesser lights among graduate programs should close up shop. For Oklahoma State, which has been improving in recent years but finds its backwater image hard to shed, such comments hit close to home. Jako suggested that some sort of national accreditation might be in order, though he op-
poses "Ph.D. birth control" on a national scale. He also suggested that, rather than large changes in the graduate program, what may be needed is a change in faculty attitude, with more attention paid to such things as exploring career options for new Ph.D.s, discussing professional and teaching issues with students, and insuring that students get early experiences in mathematics research.

Echoing this idea was William Rundell, chair of the mathematics department at Texas A&M University. Rundell's vision is for mathematics departments to "own the boundary" of the discipline so that, for example, mathematics majors are prepared to enter Ph.D. programs in a variety of areas. Unfortunately, many departments pay scant attention to undergraduates and simply complain about their academic weaknesses. Rundell pointed out that, judging by SAT or GRE scores, other departments see mathematics majors as "Rolls Royces". "We complain about our students as being miserable," he said. "But if we do that, we'll look foolish." One result is that mathematics loses many students to management and engineering.

One of the most pernicious threats to graduate programs in mathematics is simple economics. During his presentation Rundell quoted figures about the cost-per-student-credit-hour of certain courses offered at Texas A&M. He implored the audience not to write them down, lest the figures end up in the hands of his state legislature. Suffice it to say that the difference between the cost-per-student-credit-hour of certain business courses and that for graduate mathematics courses is two orders of magnitude. With the popularity of the business major and the employment troubles of mathematics Ph.D.s, the mathematics graduate program can seem the right place to cut. "Despite the prevalence of overall departmental cost/student data, these particular figures are rarely asked for," says Rundell. "They could be dangerous in the hands of those looking for simplistic solutions."

During the question period, one member of the audience said that after hearing the panelists he wasn't sure he was at the right session; he thought he had come to hear about how to defend one's graduate program against complaints of the students. Many of his students have to moonlight during graduate school, he said, and once they finish they cannot find jobs. Some he hires on as instructors, and they take the jobs because they pay marginally better than the community college across town.

Rundell had one question to ask: How much can these students program in Java? Currently, he notes, there is a real demand in major computer software industries for a combination of traditional mathematical sciences training and specific skills such as Java programming—and the salaries far exceed that of an assistant professor. Being willing to take advantage of such opportunities could give students a very different perspective on graduate school in mathematics. In his response Conway took a more traditional tack. A while back he realized that most of the Ph.D.s from his department were getting jobs at four-year institutions. "Our graduate programs have ignored this reality," he noted, as they tend to focus on preparing students for positions in research institutions. To address this problem, Conway is trying to set up a program whereby his students can teach at local community colleges to get some experience that might help them in landing jobs later on. For the mathematical community more generally, the difficulty is that no one wants to give up any part of the graduate program to do anything different. Said Conway, "We are sometimes our own worst enemies."

**Whimsical Mathematics**

Mathematical objects usually have names like \( \mathbf{x} \), \( \mathbf{Q} \), or maybe \( \mathbf{K} \), if you want to get fancy. For Colin Adams and Edward Burger, these plain-Jane names are not good enough. At their talk in Seattle, these two Williams College mathematicians favored names like Bubba, Bosco, Olive, and Carlo. One object was likened to a tumor, while a deformed torus was called a "quasimodonut". Just what were they doing with all this whimsy?

Believe it or not, they were proving theorems. For their AMS-MAA Joint Invited Address, Adams and Burger wrote, produced, and starred in a play called "Casting About: About Casting". The characters, Sam and Buddy, were workers at the Acme Casting Factory, a metal casting plant in Allentown, Pennsylvania. The show opened with slides of Adams and Burger getting ready for work, complete with hardhats and plaid shirts, while the song "Allentown" by Billy Joel played in the background. After this introduction, the two appeared onstage in their workers' getup. As they chatted during their lunch break, the mathematics crept in slowly: amid talk about work at the plant Sam mentions a new treat at the local donut shop called a "glazed handlebody".

The jokes flowed fast and corny, inspiring roars of laughter among the folks packing the 800-seat auditorium. The humor was tailor-made for this audience: where else would talk of downsizing at the "Rochester casting plant" have even caused a titter?

**BUDDY:** (Stunned) What?! (Pause) Rochester downsized?

**SAM:** Yeah. The company almost cut the entire casting division, but with some pressure
from the MAA and the AMS, they decided to back off.

BUDDY: The MAA?
SAM: Yeah, the Metalworkers Association of America.

BUDDY: Oh, yeah, and the American Molders Society. Boy, those are powerful organizations, I'm telling you.

Well, you had to be there.

Before this sort of thing could wear too thin, Sam and Buddy start discussing what kind of objects one can create from a two-piece casting mold (with each mold deformable into a ball). Buddy bets Sam $5 that the only possibilities are a ball, a donut, a "glazed handlebody", or "an apple with wormholes". The two stay in character, with Sam naming the object to be cast after himself and the two parts of the mold "Bubba" and "Bosco". He asks skeptical questions as Buddy goes through the proof, and the result is an intuitive explanation that is perhaps more understandable than a more straightforward lecture.

After a 5-minute intermission, Sam bets Buddy $5 that he can prove that one can cast anything using a 3-piece mold (provided that the object has only one boundary component). This time Sam goes through the proof of this rather surprising result, with Buddy asking the questions. The two theorems proved in the play are new results by Adams and Burger. At one point one of them says somewhat disappointedly that the results are all "theoretical". "Imagine if that's what you did all day, just sitting around chewing the cud on theoretical nonsense?" laughs the other. "Yeah, and what if they actually paid you to do it? Ah, we're being silly!"

Buddy and Sam also discuss a third result by Adams about tiling of 3-space. First they discuss tiling space by tetrahedra ("Tetrawhatdra?" one of them asks) and reminisce about when Acme Casting made bronze tetrahedral mementoes for a mathematics meeting. Adams’s surprising result, which follows from the theorem proved after the intermission, says that 3-space can be tiled with knotted tori. Saying that he read about the result in Better Homes and Gardens, Buddy claims that this method of tiling space is all the rage for decorating bathrooms. Indeed, why tile just the bathroom floor when you can tile the whole space?

BUDDY: So now the entire bathroom is filled with these knotted doughnut shaped tiles.

SAM: I love it. Seems totally pointless, but I love it. We should make and sell tiles that look like that.

BUDDY: Hey, you know what we should do? The next time there's a big math conference, we could go there and sell these knotted tiles! Heck, they went for those silly bronze tetrahedra; they'd gobble these things up.

SAM: Hey, yeah, but I got a better one. [Laughing] Maybe at their next conference, we could go and give a presentation.

BUDDY: Yeah, right [laughing]; you and me talking to an auditorium filled with mathematicians about casting and tiling. That'd be a good one. Come on, lunch is over; we'd better get back to work.

—Allyn Jackson
News about the IMU and ICM-98

At the April 1996 meeting of the AMS Eastern Section, a panel was held to discuss the activities of the International Mathematical Union (IMU) and plans for the upcoming International Congress of Mathematicians (ICM), to be held in August 1998 in Berlin.

The panel was organized and chaired by IMU president David Mumford of Harvard University. IMU secretary Jacob Palis of Instituto de Matemática Pura e Aplicada in Rio de Janeiro spoke about the International Council of Scientific Unions, of which the IMU is a member. ICM Program Committee chair Phillip Griffiths of the Institute for Advanced Study discussed the preparation of the scientific program for the ICM, and ICM Organizing Committee president Martin Grötschel of the Konrad-Zuse-Zentrum in Berlin talked about other aspects of planning for the Congress. Jeremy Kilpatrick of the University of Georgia, vice president of the IMU's International Commission on Mathematical Instruction, discussed that commission's activities. C. Herbert Clemens of the University of Utah, a member of the IMU's Commission on Development and Exchange, was not able to attend the panel, but his written remarks were read by Emma Previato of Boston University.

This article contains edited versions of the remarks of Griffiths, Grötschel, and Clemens. A progress report on ICM-98 appeared in the June 1996 issue of the Notices, page 683, and a more general article about the IMU appeared in the November/December 1994 issue of the Notices, page 1112. Further information on the IMU and ICM-98 is also available on the Web pages http://elib.zib-berlin.de/IMU/ and http://elib.zib-berlin.de/ICM98/, respectively. There are mirror sites for these servers in Copenhagen, Marseilles, Kyoto, Rio de Janeiro, and Warsaw. Further mirror sites are under construction.

Phillip A. Griffiths, Chair, ICM Program Committee

The ICM Program Committee is charged to recommend to the IMU Executive Committee the scientific program for the ICM. The committee recommends, first, the list of plenary speakers, and, second, the list of 45-minute speakers, broken into sections in the familiar way. This time there are a couple of experiments that change the process slightly. One is to organize jointly some of the scientific sections with other scientific societies, specifically with applied mathematicians (through the Committee for the International Conferences on Industrial and Applied Mathematics (CICIAM)), control theorists (through the Mathematical Programming Society), statisticians (through the Bernoulli Society), and computer scientists (a cooperating society has not yet been named). A second experiment has to do with making the process more open. So my name as chair of the Program Committee has been made public, and I put a letter on the Internet giving the provisional program that the committee arrived at when they met in December and inviting comments on it. There were in fact a number of comments, and we considered them all.

A number of the comments were organized around two particular aspects of the program. When I went back to the Program Committee and consulted with them, everyone felt that following these comments would lead to a better scientific program. So those changes were made, and now we are in the process of contacting people whom we would like to serve as chairs of the panels for the various sections and as core...
panel members. If these individuals accept, then their job is to appoint additional panelists and to develop a recommended list of talks and speakers for that section.

One change which came out of the comments was the following. Traditionally, a section would be listed as, say, algebra, and then connections would be indicated to other related sections. This means that the chair of the panel on algebra should at least consult the chair of these other panels in choosing speakers. We went one step further and stipulated that in some cases two sections should jointly decide on speakers in some general area. There are so many interesting parts about mathematics that do not fall neatly into one section, so we thought we would at least experiment with asking a few sections to jointly sponsor a talk.

There are three changes in the way that applications are dealt with in the ICM program. First, we will do joint planning with CICIAM: we will ask them to recommend a couple of panelists, the Program Committee will select a couple, and together they will propose speakers to the Program Committee. The second idea is to have an integrated session in an area of active research involving mathematics, computation, and experiment. In the session these three aspects of a particular scientific problem would be looked at by three different speakers representing these perspectives, and we would ask them to coordinate what they speak on. The third idea is, rather than having one section with a hodgepodge of talks on applications of different areas, that those talks would be put in a regular section that is closest to them mathematically. For example, many applications obviously involve partial differential equations, so rather than having just a collection of talks on applied PDE, we will put them in the section on PDE. In this way, the applied talks would be integrated with the selection of other speakers and with the structure of the section.

The question has been raised of making public the names of the members of the selection panels; in the past this information has been kept confidential, as have the names of the Program Committee members. I think it is probably better to do these experiments one step at a time. So this time let us try the experiment where my name is public and the initial program is put out for comment. We will take a look afterward to see if this works, and then we can raise the question about making public the names of the Program Committee members, the panel chairs, and/or the panel members. I think it is fine to make one person public and have that person be the conduit for comments from the community, but if you make all the names public, then there could be lobbying. And not only that—then the chair of the Program Committee will not know what is going on! So that would be my inclination. Eventually it will be up to the General Assembly, which will meet just prior to ICM-98, to evaluate how things went this time and decide what course to follow in the future.

**Martin Grötschel, President, ICM Organizing Committee**

The scientific program is the most important part of the International Congress. The Organizing Committee is just providing the framework for the program so that the Congress goes smoothly. It is, of course, a lot of work, since it will be a big meeting. We are trying to collect substantial amounts of money to make it an interesting and pleasant Congress for everybody.

Berlin is a big city that has three universities and two research institutes in mathematics: Humboldt University, Technische University, and the Free University; the Weierstrass Institute (WIAS) and the Konrad-Zuse-Zentrum (ZIB), where I am from. There is a new university in Potsdam (the capital of the state of Brandenburg), with which we are also working. Each institution has representatives on the Organizing Committee.

Serving on the Board of Directors of the Organizing Committee as honorary president is Friedrich Hirzebruch, who tried four times to invite the Congress to Germany after World War II and this time was successful. We are very happy about this. The other members of the Board are Secretary General J. Winkler, from the Technische University, who will work on the local arrangements; Vice President Martin Aigner, from the Free University, who is responsible for public relations; and Treasurer J. Sprekels from the Weierstrass Institute.

We are trying to provide a good framework for the scientific program and also to come up with additional activities for the attendees and the general public. The money we have raised so far is sufficient to run the Congress. Now we are trying to get additional money for extra activities. We will rent a special building for evening talks as well as for performances and art exhibitions. We will try to attract high school students and have classes coming in for tours. There will be a video show, probably running every day, which will include 10 to 20 short movies about mathematics. The biggest and most expensive project is on mathematics and music. It is very expensive to hire an orchestral But there is support from the Academy of Arts and Music in Berlin, and we are discussing with them how to stage an event which would include music performances and talks about mathematics and music. What is going to come out of that I can—
not tell because it is still in the process of development.

In addition to an art exhibition (preliminary title: "Mathematics and the Arts") featuring well-known painters, we are planning another exhibition of mathematical models. This is a joint project with the Deutsches Museum in Munich, where some of the models will actually be produced. And something exciting happened just a few months ago. The Humboldt University is the oldest university in Berlin. It was in a state of transition because of the unification and subsequent internal restructuring and somehow lost some inventory. An art historian and a mathematician rediscovered a lot of mathematical models somewhere in the corner of a basement. The models had been produced perhaps 100 or 150 years ago. Now they are trying to dig them out and register them. Maybe we can also use this material in our exhibition.

We are aware of the fact that many very good mathematicians come from countries with little financial means. We will try our best to raise money to support them. The Special Development Fund from the IMU will pay for travel for mathematicians from developing countries. We will provide local support and will make a special effort to bring in people from Eastern Europe.

Also, hotel costs are an important factor. Berlin is a big city, and it is not cheap. But there are inexpensive accommodations, and we will make them available.

We have set up a Web server for the Congress, where you can do what we call "preliminary preregister". We say "preliminary preregister" because we learned that for the ICM you "preregister" prior to the Congress and you "register" at the Congress. "Preliminary preregistration" just means that you get on the mailing list and receive information. I checked two weeks ago, and we had 1,300 people preliminarily preregistered, which I thought was quite good. We have written to all national mathematical societies to ask them to publish an announcement about this service in their newsletters.

C. Herbert Clemens, Member, IMU Commission on Development and Exchange

I once heard a comment by a mathematician from the former Soviet Union when asked some years ago how he became a mathematician. He said that it was for him the only window of reason, logic, and order in an impossibly crazy world. It was the refuge of last resort for the mind, saving it from inevitable insanity. That in a society in which one was relatively safe from physical assault and personal insult and injury. However fundamental was that motivation for him and for many other scholars of those societies in that era, how much more fundamental it must be for the isolated intelligent individual in some far corner of Africa, Asia, or, for that matter, in any of the physically dangerous, economically deprived, and scientifically barren corners of our world! (In fact, not all such places are far away, at least not physically far away, from the room in which this AMS meeting is taking place.)

The professional impediments of most of us pale into nothingness compared to those of, say, bright young university students of mathematics in Mogadishu in the mid-1980s, students whose school mathematical training and culture, according to Italian colleagues who taught there at the time, would stand up well beside their European counterparts. Closer to my own personal experience was the situation of some
young Chilean mathematicians in the mid-1970s, whose experiences mirrored in miniature and from the reverse side of the political spectrum the madness of the cultural revolution in China ten years earlier.

Improbably yet inevitably, even in these environments, young people still do continue to find a book which inspires or a mentor who opens their personal window of sanity. On the scientific side, it is often the subject mathematics which is the intellectual instrument of that opening. The subject of this report, the Commission on Development and Exchange of the IMU, or CDE for short, is one of the few professional mechanisms that we mathematicians have to reach out to our colleagues and their students in many obscure places in which an orderly life, let alone a mathematical life, is still extremely difficult.

The CDE presently runs two programs aimed at supporting mathematics and mathematicians in developing countries. One program applies to individuals and supports research visits, chiefly by offering partial travel support. The other gives partial support to conferences organized by mathematical groups in developing countries.

The individual grants, usually at the level of $1,000 or less, must be matched by support for local expenses given by the research center which the mathematician is visiting, and the visit must be for a month or more in duration. However, visits of six months or more are rarely funded, since it is assumed in such cases that ongoing local support from the inviting center will suffice to recoup travel costs. Individual mathematicians apply by submitting a curriculum vitae, a proposed program of joint research with a mathematician at the host institution, together with a letter of invitation from that institution. At the end of the research visit, the support recipient submits a final scientific report to the CDE.

The CDE gives supplementary support for research conferences organized in developing countries, on conditions including the stipulation that the conference be regional in nature, not limited to a single country, and open to all working mathematicians regardless of nationality. The level of support is typically on the order of $2,000 and is meant to encourage other potential funders and to encourage special attention to CDE priorities, priorities such as making possible conference participation by mathematicians in nearby countries without the means to sponsor such activities. Again, the CDE responds to well-documented and mathematically sound applications from conference organizing committees. The CDE does not initiate the support process, but rather responds to requests. Due to the relatively small budget within which the CDE operates, conference support is limited to research, as opposed to training, conferences.

A variant on CDE support to research conferences is support for "working teams", that is, small groups of mathematicians in developing countries whose work centers around a single mathematical theme. Typically, these groups have a continuing mathematical contact with a center in a "mathematically developed" country. All grants went to individuals and entities in Asia and Africa, with the exception of a single individual grant to a Latin American mathematician.

In 1995 the CDE supported seven individual mathematicians for a total of $8,000, six conferences for a total of $12,000, and two working groups for $4,000. The CDE received $30,000 plus an administrative budget of $4,500 from entities internal to the IMU and another $10,000 from UNESCO. As can be seen from these budgets, the CDE is very limited in the number of grants it can give, as well as in the size of grants. However, the CDE's efforts to be geographically balanced and even-handed and to observe rather rigorous mathematical standards have also been factors in limiting the number of grants. Even at present funding levels, the CDE could raise its grant output somewhat if its programs were more widely known, an eventuality that would presumably generate more fundable applications.

Which brings me finally to a couple of questions the CDE would like to put to the mathematical community. First of all, should we seek to expand the kind of mathematical activity we fund? This might take the form of continuing and extending the experimental policy of supporting working groups, perhaps in the direction of supporting groups of advanced students and mathematicians just starting out. Secondly, should the CDE seek to expand the size and number of its grants by seeking outside money from foundations, businesses, and governments through its parent body, the IMU?

So I would like to end with these questions to the mathematical community. Are we doing enough to help our colleagues in developing countries have a productive professional life themselves and to encourage those who come after them? If we should do more, what kinds of activities should we consider? And finally, what about the tension between access and mathematical standards? Should we try to support, for example, young talent starting out, perhaps even at the advanced-student level, even at the risk of making (costly) mistakes with a relatively small budget?
George Elliott Receives CRM/Fields Institute Prize

GEORGE ELLIOTT of the University of Toronto and University of Copenhagen has received the CRM/Fields Institute Prize from The Fields Institute for Research in Mathematical Sciences (Toronto) and the Centre de Recherche Mathématiques (Montreal). The prize recognizes exceptional achievement in the mathematical sciences. Recipients are chosen on the basis of outstanding contributions to the advancement of research, with research having been done primarily in Canada or in affiliation with a Canadian university. An honorarium is provided, and recipients present lectures at the Centre de Recherche Mathématiques and The Fields Institute. The title of Elliott's lecture was "How many stars in the sky?...How many C*-algebras?"

—John Chadam, former director, The Fields Institute

Peter Lax Elected to Philosophical Society

In late April, the American Philosophical Society elected thirty-one new resident members and eight foreign members. Among those elected was PETER D. LAX of the Courant Institute of Mathematical Sciences.

—Physics Today

Visiting Mathematicians

(Supplementary List)

Mathematicians visiting other institutions during the 1996–97 academic year were listed in the July 1996 issue of the Notices, pp. 784–786. The following is an update to that list (home countries are listed in parentheses).

SERGEY V. BOLOTIN (Russia), University of Wisconsin, Madison, Dynamical Systems, 9/96–12/96.

GILLES GODEFROY (France), University of Missouri, Functional Analysis, 8/96–7/97.

HELGE HOLDEN (Norway), University of Missouri, Partial Differential Equations, 8/96–7/97.

ASHOK MAITRA (India), University of Maryland, Baltimore County, Statistics, 8/96–6/97.

SUNDARAM THANGAVELU (India), University of New Mexico, Harmonic Analysis, 8/96–5/97.


JIONGMIN YONG (People's Republic of China), University of Maryland, Baltimore County, Applied Mathematics, Control Theory, 8/96–6/97.

Deaths

ARNOLD L. FASS, of Coral Springs, Florida, died on July 21, 1996. Born on April 2, 1922, he was a member of the Society for 48 years.

JAMES L. HOWLAND, of Aylmer, Canada, died on June 9, 1996. Born on January 24, 1929, he was a member of the Society for 40 years.

WILLIAM H. LEMAY, of Birmingham, Michigan, died on July 20, 1996. Born on December 22, 1944, he was a member of the Society for 26 years.

S. S. McNEARY, professor emeritus of Drexel University, Philadelphia, Pennsylvania, died on June 25, 1996. Born on September 16, 1913, he was a member of the Society for 52 years.

ABBA V. NEWTON, professor emeritus of Vassar College, died on May 5, 1996. Born on February 19, 1908, she was a member of the Society for 60 years.

ERNST A. PROPS, professor at Eastern New Mexico University, died in November 1995. Born on February 5, 1909, he was a member of the Society for 49 years.

FRANCIS REGAN, professor and chair emeritus of St. Louis University, died on February 18, 1996. Born on January 10, 1903, he was a member of the Society for 63 years.

AUBREY H. SMITH, of West Lafayette, Indiana, died on March 11, 1996. Born on October 3, 1905, he was a member of the Society for 71 years.
American Mathematical Society Centennial Fellowships

Invitation for Applications, 1997–1998

Deadline December 1, 1996

The AMS Centennial Research Fellowship Program makes awards annually to outstanding mathematicians to help further their careers in research. Recently, the AMS Council approved changes in the rules for the fellowships. From 1984–1996, the fellowship program was aimed at midcareer mathematicians. The changes adopted last year redirected the fellowship program toward recent Ph.D.s.

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

The stipend for fellowships awarded for 1997–98 is expected to be approximately $37,000, with an additional expense allowance of about $1,500. Acceptance of the fellowship cannot be postponed. Fellowship holders may use their stipend as full support for a year or may combine it with half-time teaching and use it as half support over a two-year period. Applications should include a short research plan describing both an outline of the research to be pursued and a program for using the fellowship, including institutions at which it will be used and reasons for the choices. The selection committee will base its decision on both the research potential of the applicant, based upon track record and letters of recommendation, and on the quality and feasibility of the research plan.

The number of fellowships to be awarded is small and depends on the amount of money contributed to the program. The Trustees have arranged a matching program from general funds in such a way that funds for at least one fellowship are guaranteed. Because of the generosity of the AMS membership, it has been possible to award two to four fellowships a year for the past ten years.

The deadline for receipt of applications is December 1, 1996. Awards will be announced in February 1997 or earlier if possible.

For application forms, write to the Executive Director, American Mathematical Society, P.O. Box 6248, Providence, RI 02940-6248, or send electronic mail to ams@ams.org. Application forms are also available on the World Wide Web via the Internet at URL http://www.ams.org/committee/profession/. Please note that completed applications and references should not be sent to the AMS, but to the address given on the application and reference forms.

—AMS Announcement
NRC Associateship Programs at U.S. Government Research Facilities

The National Research Council (NRC) announces the 1997 Resident, Cooperative, and Postdoctoral Research Associateship Programs to be conducted on behalf of over 100 research laboratories throughout the U.S., representing nearly all U.S. government agencies with research facilities. The programs provide opportunities for Ph.D. scientists and engineers of unusual promise and ability to perform research on problems largely of their own choosing yet compatible with the research interests of the sponsoring laboratory.

Approximately 350 new full-time associateships will be awarded on a competitive basis in 1997 in a variety of areas, including mathematics. Most of the programs are open to both U.S. and non-U.S. nationals, and to both recent doctoral recipients and senior investigators.

Awards are made for one or two years, renewable for a maximum of three years; senior applicants who have held the doctorate at least five years may request shorter periods. Annual stipends for recent Ph.D.s for the 1997 program year range from $30,000 to $45,500, depending upon the sponsoring laboratory; stipends will be appropriately higher for senior associates. Financial support is provided for allowable relocation expenses and for limited professional travel. The host laboratory provides the associate with programmatic assistance including facilities, support services, equipment, and travel needed for the conduct of the research program.

Applications submitted to the NRC are accepted on a continuous basis throughout the year. Those postmarked no later than January 15 will be reviewed in February, by April 15 in June, and by August 15 in October. Initial awards will be announced in March and April (and July and November for the two later competitions), followed by awards to alternate candidates later.

Information on specific research opportunities and participating federal laboratories, as well as application materials, may be obtained from: National Research Council, Associateship Programs (TJ 2114/D3), 2101 Constitution Avenue, NW, Washington, DC 20418; fax 202-334-2759; e-mail rap@nas.edu. Information may also be found on the World Wide Web at http://www2.nas.edu/rap/welcome.html.

— NRC Announcement

NRC Grants for Central/Eastern Europe Collaborations

The Office of Central Europe and Eurasia of the National Research Council (NRC) offers grants to individual Amer-
Nominations Sought for the Fields Medal and Nevanlinna Prize

The Executive Committee of the International Mathematical Union has appointed a Fields Medals Committee and a Nevanlinna Prize Committee to select the awardees. The names of the members of these committees will not be announced publicly. An individual can contribute to the selection process by contacting the national mathematical committee of his or her country. For U.S. mathematicians, the relevant body is the U.S. National Committee, which is organized through the Board on Mathematical Sciences of the National Research Council. (The national mathematical committees of other countries may be found by looking up the list of IMU member countries in the IMU server, http://elib.zib-berlin.de/IMU/.) The National Committees can, if they wish, suggest candidates for the Fields Medal and Rolf Nevanlinna Prizes to be awarded at the Opening Ceremony of the Congress.

—from ICM-98 Announcement

"Virtual Mentors" Needed for Online Career Planning Site

The National Research Council (NRC) has developed a World Wide Web service called the Career Planning Center for Beginning Scientists and Engineers (http://www2.nas.edu/cpc/). The Center provides information and guidance to students who are trying to get jobs, planning their careers, or making educational choices. Through the Center, users can ask questions, post jobs, provide advice, review the latest employment trends, and request to be linked to an online mentor.

The Center has been very successful, attracting over 6,000 registrants since its startup in February 1996. It has been so popular that the Center now needs more scientists and engineers who are willing to serve as “virtual mentors” to the undergraduate and graduate students and postdocs who use the Center. All of the correspondence is by e-mail, so the burden is not onerous, yet the benefits are many.

Mentors form personal relationships with young scientists or engineers and have the opportunity to discuss many issues, from ethics to how to write a good résumé. Few pleasures are greater than that of inspiring and guiding enthusiastic young scientists and engineers as they prepare to launch their own careers.

Mathematics is one of the areas in which mentors are especially needed. In addition, those who can provide general career guidance (especially women or couples in dual science and engineering careers) and those who have nonacademic experience would be especially helpful. For more information, or to sign up as a mentor, access the mentor form at http://www2.nas.edu/cpcadv.mentor.html, or send an e-mail message to ewojtasz@nas.edu, with the subject line “Mentor Volunteer.”

—from NRC Announcement
New NSF Report on Undergraduate Education

Introductory college science and math courses serve largely as a filter, screening out all but the most promising students and leaving the majority of college graduates—including most prospective teachers—with little understanding of how science works, according to a new study conducted for the National Science Foundation.

As a result, "despite the observation that America's basic research in science, mathematics, and engineering is world-class, its education is still not," according to the independent team of reviewers. "America has produced a significant share of the world's great scientists while most of its population is virtually illiterate in science," the study concludes.

Because few teachers, particularly those at the elementary level, experience any collegiate science teaching that stresses the skills of inquiry and investigation, they simply never learn to use those methods in their teaching, the report states.

The findings in the report, called Shaping the Future: New Expectations for Undergraduate Education in Science, Mathematics, Engineering, and Technology, were made public at a conference held in the summer in Washington, D.C. The nation's goal for undergraduate education, it states, should be that all students have access to supportive, excellent undergraduate education in science, mathematics, engineering, and technology and that all students learn these subjects by direct experience with the method and processes of inquiry.

Some institutions, including those that sent representatives to the conference, already are making the changes needed to help them meet that goal, officials noted, but most are not. This latest review of undergraduate programs continues NSF's efforts to improve the quality of collegiate science, math, engineering, and technology programs that began a decade ago with a study that became known as the Neal Report.

The new report's findings were compiled over the course of a year by a nine-member committee of officials of two-year and four-year institutions, led by Melvin D. George, president emeritus of St. Olaf College. The committee's main recommendation is that college science and math programs should be refocused in order to better educate the 80% of students who do not major in the scientific disciplines.


—from NSF News Release
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/committee/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.
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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 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.

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<th>Secondary Interests optional</th>
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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.

<table>
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<td>University or Company</td>
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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.

- [ ]  
- [ ]  
- [ ]  
- [ ]
| 00 | General                          |
| 01 | History and biography           |
| 03 | Logic and foundations           |
| 04 | Set theory                      |
| 05 | Combinatorics                   |
| 06 | Order, lattices, ordered algebra 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 |
Position
The Society is seeking a candidate for the position of Secretary. The Secretary of the American Mathematical Society is appointed by the Council for a two-year term, this one starting February 1, 1999. The appointment by the Council for this term will be made at its 1998 winter meeting in order that the Secretary-designate may be able to observe the conduct of Society business for a full year before taking office.

Qualifications
The Secretary should be a research mathematician and must have substantial knowledge of Society activities. Although a term is for two years, the candidate should be willing to make a longer-term commitment, for it is expected that the new Secretary will be reappointed for subsequent terms pending successful performance reviews.

Duties
The position of the Secretary is a key one in the AMS. The Secretary participates in formulating policy for the Society and plays an important role in maintaining its institutional memory. The duties of the office include:

• Organizing and coordinating the Council and its committees.
• Serving as an ex officio member of the Council, the Executive Committee, the Agenda and Budget Committee, the Liaison Committee, the Long Range Planning Committee, the Committee on Meetings and Conferences, and the Committee on the Profession. The Secretary also serves as a non-voting ex officio member of the Committee on Education, Committee on the Profession, and Committee on Science Policy.
• Working closely with the President to coordinate and administer the activities of committees.
• Overseeing, together with the Associate Secretaries, the scientific program of all Society meetings.

It will be necessary for the candidate to obtain sufficient release time from regular employment in order to carry out the functions of the office. The Society is prepared to negotiate, with the candidate and his/her employer, the financial arrangement required to make this possible.

Applications
A Search Committee with Roy Adler as chairman has been formed to seek and review candidates. Persons wishing to be considered or to make a nomination should inform:

The Search Committee
C/o Robert Fossum
University of Illinois
Department of Mathematics
1409 West Green Street
Urbana, IL 61801-2975

and supply supporting documentation before January 31, 1997, to receive full consideration.
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.

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. Recently President Clinton announced his intention to nominate eight new members to the NSB; these nominations must be confirmed by the Senate. Among the nominees is mathematician Richard Tapia of Rice University.

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

F. Albert Cotton, W.T. Doherty-Welch Foundation Distinguished Professor of Chemistry and Director, Laboratory for Molecular Structure and Bonding, Texas A & M University.
Sanford D. Greenberg, Chairman and CEO, TEI Industries, Inc.
Charles E. Hess, Professor and Director of International Programs, University of California Davis, California.
John E. Hopcroft, Joseph Silbert Dean of Engineering, Cornell University.
Neal F. Lane, Director, National Science Foundation (ex officio).
Shirley M. Malcom, Head, Directorate for Education and Human Resources Programs, American Association for the Advancement of Science.
Eve L. Menger, Director, Technical Services and Administration, Corning, Inc.
Claudia I. Mitchell-Kernan, Vice Chancellor, Academic Affairs and Dean, Graduate Division, University of California, Los Angeles.
Diana Natalicio, President, The University of Texas at El Paso (vice chair).
James L. Powell, President, 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.
Robert M. Solow, Institute Professor, Department of Economics, Massachusetts Institute Technology.
Warren M. Washington, Director, Climate & Global Dynamics Division, National Center for Atmospheric Research.

John A. White Jr., Dean, College of Engineering, Georgia Institute of Technology.
Richard N. Zare, Marguerite Blake Wilbur Professor of Chemistry, Stanford University (chair).

MPS Advisory Committee
The role of the Mathematical and Physical Sciences (MPS) Advisory Committee for the National Science Foundation (NSF) is to provide advice, recommendations, and oversight concerning NSF's Mathematical, Physics, Astronomy, Materials, and Chemistry programs. Below are the names, titles, and affiliations of the members of the MPS Advisory Committee.

Erich Bloch, Distinguished Fellow, Council on Competitiveness.
Praveen Chaudhari, IBM.
James Cronin, Enrico Fermi Institute, University of Chicago.
James Economy, Professor and Head of Department of Materials Science and Engineering, University of Illinois.
Judy Giordan, Vice President, Henkel Corporation.
David L. Goodstein, Vice Provost, California Institute of Technology.
Susan Graham, Computer Science Division, University of California, Berkeley.
Richard H. Herman, Dean, College of Computer, Mathematical, and Physical Sciences, University of Maryland (chair).
William M. Jackson, Department of Chemistry, University of California.
Lynn Jelinski, Biotechnology Program, Cornell University.
Charles Kennel, Executive Vice Chancellor, University of California.
James S. Langer, Department of Chemistry, University of California.
Yuan T. Lee, President, Academia Sinica, Taiwan.
Joseph Miller, Lick Observatory, University of California.
Harry Morrison, Dean of Science, Purdue University.
Mara Prentiss, Department of Physics, Harvard University.
John M. Rowell, Consultant.
Joseph Taylor, Department of Physics, Princeton University.
Isiah M. Warner, Chair, Department of Chemistry, Louisiana State University.
Margaret Wright, AT&T Bell Labs.

Upcoming Deadlines

November 6, 1996 (Applied Mathematics, excluding Mathematical Biology) dms-am@nsf.gov, (Statistics and Probability) dms-sp@nsf.gov, (Geometric Analysis) dms-gm@nsf.gov, (Topology and Foundations) dms-tf@nsf.gov; December 4, 1996 (Computational Mathematics) dms-cm@nsf.gov, (Analysis-formerly Classical and Modern Analysis) dms-anal@nsf.gov, (Mathematical Biology) dms-mbio@nsf.gov: Target dates for proposals for support for research from fiscal year 1997 funds from the Division of Mathematical Sciences (DMS) of the National Science Foundation (NSF). For further information, see World Wide Web page http://www.nsf.gov/mps/dms/; telephone 703-306-1870.
November 1, 1996: Deadline for applications for NSF International Research Awards. For information contact: Division of International Programs, National Science Foundation, 4201 Wilson Boulevard, Arlington, VA 22230; telephone 703-306-1706; fax 703-306-0474; TDD 703-306-0090; e-mail sparris@nsf.gov; World Wide Web http://www.nsf.gov:80/sbe/int/start.htm./

December 1, 1996: American Mathematical Society Centennial Fellowships. For application forms, write to the Executive Director, American Mathematical Society, P.O. Box 6248, Providence, RI 02940-6248, or send electronic mail to ams@ams.org. Application forms are also available on the World Wide Web via the Internet at URL http://www.ams.org/committee/profession/.


January 30, 1997: Nominations for the D. Ray Fulkerson Prize in Discrete Mathematics. Eva Tardos, chair of the Fulkerson Prize Committee, Department of Computer Science, Cornell University, Ithaca, NY 14850; e-mail eva@cs.cornell.edu.


Where to Find It

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

Advanced Research Projects Agency, program officers October 1996, p. 1198
Air Force Office of Scientific Research, program officers October 1996, p. 1198
AMS e-mail addresses October 1996, p. 1166
AMS Ethical Guidelines June 1995, p. 694
AMS Officers and Committee Members September 1996, p. 1009
AMS Proposed Amendments to the Bylaws June 1995, p. 692; September 1995, p. 1022
Army Research Office, program officers October 1996, p. 1198
Board on Mathematical Sciences May 1996, p. 581
Board on Mathematical Sciences Staff April 1996, p. 460
Department of Energy Mathematics Program, program officers October 1996, p. 1199
JPBM Public Information Office (new address) December 1995, p. 1563

Mathematics Education Program Officers at NRC October 1995, p. 1161

Mathematics Research Institutes Contact Information: The Fields Institute, The Geometry Center, Institute for Advanced Study (IAS), Institute for Mathematics and its Applications (IMA), Mathematical Sciences Institute (MSI), Mathematical Sciences Research Institute (MSRI), Center for Discrete Mathematics and Theoretical Computer Science (DIMACS), Centre de Recherches Mathématiques (CRM) April 1996, p. 461

National Science Board of NSF, members May 1995, p. 589

NSF, mathematical scientists on the Advisory Committee for the Mathematical and Physical Sciences Directorate April 1996, p. 460

NSF, program officers in math October 1996, p. 1200

NSF, program officers in math education October 1996, p. 1199

National Security Agency, program officers October 1996, p. 1199

Office of Naval Research, program officers October 1996, p. 1199
Mathematics Calendar

November 1996

* 6-8 DIMACS Workshop on Performance of Realtime Applications on the Internet, DIMACS Center, Rutgers University, Piscataway, New Jersey.
Invited Speakers: A. Agrawala (University of Maryland), G. Polyzos (University of California, San Diego), S. Shenker (Xerox Parc).
Contacts: M. Garzia, AT&T, nager@ogps.att.com; tel: 908-949-1905; fax 908-949-3313.
Local Arrangements: P. Pravato, DIMACS Center, pravato@dimacs.rutgers.edu; tel: 908-445-5929.
Information: WWW information: http://dimacs.rutgers.edu/Workshops/index.html.
Short Description: Due to limited space you must register to attend the workshop. Please make sure to register early by filling out the registration form and sending it to pravato@dimacs.rutgers.edu.

* 11-13 Topics in Semiconductor Circuit, Device, and Process Simulation, University of Texas at Austin, Texas.
Audience: This course will provide engineers and managers with a deeper understanding of the underlying mathematical principles behind current process, device, and circuit simulators, enabling them to apply this knowledge to better utilize simulation as an integral part of the design process.
Faculty: G. Carey, B. Mulvaney, W. Richardson.
Material: The course will emphasize simulation methods for circuit analysis, semiconductor devices, and process modeling: mathematical models, numerical techniques, simulation pitfalls, applications studies, and solution strategies of current simulators. The course will consist of approximately 20 hours of lectures based on the new text by the lecturers: Circuit, Process, and Device Simulation: Mathematical and Numerical Aspects (Wiley, 1996). For further information see http://cewww.utexas.edu/.

December 1996

* 30-January 8 14th Jerusalem Winter School in Theoretical Physics, Victor Rothshild Memorial Symposia, Institute for Advanced Studies at the Hebrew University, Jerusalem, Israel.
Workshop Topic: Dualities and Symmetries.
Organizers: E. Witten (director), E. Rabinovici (coordinator).
Speakers: P. Aspinwall (Rutgers University), A. Giveon (Hebrew University), M. Green (Cambridge University), J. Harvey (University of Chicago), N. Seiberg (Rutgers University), A. Sen (Metha Research Institute), P. Townsend (Cambridge), E. Witten (IAS Princeton).

Description of Topic: A very new understanding of the dynamics of field theory and string theory has emerged through the use of duality and a better understanding of the role of extended objects. These developments have made possible the unearthing of many perturbative and nonperturbative relations between different theories which often exhibit apparently very different particle and symmetry content, as well as different topological and space-time structures. The 1996/97 Jerusalem School will examine such exact and approximate relations and their dynamical consequences, noting various efforts to embed them in unifying frameworks. The School will consist of a series of lectures, many of which will describe recent developments. Topics
include: low-energy limits and duality in systems closed strings, open strings and D-branes, nonperturbative appearance of light excitations in field theory and string theory, the emergence of unifying features in higher-dimensional systems and their compactifications to lower dimensions. Some necessary mathematical background will be covered.

Applications and Information: The School is intended for advanced graduates and postdoctoral students. Registration fee: $240. Hotel accommodations: $391. Some financial support is available for applicants upon request. Candidates must send a C.V., an abstract of research interests, and a letter of recommendation. For application forms write to: The Jerusalem Winter School, Institute for Advanced Studies, The Hebrew University of Jerusalem, Givat Ram, Jerusalem, Israel; fax: 972-2-6523429; e-mail: advanc@ms.huji.ac.il; http://www.ma.huji.ac.il/
Deadline: October 31, 1996.

January 1997
*12-17 Midrasha Mathematicae: Winter School in Dynamical Systems, Institute for Advanced Studies at the Hebrew University, Jerusalem, Israel.

Speakers: M. Pollicott (University of Manchester): Decay of Correlations and Counting Problems in Hyperbolic Systems; N. Simanyi (Hungarian Academy of Sciences): Ergodicity in Hard Ball Models; S. van Strien (University of Warwick): Recent Progress in Complex Dynamics.

Information: Advanced graduate students and research mathematicians in dynamical systems are welcome to attend. Registration fee: $50. Limited support will be available. For more information and applications: Institute for Advanced Studies, Hebrew University of Jerusalem, Givat Ram, Jerusalem 91904, Israel; fax: 972-2-6523429; e-mail: advanc@ms.huji.ac.il; abstracts of talks available at http://www.ma.huji.ac.il/.

March 1997
*14-17 Eighth SIAM Conference on Parallel Processing for Scientific Computing, Hyatt Regency Minneapolis on Nicollet Mall, Minneapolis, Minnesota.

Sponsor: SIAM Activity Group on Supercomputing.

Co-chairs: M. Heath (Univ. of Illinois, Urbana), V. Torczon (College of William and Mary).


Information: For additional information contact: SIAM, tel: 215-382-9800; e-mail: meetings@siam.org; WWW: http://www.siam.org/conf.htm.

April 1997
*11-13 Southwest Dynamical Systems Conference, University of North Texas, Denton, Texas.

Information: Information is available on the conference Web page: http://www.unt.edu/"dada0004/swdynamics.html.


Plenary Speakers: W. Fulton, A. Lubotsky, P. Lions.


Information: For further details: e-mail G. de Barra at g.debarra@rhbnc.ac.uk.

*28-May 2 International Conference on Random Dynamical Systems, University of Bremen, Germany.

Program: Invited speakers will give survey lectures on current and future trends in their research fields. Besides, research and poster sessions will give other participants, in particular younger researchers, the opportunity to present their own research to a wide audience of experts.

Topics: All aspects of random dynamical systems, in particular random attractors, stochastic bifurcation, generation and representation of random dynamical systems, stochastic chaos, Lyapunov exponents, entropy and pressure, Markov systems.


Program Committee: L. Arnold (Bremen), D. Elworthy (Warwick), R. Khasminskii (Wayne University), H. Kunita (Kyushu University).
Publication: The organizers plan to publish conference proceedings. These are not limited to contributions to the conference, but they should represent a systematic and consistent introduction and overview of the theory of random dynamical systems and its main topics.

Information: For further information see: http://www.mathematik.uni-bremen.de/~mkeller/FG3/Conference/index.html or via M. Gundlach (gundlach@mathematik.uni-bremen.de).

May 1997
*13-16 Int.Conf.on Analytic Tableaux and Related Methods (TABLEAUX'97), Abbaye des Premontres, Pont-a-Mousson, France.

Topics: Analytic tableaux in various logics (theory and applications), specific related techniques and concepts, related methods (model elimination, sequent calculi, ...), new calculi and methods for theorem proving in classical and nonclassical logics, systems, tools and applications.

Program Chair: D. Galmiche.


Submissions: Send in PostScript format to tab97@loria.fr or galmiche@loria.fr by November 22, 1996.

Tutorials: Proposals for high-quality tutorials are solicited in all areas of analytic tableaux and related methods from academic research to applications. Deadline November 1, 1996.

Information: For more information see World Wide Web page: http://www.loria.fr/tab97/.


Program: The symposium will bring together scientists from various branches of (applied) mathematics, physics, chemistry, and biology who have been working on molecular dynamics and molecular modelling. The broad purposes of the symposium are (i) to provide an international forum for communicating state-of-the-art developments in molecular modelling algorithms and (ii) to improve the prospects for future international collaborations by emphasizing the involvement of younger scientists from both sides of the Atlantic.

Format: The workshop will take place Tuesday-Saturday in the new building of the Konrad-Zuse-Zentrum on the campus of the Freie Universitat Berlin. The format will include invited presentations, contributed presentations (25 min.), and poster presentations. Space is limited to about 100 participants. Some funds might be available to assist with expenses (depending on our success in raising funds).

Invited Speakers: A partial list of speakers includes T. H. C. Berendsen (Groningen), J. Board (Duke), B. R. Brooks (NIH), H. Grubmüller (Munich), W. F. van Gunsteren (ETH), J. Hermans (UNC), M. Holst (Caltech), M. Kuczera (KU), A. Mark (ETH), B. Leimkuhler (UK), S. Reich (ZIB), T. Schlick (NYU), K. Schulten (UIUC), Ch. Schütte (ZIB), R. D. Skeel (UIUC).

Organizers: The workshop is being organized by B. R. Brooks, W. F. van Gunsteren, J. Hermans, A. Mark, B. Leimkuhler, and R. D. Skeel with P. Deufhard and S. Reich as the local organizing committee.

Information: For further information, registration, and submission material see our
June 1997

*2-4 8th Int'l Conf on Rewriting Techniques and Applications (RTA-97), Sitges, Barcelona, Spain.

**Topics:** Term rewriting systems, Symbolic and algebraic computation, Constrained rewriting and deduction, Equational programming languages, String and graph rewriting, Completion techniques, Rewrite-based theorem proving, Unification and matching algorithms, Conditional and typed rewriting, Constraint solving, Higher-order rewriting, Lambda calculi, Parallel/distributed rewriting and deduction.

**Submissions:** In addition to full research papers, descriptions of new working systems (4 proceedings pages) and problem sets that provide realistic, interesting challenges in the field of rewriting techniques are also welcome. Submissions must reach the program chair at the address below no later than November 6, 1996.

**Program Chair:** H. Comon, RTA-97, LRI and CNRS, Bât. 490, Université Paris-Sud, 91405 Orsay, France; tel: +33-01-69-41-66-35; fax: +33-01-69-41-65-86; e-mail: rta97@lri.fr.


July 1997

*14-18 9th International Conference on Formal Power Series and Algebraic Combinatorics (FPSAC'97), University of Vienna, Vienna, Austria.

**Topics:** Algebraic and bijective combinatorics and their relations with other parts of mathematics, computer science and physics.

**Program:** Invited lectures, contributed presentations, poster session, problem session, and software demonstrations.

**Deadlines:** For submission of communications and posters: November 15, 1996; for submission of software demonstrations: January 15, 1997.

**Invited Speakers:** G. Andrews (USA; not confirmed yet), J. Borwein (Canada, A. Dress (Germany), T. Guttman (Australia), M. Halman (USA), M. Mendes France (France), R. Simion (USA; not confirmed yet), A. Vershik (Russia), one more speaker to be announced.

**Call for Papers and Posters:** Authors are invited to submit extended abstracts of at most twelve pages before November 15, 1996. Preferred way of submission is by sending ONE PostScript file by e-mail to fpsac97@risc.uni-linz.ac.at. If an author is not able to send a PostScript version of his/her extended abstract, four copies of the extended abstract should be mailed to P. Paule, Chairman of the Program Committee of FPSAC'97, RISC, Johannes Kepler Universität, A-4040 Linz, Austria.

The submitted papers should begin with a summary written in the two official languages of the conference, English and French (translations will be provided if necessary). Authors should indicate the mode of presentation which they consider appropriate for their paper: lecture or poster session. The notifications of acceptance or rejection are scheduled for the beginning of March 1997.

**Open Problem Session:** Contributions to the problem session are invited in advance of the conference dates. If possible, problems should be submitted by e-mail to the address above.

**Software Demonstrations:** Demonstration of software relevant to the topics of the conference. People interested in giving a software demonstration should submit a paper as described above, including the hardware requirements, before January 15, 1997, by e-mail to the above address.

**Participant Support:** Limited funds are available for partial support of participants, in particular for students and scientists from Eastern countries. Requests should contain a letter of recommendation and include the estimated transportation and living expenses as well as the amount of support available from other sources. All requests should be sent in duplicate by January 15, 1997, to the following address: C. Krattenthaler, Chairman of the Organizing Committee of FPSAC’97, Institut für Mathematik, Universität Wien, Strudlhofgasse 4, A-1090 Vienna.

**Location:** The conference will take place at the Institut für Mathematik of the Universität Wien. The first talk is scheduled on July 14, 1997, at 9:00 a.m.

**Information:** A WWW site, http://radon.mat.univie.ac.at/People/Kratt/fpsac97.html, which will always contain the latest state of affairs, has been set up for the conference. For further information, send e-mail to fpsac97@radon.mat.univie.ac.at.

August 1997

*4-7 Southern Africa Mathematical Sciences Association (SAMSa) International Conference on Gender and Mathematics, University of Zimbabwe, Harare, Zimbabwe.

**Important Dates for Authors:** Deadline for submission of papers: May 1997; Notification of acceptance: June 1997.

**Information:** For more information about the conference contact: D. Vuma (Conference organizer and SAMSa Treasurer), Mathematics Department, University of Zimbabwe, P.O. MP 167, Harare, Zimbabwe; e-mail: vuma@maths.unz.zw; fax: 263-4-333407; tel: 263-4-302311.

September 1997

*24-26 Int'l Sympos. on Theoretical Aspects of Computer Software (TACS'97), Tohoku University, Sendai, Japan.

**Topics:** Theoretical aspects of the design, semantics, analysis, and implementation of programming languages and systems; calculi and models of concurrency and parallel computation; categories and types in computer science; formalisms, methods, and systems for program specification, verification, synthesis, and optimization; constructive, linear, and modal logics in computer science; logics of programs.


**Program Chairs:** M. Abadi, Systems Research Center, Digital Equipment Corporation, Palo Alto, CA 94301; e-mail: mab@dec.com; T. Ito, Dept. of Computer and Mathematical Sciences, Graduate School of Information Sciences, Tohoku University [Aoba campus], Sendai, 980, Japan; e-mail: ito@toc.ecei.tohoku.ac.jp.

**Submissions:** By e-mail to TACS97-submission@toc.ecei.tohoku.ac.jp. The length limit is 6,000 words. Deadline: January 10, 1997.

**Inquiries:** TACS97@toc.ecei.tohoku.ac.jp.

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.

March 1998

*25-28 Global Analysis 30 Years Later, University of Cincinnati, Cincinnati, Ohio.

**Purpose:** This meeting looks back to the 1968 AMS Summer Mathematics Institute on Global Analysis. The 1968 meeting was dominated by Smale's lectures on hyperbolic systems and was a major event in shaping the modern developments of dynamical systems. The 1998 meeting will explore the impact of these lectures on the last 30 years in dynamical systems.

**Program:** This four-day conference will mainly consist of hour lectures, but some sessions for shorter contributed papers will be included. Many of the original participants will be plenary speakers. A social event is planned.

**Funding:** This conference is funded by grants from the Taft Foundation and the National Science Foundation.

**Information:** For additional information contact C. McCord or K. Meyer at Department of Mathematics, University of Cincinnati, Cincinnati, OH, 45221-0025 or GLOBAL@MAT.UC.EDU.
What is ETAPS? Starting in 1998, a new annual meeting covering a wide range of topics in software science will take place in Europe each spring in the slot currently occupied by CAAP/ESOP/CC and TAPSOFT. The European Joint Conferences on Theory and Practice of Software (ETAPS) will be a loose and open confederation of existing and new conferences and other events. The overall aim is to create a popular annual meeting that will act as a strong magnet for academic and industrial researchers working on topics related to software science.

Topics: The events that comprise ETAPS will address various aspects of the system development process, including specification, design, implementation, analysis, and improvement. The languages, methodologies, and tools which support these activities are all well within its scope. Different blends of theory and practice will be represented, with an inclination towards theory with a practical motivation on one hand and soundly based practice on the other. Many of the issues involved in software design apply to systems in general (including hardware systems), and the emphasis on software is not intended to be exclusive.

Satellite Events: People interested in organizing satellite events should contact: J. Fiadeiro, Dept. of Informatics, Faculty of Sciences, University of Lisbon, Campo Grande, 1700 Lisboa, Portugal; tel: 351-1-7500123; fax: 351-1-7500084; e-mail: fiadeiro@di.fc.ul.pt.

Participating Conferences: 1. Foundations of Software Science and Computation Structures (FoSSaCS): The scope of FoSSaCS is syntactic, algebraic, logical, and semantic methods for describing, analyzing, transforming, and verifying programs and systems. The focus is on foundational aspects of such methods rather than on their applications. Topics include: computational and syntactic foundations of software science, transition systems and models of concurrency, data structures and types, domain theory and denotational (fixed-point) semantics. Program Committee Chair: M. Ni­vat (Paris).

2. Fundamental Approaches to Software Engineering (FASE): To enhance software quality, the software production process requires systematic methods, firmly grounded on scientifically justified techniques. Fundamental approaches are sought, possibly integrating so-called formal and informal aspects, providing the bridge between the­ory and practice and aimed at producing engineering methods and tools for the various phases of software development. FASE is intended to provide a forum where different fundamental approaches to problems of software specification, development, validation and verification are presented, compared, and discussed. Topics include: methods for the production of provably correct software and its verification; integration of informal and formal methods; formal approaches for real-time, concurrent, distributed and object-oriented systems; scientifically sound approaches to testing and measurement; fundamental aspects of the specification, design and verification of hardware components and hybrid systems; reports on the engineering or scientific lessons gained from industrial experiences in the use of formal and semiformal methods. Program Committee Chair: E. Astesiano (Genova).

3. European Symposium on Programming (ESOP): ESOP is devoted to fundamental issues in the specification, analysis, and implementation of programming languages and systems. It particularly welcomes re­search that bridges the gap between theory and practice: for example, practical studies based on theoretical developments and theoretical developments with a clearly identified potential for practical application. Topics include: programming paradigms and their integration, including functional, logic, concurrent and object-oriented; semantics facilitating the formal development and implementation of programming languages and systems; advanced-type systems; program analysis; program transformation. Program Committee Chair: C. Han­kin (London).

4. International Conference on Compiler Construction (CC): CC is a forum for presentation and discussion of recent developments in compiler construction, language implementation, and language design. Its scope ranges from compilation methods and tools to implementation techniques for specific requirements of languages and target architectures and includes language design and programming environment issues related to language translation. Topics include: tools for any phase of compilation; methods for code generation and optimization; compilation for parallel architectures; translation of computer languages (impera­tive, functional, logic, object-oriented, parallel, etc.); translation of application and specification languages; other tools closely related to compiler construction—e.g., debuggers, data-flow analyzers, etc. Program Committee Chair: K. Koskimies (Tampere).

5. Tools and Algorithms for Construction and Analysis of Systems (TACAS): Many similar tools and algorithms have been independently developed in various areas of computer science like automata and language theory, verification and synthesis of hardware and software systems, type and proof theory, and logic. TACAS is a forum for discussion of the principles and application-independent features of such algorithms and their implementation, with the aim to increase the reliability, flexibility, and efficiency of current tools by highlighting common problems, heuristics, data structures, and solutions. TACAS overlaps with the other events of ETAPS and is intended to attract contributions that stimulate discussions among the various communities. Program Committee Chair: B. Steffen (Passau).

New Publications Offered by the AMS

American Mathematical Society Translations—Series 2

Problems of Reducing the Exhaustive Search
V. Kreinovich and G. Mints, Editors
Volume 178

This collection contains translations of papers on propositional satisfiability and related logical problems which appeared in Problemy Sokrashcheniya Perebora, published in Russian in 1987 by the Scientific Council "Cybernetics" of the USSR Academy of Sciences. The problems form the nucleus of this intensively developing area. This translation is dedicated to the memory of two remarkable Russian mathematicians, Sergei Maslov and his wife, Nina Maslova.

Maslov is known as the originator of the inverse method in automated deduction, which was discovered at the same time as the resolution method of J. A. Robinson and has approximately the same range of applications. In 1981, Maslov proposed an iterative algorithm for propositional satisfiability based on some general ideas of search described in detail in his posthumously published book, Theory of Deductive Systems and Its Applications (1986; English 1987).

This collection contains translations of papers on propositional satisfiability and related logical problems. The papers related to Maslov's iterative method of search reduction play a significant role.

Contents

October 1996, 189 pages (hardcover),
ISBN 0-8218-0386-7, LC 96-27577, ISSN 0065-9290
1991 Mathematics Subject Classification: 68Q15, 03D15, 68Q60
Individual member $47, List $79, Institutional member $83
To order, please specify TRANS2/178N

AMS/IP Studies in Advanced Mathematics

Geometric Topology
William H. Kazez, Editor

This is a two-part volume reflecting the proceedings of the 1993 Georgia International Topology Conference held at the University of Georgia during the month of August. The texts include research and expository articles and problem sets. The conference covered a wide variety of topics in geometric topology.

Features:
• Kirby’s problem list, which contains a thorough description of the progress made on each of the problems and includes a very complete bibliography, makes the work useful for specialists and non-specialists who want to learn about the progress made in many areas of topology. This list may serve as a reference work for decades to come.
• Gabai’s problem list, which focuses on foliations and laminations of 3-manifolds, collects for the first time in one paper definitions, results, and problems that may serve as a defining source in the subject area.

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

Contents
Part 1: J. H. Rubinstein, Polyhedral minimal surfaces, Heegaard splittings and decision problems for 3-dimensional manifolds; D. Auckly, Surgery numbers of 3-manifolds: a hyperbolic example;
New Publications Offered by the AMS

Fields Institute Communications

Nonlinear Dynamics and Time Series
Colleen D. Cutler and Daniel T. Kaplan, Editors

This book is a collection of research and expository papers reflecting the interfac ing of two fields: nonlinear dynamics (in the physiological and biological sciences) and statistics. It presents the proceedings of a four-day workshop entitled "Nonlinear Dynamics and Time Series: Building a Bridge Between the Natural and Statistical Sciences" held at the Centre de Recherches Mathématiques (CRM) in Montréal in July 1995. The goal of the workshop was to provide an exchange forum and to create a link between two diverse groups with a common interest in the analysis of nonlinear time series data.

The editors and peer reviewers of this work have attempted to minimize the problems of maintaining communication between the different scientific fields. The result is a collection of interrelated papers that highlight current areas of research in statistics that might have particular applicability to nonlinear dynamics and new methodology and open data analysis problems in nonlinear dynamics that might find their way into the toolkits and research interests of statisticians.

Features:
- A survey of state-of-the-art developments in nonlinear dynamics time series analysis with open statistical problems and areas for further research.
- Contributions by statisticians to understanding and improving modern techniques commonly associated with nonlinear time series analysis, such as surrogate data methods and estimation of local Lyapunov exponents.
- Starting point for both scientists and statisticians who want to explore the field.
- Expositions that are readable to scientists outside the featured fields of specialization.

Contents


November 1996, 260 pages (hardcover), ISBN 0-8218-0521-5, ISSN 1069-5265
1991 Mathematics Subject Classification: 62M10, 58F13; 62M20
Individual member $47, List $79, Institutional member $63
To order, please specify FIC-CUTLERN
Mathematical Surveys and Monographs

Integer-Valued Polynomials
Paul-Jean Cahen and Jean-Luc Chabert
Volume 48

Integer-valued polynomials on the ring of integers have been known for a long time and have been used in calculus. Polya and Ostrowski generalized this notion to rings of integers of number fields. More generally still, one may consider a domain \( D \) and the polynomials (with coefficients in its quotient field) mapping \( D \) into itself. They form a \( D \)-algebra—that is, a \( D \)-module with a ring structure. Appearing in a very natural fashion, this ring possesses quite a rich structure, and the very numerous questions it raises allow a thorough exploration of commutative algebra. Here is the first book devoted entirely to this topic.

Features:
- Thorough reviews of many published works.
- Self-contained text with complete proofs.
- Numerous exercises.

Contents

Coefficient values; Additive structure; Stone-Weierstrass; Integer-valued polynomials on a subset; Prime ideals; Multiplicative properties; Skolem properties; Invertible ideals and the Picard group; Integer-valued derivatives and finite differences; Integer-valued rational functions; Integer-valued polynomials in several indeterminates; References; List of symbols; Index.

Memoirs of the American Mathematical Society

Degenerate Principal Series for Symplectic and Odd-Orthogonal Groups
Chris Jantzen
Volume 124, Number 590

This memoir studies reducibility in a certain class of induced representations for \( S\ell_p(F) \) and \( SO_{2n+1}(F) \), where \( F \) is \( p \)-adic. In particular, it is concerned with representations obtained by inducing a one-dimensional representation from a maximal parabolic subgroup (i.e., degenerate principal series representations). Using the Jacquet module techniques of Tadić, the reducibility points for such representations are determined.

When reducible, the composition series is described, giving Langlands data and Jacquet modules for the irreducible composition factors.

Contents

Introduction; Notation and preliminaries; Components: useful special cases; Irreducibility points; Components: the "ramified" case; Components: the "unramified" case; Composition series; References.

Stratifying Endomorphism Algebras
Edward Cline, Brian Parshall, and Leonard Scott
Volume 124, Number 591

Suppose that \( R \) is a finite-dimensional algebra and \( T \) is a right \( R \)-module. Let \( A = \text{End}_R(T) \) be the endomorphism algebra of \( T \). This memoir presents a systematic study of the relationships between the representation theories of \( R \) and \( A \), especially those involving actual or potential structures on \( A \) which "stratify" its homological algebra. The original motivation comes from the theory of Schur algebras and the symmetric group, Lie theory, and the representation theory of finite dimensional algebras and finite groups.

The book synthesizes common features of many of the above areas, and presents a number of new directions. Included are an abstract "Specht/Weyl module" correspondence, a new theory of stratified algebras, and a deformation theory for them. The approach reconceptualizes most of the modular representation theory of symmetric groups involving Specht modules and places that theory in a broader context. Finally, the authors formulate some conjectures involving the theory of stratified algebras and finite Coxeter groups, aiming toward understanding the modular representation theory of finite groups of Lie type in all characteristics.

Contents

Preliminaries; Stratified algebras; Stratifying endomorphism algebras; Stratifications and orders in semisimple algebras; Examples; Some conjectures for finite Coxeter groups and further remarks; References.
Analytic Deformations of the Spectrum of a Family of Dirac Operators on an Odd-Dimensional Manifold with Boundary

P. K. and E. Klassen

The subject of this memoir is the spectrum of a Dirac-type operator on an odd-dimensional manifold M with boundary and, particularly, how this spectrum varies under an analytic perturbation of the operator. Two types of eigenfunctions are considered: first, those satisfying the "global boundary conditions" of Atiyah, Patodi, and Singer and second, those which extend to $L^2$ eigenfunctions on $M$ with an infinite collar attached to its boundary.

The unifying idea behind the analysis of these two types of spectra is the notion of certain "eigenvalue-Lagrangians" in the symplectic space $L^2(\partial M)$, an idea due to Mrowka and Nicolaescu. By studying the dynamics of these Lagrangians, the authors are able to establish that those portions of the two types of spectra which pass through zero behave in essentially the same way (to first non-vanishing order). In certain cases, this leads to topological algorithms for computing spectral flow.

Contents

Introduction; Basics; Eigenvalue and tangential Lagrangians; Small extended $L^2$-eigenvalues; Dynamic properties of eigenvalue Lagrangians on $\mathcal{X}(R)$ as $R \to \infty$; Properties of analytic deformations of extended $L^2$-eigenvalues; Time derivatives of extended $L^2$ and APS eigenvalues; Bibliography.


1991 Mathematics Subject Classification: 58G03, 58G25, 58G20, 58G18

Individual member $19, List $32, Institutional member $26
To order, please specify MEMO/124/592N

Completely Positive Hypergroup Actions

Ajit Iqbal Singh

It is now well known that the measure algebra $M(G)$ of a locally compact group can be regarded as a subalgebra of the operator algebra $B(B(L^2(G)))$ of the operator algebra $B(L^2(G))$ of the Hilbert space $L^2(G)$. In this memoir, the authors study the situation in hypergroups and find that, in general, the analogous map for them is neither an isometry nor a homomorphism. However, it is completely positive and completely bounded in certain ways. This work presents the related general theory and special examples.

Contents

Presentations; Complete positivity and other properties for presentations and opresentations; Presentations of hypergroups and associated actions; Some concrete presentations and actions of hypergroups; References.

November 1996, 68 pages (softcover), ISBN 0-8218-0539-8, LC 96-29324, ISSN 0065-9266

1991 Mathematics Subject Classification: 43A10, 43A35, 46K05, 47A20, 47B55, 47C15, 47D25, 47D30

Individual member $20, List $34, Institutional member $27
To order, please specify MEMO/124/593N

The Fundamental Lemma for the Shalika Subgroup of $GL(4)$

Solomon Friedberg and Hervé Jacquet

The authors establish the fundamental lemma for a relative trace formula. This fundamental lemma asserts that pairs of local orbital integrals, one integral of each pair arising on $GSp(4)$ and the other on $GL(4)$, are equal. The orbital integrals in question are exponential sums, and the fundamental lemma may also be described as a matching of Kloosterman and relative Kloosterman sums on the two different groups. To show that these are equal for each relevant Weyl groups element, the authors compute the Mellin transforms and match them in all cases. The authors also describe the L-function heuristics which motivate this work, its possible generalizations, and an application of the relative trace formula to the study of L-packets.

Contents

Introduction and statement of results; Evaluation of the integral for the main H-relevant double cosets; Evaluation of the integrals for the other H-relevant double cosets; Evaluation of the GSp(4) integral for the main double cosets; Evaluation of the GSp(4) integrals for the other relevant double cosets; References.

November 1996, 149 pages (softcover), ISBN 0-8218-0540-1, LC 96-33174, ISSN 0065-9266

1991 Mathematics Subject Classification: 11F70; 11F46, 11F72, 11L05, 22E50

Individual member $24, List $40, Institutional member $32
To order, please specify MEMO/124/594N

Translations of Mathematical Monographs

Infinite-Dimensional Lie Groups

Hideki Omori

Volume 158

This book develops, from the viewpoint of abstract group theory, a general theory of infinite-dimensional Lie groups involving the implicit function theorem and the Frobenius theorem. Omori treats as infinite-dimensional Lie groups all the real, primitive, infinite transformation groups studied by É. Cartan. The book discusses several noncommutative algebras such as Weyl algebras and algebras of quantum groups and their automorphism groups.
The notion of a noncommutative manifold is described, and the deformation quantization of certain algebras is discussed from the viewpoint of Lie algebras.

This edition is a revised version of the book of the same title published in Japanese in 1979.

Contents
Introduction; Infinite-dimensional calculus; Infinite-dimensional manifolds; Infinite-dimensional Lie groups; Geometrical structures on orbits; Fundamental theorems for differentiability; Groups of $C^\infty$ diffeomorphisms on compact manifolds; Linear operators; Several subgroups of $D(M)$; Smooth extension theorems; The group of diffeomorphisms on cotangent bundles; Pseudodifferential operators on manifolds; Lie algebra of vector fields; Quantizations; Poisson manifolds and quantum groups; Weyl manifolds; Infinite-dimensional Poisson manifolds; Appendices; References; Index.

November 1996, 415 pages (hardcover), ISBN 0-8218-4575-6, LC 96-38349, ISSN 0065-9282

1991 Mathematics Subject Classification: 58B25, 22E99, 81C25

Individual member $59, List $99, Institutional member $79

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**Best Approximation by Linear Superpositions (Approximate Nomography)**

S. Ya. Khavinson

**Volume 159**

This book deals with problems of approximation of continuous or bounded functions of several variables by linear superposition of functions that are from the same class and have fewer variables. The main topic is the space of linear superpositions $D$ considered as a subspace of the space of continuous functions $C(X)$ on a compact space $X$. Such properties as density of $D$ in $C(X)$, its closedness, proximality, etc. are studied in great detail. The approach to these and other problems based on duality and the Hahn-Banach theorem is emphasized. Also, considerable attention is given to the discussion of the Diliberto-Straus algorithm for finding the best approximation of a given function by linear superpositions.

Contents
Discussing Kolmogorov's theorem; Approximation of functions of two variables by sums $q(x)+\psi$; Problems of approximation by linear superpositions; References.

November 1996, approximately 175 pages (hardcover), ISBN 0-8218-0422-7, ISSN 0065-9282

1991 Mathematics Subject Classification: 41-XX; 41A50, 41A52

Individual member $41, List $69, Institutional member $55

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### University Lecture Series

**Vertex Algebras for Beginners**

Victor Kac

**Volume 10**

This book is an introduction to algebraic aspects of conformal field theory, which in the past decade revealed a variety of unusual mathematical notions. Vertex algebra theory provides an effective tool to study these notions in a unified way.

Here, a mathematician will encounter new algebraic structures that originated from Einstein's special relativity postulate and Heisenberg's uncertainty principle. A physicist will find familiar notions presented in a more rigorous and systematic way, which may lead to a better understanding of foundations of quantum physics.

Contents
Wightman axioms and vertex algebras; Calculus of formal distributions; Local fields; Structure theory of vertex algebras; Examples of vertex algebras and their applications; Bibliography; Index.


1991 Mathematics Subject Classification: 17B69, 17B65, 81T40

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### AMS Publications Not in Series

**Combined Membership List, 1996–1997**

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, the Mathematical Association of America, and the Society for Industrial and Applied Mathematics.

There are two lists of individual members. The first is a complete alphabetical list of all 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 providing 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.
November 1996, approximately 392 pages (softcover),
ISBN 0-8218-0186-4
1991 Mathematics Subject Classification: 0C
Individual member $36, List $60, Institutional member $48
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Sémaintres et Congrès

Actes de la Table Ronde de Géométrie Différentielle en l'honneur de Marcel Berger
Arthur L. Besse, Editor
Number 1

This collection presents the proceedings from a Roundtable in Differential Geometry organized at the CIRM in Luminy (France) in July 1992 honoring the work of Marcel Berger. The contributions cover most of the fields studied by Berger in differential geometry: holonomy, curvature, spectrum of the Laplacian, isoperimetric and isosystolic inequalities, and some related subjects, such as Alexandrov spaces, elastic, and subriemannian geometry. The authors are mainly geometers who worked with Berger at some time. There are also contributions from younger geometers, and some papers include a brief review—keeping non-experts in mind—of recent results in the authors' particular fields.

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
U. Abresch and V. Schroeder,  Analytic manifolds of nonpositive curvature; C. Anne, Formes différentielles sur des variétés avec des anges finies; W. Ballmann and F. Ledrappier, Discretization of positive harmonic functions on Riemannian manifolds and Martin boundary; R. Bryant, Classical, exceptional and exotic holonomies: a status report; E. Calabi, Extremal isosystolic metrics for compact surfaces; G. Carron, Inégalités isopérimétriques de Faber-Krahn et conséquences; Y. Colin De Verdière, Le spectre du laplacien: Survol partiel depuis le BGM et problèmes; Y. Colin De Verdière et F. Mathieu, Empilements de cercles et approximations conformes; P. Delanoé, Equi-harmonic and scalar curvature conformes; M. Gromov, Systoles and intersystolic inequalities; K. Grove, Ramifications of the classical sphere theorem; E. Hebey, From the Yamabe problem to the equivariant Yamabe problem; N. Koiso, On the motion of a curve towards elastica; J. Lohkamp, Ricci curvature modulo homotopy; F. Pelletier and L. Valere-Bouche, The problem of geodesics, intrinsic derivation and use of control theory in singular sub-Riemannian geometry; H. Pesce, Nilvarietés isospectrales; K. Shiohama and M. Tanaka, Cut loci and distance spheres on Alexandrov surfaces; T. Shioya, Geometry of total curvature; T. Yamaguchi, A convergence theorem in the geometry of Alexandrov spaces.

Israel Mathematical Conference Proceedings

Stochastic Analysis: Random Fields and Measure-Valued Processes
Jean-Pierre Fouque, Kenneth J. Hochberg, and Ely Merzbach, Editors
Volume 10

This volume contains papers on probability theory and stochastic analysis resulting from two international conferences held at the Department of Mathematics of Bar-Ilan University in 1993 and 1995. The work includes expository and advanced research presentations, presenting an accurate reflection of the nature, scope, and vibrancy of these conferences on stochastic analysis.

Israel Mathematical Conference Proceedings series is published by Bar-Ilan University of Israel and distributed worldwide by the AMS.

Contents
S. Albeverio, Z. Haba, and F. Russo, On non linear two-space dimensional wave equation perturbed by space-time white noise; C. Bandle, M. Dozzi, and R. Schott, Blow up behaviour of a stochastic partial differential equation of reaction-diffusion type; A. Benassi, S. Jaffard, and D. Roux, Gaussian elliptic processes; T. Bojdecki and L. G. Gorostiza, Self-intersection local time for Gaussian S'-processes, and application to fluctuation limits of branching particle systems; R. C. Dalang and J. B. Walsh, Local structure of level sets of the Brownian sheet; D. A. Dawson, K. J. Hochberg, and V. Vinogradov, On weak convergence of branching particle systems undergoing spatial motion; M. L. Esquivel, On the local behavior of the Brownian sheet; A. M. Etheridge, Superprocesses, branching processes and an explosive PDE; J.-P. Fouque, Waves in random media and two-parameter diffusions; K. J. Hochberg and A. Madrecci, Itô formulas for higher-order asymptotically stable motions and applications; R. Leandre, Loop space of a developable orbifold; L. Manevitz and E. Merzbach, Multi-parameter stochastic processes via non-standard analysis; D. Nualart and M. Thieullen, Anticipative stochastic differential equations driven by a multidimensional Brownian motion; E. Parzen, Comparison change analysis and change empirical processes; K. Takaoka, A class of path transformations of one-dimensional Brownian motion; V. Vinogradov, On weak convergence for two families of conditioned random functions.

September 1996, 214 pages (softcover),
ISSN 0792-4119
1991 Mathematics Subject Classification: 60-06
Individual member $27, List $45, Institutional member $36
To order, please specify IMCP/96/97N

November 1996 Notices of the AMS 1391
New Publications Offered by the AMS

Individaul AMS member $81, List $90
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Videotapes

The New Shepherd’s Lamp
Jean-Pierre Bourguignon

From geocentrism to heliocentrism, the planetary system has inspired a host of idealized representations. Mathematics has played a crucial role. Inspired by Ptolemy, Copernicus, Tycho Brahe, Kepler, and Newton, a host of discoveries, revolutions, and new movements of thought has taken place.

This program emphasizes the contribution of Lagrange, who sparked many mathematical breakthroughs, and invites viewers to experience the transition from our three-dimensional space to the “space of elliptical movements”. In addition, the video spotlights the role of Poincaré, whose findings remain vitally pertinent today. Providing an overall view and a closer perception of the movement of ideas, the film demonstrates how mathematics swings between the utilitarian and the purely speculative.

Published by CNRS Audiovisuel and distributed worldwide, except in France, by the American Mathematical Society.
1995, NTSC format on 1/2” VHS videotape; approx. 28 minutes,
1991 Mathematics Subject Classification 58
All AMS members $35, List $44
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AMS Publications of General Interest

The AMS is pleased to present these selections that represent issues of interest to mathematicians, mathematics educators and librarians at institutions that support mathematics education and research. Included are books that are amusing, historical, informative, and intriguing. Whether you're looking for a gift or choosing something for yourself, selections from this list will enrich and enhance any mathematical books collection.

Golden Years of Moscow Mathematics
Smilka Zdravkovska, Mathematical Reviews, Ann Arbor, MI, and Peter L. Duren, University of Michigan, Ann Arbor

The present collection of articles will do much to fill [the] gap in Western understanding of Russia ... Sosnitskii provides a unique insight into this history from the point of view of a Western mathematician who went to live in the Soviet Union during the Khroushchev thaw in the 1950s ... The final article is a bibliography of the history of Soviet Mathematicians which is thorough and well-organized.

Mathematical Impressions
Anatolii T. Fomenko

The quality of reproduction is very high.

How to Teach Mathematics: a personal perspective
Steven G. Krantz, Washington University, St. Louis, MO

... an original contribution to the educational literature on teaching mathematics at the post-secondary level. The book itself is an explicit proof of the author's claim "teaching can be rewarding, useful, and fun".

The Joy of \TeX, A Gourmet Guide to Typesetting with the \TeX Macro Package
M. D. Spivak

1990, ISBN 0-8218-2997-1, 309 pages (softcover), List $39, All AMS members $32. To order, please specify JOYTNP

Mathematics and Sports
L. E. Sadovskii, Institute of Railroad Transportation Engineering, Moscow, Russia, and A. L. Sadovskii, Texas A & I University, Kingsville

... a nice survey of applications of mathematics in sporting events.

What’s Happening in the Mathematical Sciences, 1995–1996
Barry Cipra

... a stylish format ... largely accessible to laymen ... This publication is one of the snapshot examples of a growing genre from scientific societies seeking to increase public understanding of their work and its societal value.
Classified Advertisements

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

ARIZONA

NORTHERN ARIZONA UNIVERSITY
Assistant Professor
Mathematics

Tenure-track assistant professorship starting fall 1997. A doctorate in mathematics or applied mathematics is required. Candidates should have a strong theoretical background and interest in numerical analysis, as well as the ability to contribute to an interactive research group in dynamical systems and applied mathematics and to teach a wide variety of courses. Experience or interest in teaching mathematics in a multicultural environment would be desirable. Qualifications also include substantial evidence of high quality teaching and potential for a productive research program. Send a letter of application, transcripts, a curriculum vitae, and three letters of reference to: Mathematics Screening Committee, Northern Arizona University, Box 5717, Flagstaff, AZ 86011. Review of applications begins December 1, 1996. The search will remain open until the position is filled.

NAU is an Equal Opportunity/Affirmative Action Institution. Minorities, persons with disabilities, veterans, and women are encouraged to apply.

CALIFORNIA

UNIVERSITY OF CALIFORNIA, IRVINE
Department of Mathematics
Irvine, CA 92697-3875

Applications are invited for three tenure-track assistant professor positions with the possibility of upgrading one of them to a tenure level position for an appropriate candidate. The search will be in areas that complement the existing strengths of the department. Priorities will be placed on the following areas:
1) algebra with emphasis in algebraic and arithmetic geometry.
2) applied and computational mathematics.
3) analysis and PDE.
4) geometry and topology.

Candidates must possess a Ph.D. Very strong potential in research and teaching is required for the position. Applicants should send a curriculum vitae, a list of publications, preprints, reprints, and a research plan to the Assistant Professor Search Committee at the above address. They should also arrange for four letters of recommendation to be sent to the Assistant Professor Search Committee. Applicants are encouraged to use the AMS cover sheet.

The deadline for applications is December 31, 1996, 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 several one- or two-year visiting assistant professor positions in the following areas of research: 1) applied and computational mathematics; 2) geometry and topology (includes geometric analysis); 3) analysis and PDE (includes mathematical physics); 4) algebra and number theory (includes algebraic and arithmetic geometry); 5) logic and set theory; 6) probability. Candidates must possess a Ph.D. Strong promise in research and teaching is required. Current annual salary is set at $37,700. Teaching load: 5 to 6 quarter courses per year. Applicants should send a résumé, preprints, dissertation abstract, and ask three people to send letters of recommendation to: Visiting Assistant Professor Search Committee, at the above address. The deadline for application is January 3, 1997. The University of California is an Equal Opportunity Employer committed to excellence through diversity.

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 1995 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 1997 issue-October 25, 1996; February 1997 issue-November 25, 1996; March 1997 issue-December 31, 1996; April 1997 issue-January 29, 1997; May 1997 issue-February 27, 1997; June/July 1997 issue-May 9, 1997. 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 near the Classified Advertisements in the January and July issues of the Notices.

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@math.ams.org. AMS location for express delivery packages is 201 Charles Street, Providence, Rhode Island 02904. Advertisers will be billed upon publication.

1394 Notices of the AMS Volume 43, Number 11
UNIVERSITY OF SOUTHERN CALIFORNIA
Los Angeles, California

The Department of Mathematics expects two tenure-track positions at the assistant or associate professor level, in addition to several visiting and postdoctoral positions. Applicants must show exceptional promise in research and teaching.

To apply, please submit the following materials in a single package: letter of application (including your e-mail address and fax number), the AMS Cover Sheet, and a curriculum vitae. Candidates for assistant professor, visiting and/or postdoctoral positions should also arrange for three letters of recommendation to be sent. Mail all materials to: Chair of Appointments Committee, Department of Mathematics, DRB 155, University of Southern California, Los Angeles, CA 90089-1113. Review of applications will begin Dec. 1, 1996. Additional information about USC can be found on the Web at http://www.usc.edu/. USC is an Equal Opportunity/Affirmative Action Employer.

PEPPERDINE UNIVERSITY

Pepperdine University invites applications for a possible tenure-track position in mathematics at the rank of assistant professor. In exceptional cases, a more advanced rank may be considered. A Ph.D. in mathematics is required, as is strong promise in teaching and research. Although the area of research specialization is open, the ability to teach statistics or to assist in the initiation of an undergraduate research program will be viewed favorably. Responsibilities include effective teaching, conducting original research, and performing service activities in a 2:1:1 ratio. The teaching load is three courses (typically four units per course) in each of the fall and spring semesters.

Pepperdine University is located in the picturesque Santa Monica Mountains overlooking the Pacific Ocean. The Natural Science Division—one of the seven academic divisions in Seaver College of Letters, Arts, and Sciences—includes biology, chemistry, computer science, mathematics, nutritional science, physics, and sports medicine, and currently employs four full-time mathematicians. Committed to the encouragement of Christian faith and values among faculty and students, Pepperdine is an independent Christian university religiously affiliated with the Churches of Christ. The governing authority is vested in a self-perpetuating Board of Regents. Pepperdine gives preference to candidates whose faith and religious commitment are consistent with the denominational affiliation of the university. Pepperdine is an Equal Opportunity Employer. Women and minorities are encouraged to apply.

To apply for the position, please send the following materials ONLY: cover letter, vita, and names and addresses of three references. Applicants are encouraged to include in their cover letter a statement addressing their appropriateness for the position in light of the mission of the university, which may be accessed on the World Wide Web at http://www.pepperdine.edu/mission.htm. Please send materials to: Dr. Randy Maddox, Natural Science Division, Pepperdine University, 24255 Pacific Coast Hwy., Malibu, CA 90263. Applications received by December 1 will receive full consideration.

UNIVERSITY OF CALIFORNIA, LOS ANGELES
Department of Mathematics
Regular Positions in Pure and Applied Mathematics

The UCLA Department of Mathematics invites applications for two or more tenure-track positions in pure or applied mathematics. Exceptional promise in research and teaching is required. Positions are initially 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: John B. Garnett, 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 $42,900. 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, 1997.

(2) One or two research assistant professorships in computational and applied mathematics. Applicants must show very strong promise in research and teaching. Salary $42,900. 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, 1997.

(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 $45,800. 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 $38,904 or more, depending on experience. Preference will be given to applications completed by February 1, 1997.


(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: John B. Garnett, Chair, Department of Mathematics, University of California, Los Angeles, CA 90095-1555. Attn: Staff Search. UCLA is an Equal Opportunity, Affirmative Action Employer.

STANFORD UNIVERSITY
Department of Mathematics
Assistant Professorships in honor of Gabor Szego

The department expects to make one or more appointments in 1997-98 for these special two-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 1995. 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 and information concerning teaching experience, and should arrange to have three letters of recommendation sent to Prof. Gunnar Carlsson, Chairman, Department of Mathematics, Stanford University, Stanford, CA 94305-2125, by December 15, 1996. 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 1997, among the following fields: (1) analysis, (2) geometry or topology, (3) algebra, number theory,
Classified Advertisements

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 December 15, 1996.

Stanford is an Equal Opportunity, Affirmative Action Employer, and welcomes applications from women and minorities.

UNIVERSITY OF CALIFORNIA, SANTA BARBARA
Department of Mathematics

The University of California, Santa Barbara, invites applications for the following positions in the Department of Mathematics, beginning fall 1997.

(1) Two Tenure-Track Positions: One in analysis at the assistant professor level, and one in either analysis or in numerical analysis/applied mathematics at either the assistant professor level or the associate professor level. Appointment is effective July 1, 1997, and candidates must possess a Ph.D. by September 1997. For the position in the fields of numerical analysis and applied mathematics, there is particular interest in individuals with expertise useful for the numerical resolution of nonlinear problems arising in an applied science such as electromagnetics, fluid dynamics, material science, or semiconductor theory. For both positions, demonstrated research excellence and potential to become an effective teacher are required. Candidates who best enhance the long-term research plans of the department will be given preference.

(2) Ky Fan Assistant Professorship: Candidates will be considered in the following mathematical areas: algebra, theoretical computer science, differential geometry, analysis, numerical analysis/applied mathematics, and low-dimensional topology. The Ky Fan Assistant Professorship is a special two-year nonrenewable position which carries a research stipend and a course load of four one-quarter courses per year. Appointment is effective July 1, 1997. Candidates must possess a Ph.D. by September 1997 and should have held their Ph.D. for no more than five years as of January 1, 1997. Selection will be based primarily on research achievement, but evidence of satisfactory teaching is necessary and departmental research priorities will be taken into account.

(3) Special Visiting Positions: Subject to availability of funds, one or more special one-year visiting assistant professorships in the research areas mentioned under (1) and (2) above, with possibility of a second year, carrying a teaching load of 5 or 6 one-quarter courses per year. Applicants for the Ky Fan and the tenure-track positions will automatically be considered for the visiting positions. Excellence in research, potential for interaction with other faculty and evidence of good teaching required. Candidates must possess a Ph.D. by September 1997.

Applicants should send the following materials to either the Analysis Committee, the Numerical/Applied Committee, or the Visiting Appointments Committee, as appropriate, at the Department of Mathematics, University of California, Santa Barbara, CA 93106-3080: a vita, a publication list, and a statement of research interests and the American Mathematical Society Cover Sheet (available online at http://www.ams.org). Include an e-mail address if available. Applicants should also arrange to have at least four letters of recommendation sent to the appropriate committee. Applicants for the tenure-track positions will automatically be considered for any visiting positions (including the Ky Fan Assistant Professorship) upon request, so duplicate applications are unnecessary. Applications which are complete by January 3, 1997, will be given full consideration.

UCSB is an Affirmative Action/Equal Opportunity Employer.

UNIVERSITY OF CALIFORNIA, DAVIS
Department of Mathematics

Applications are invited for anticipated positions at either the assistant, associate, or full professor level and Visiting Research Assistant Professorship (VRAP) positions in the Department of Mathematics, University of California, Davis, effective July 1, 1997. These positions are contingent on budgetary and administrative approval.

Appointments of the assistant, associate, or full professor positions will be made commensurate with qualifications. Minimum qualifications include a Ph.D. degree in mathematical sciences and great promise in research and teaching. Candidates for the associate or full professor position must have demonstrated outstanding attainment in research and teaching. Duties include mathematical research, undergraduate and graduate teaching, and service. The Department of Mathematics is recruiting at the assistant and/or the associate professor level in the following areas: (1) applied mathematics and (2) geometry/topology; and at the assistant, associate, or full professor level in the areas of (3) numerical analysis/scientific computation and (4) analysis/partial differential equations.

The VRAP positions are renewable for a total of three years with satisfactory performance in research and teaching. The VRAP applicants are required to have completed their Ph.D. no earlier than 1993. The Department of Mathematics is interested in applicants in the following areas for the VRAP positions: 1) algebra, 2) analysis/PDEs, 3) applied mathematics, 4) computational mathematics, 5) geometry/topology, 6) mathematical physics.

The tenure-track positions are open until filled, but to assure consideration, applications should be received by December 16, 1996. The application deadline for the VRAP positions is February 3, 1997. To initiate the application process, request an application package by writing an e-mail message to forms@math.ucdavis.edu. Those who do not have access to e-mail can obtain the package by writing to:

Chair of Search Committee
Department of Mathematics
University of California
Davis, California 95616-8633

The Department of Mathematics at UC Davis is an Affirmative Action Employer with a strong institutional commitment to the achievement of diversity among its faculty and staff. In this spirit, we are particularly interested in receiving applications from women, persons of color, and persons from other underrepresented groups.

FLORIDA

UNIVERSITY OF CENTRAL FLORIDA
Department of Mathematics
Orlando, FL 32816-1364

Applications are invited for at least one tenure-track position starting August 1997 at the rank of assistant professor. Candidates must have a Ph.D. in mathematics at the time of application and a history of good teaching, strong research, and grant funding (or a high potential for funding). Fields of interest include wave propagation through random media, functional analysis, graph theory and combinatorics, numerical analysis, differential equations, approximation theory, and related areas of applied mathematics. The Department offers a BS, MS, and Ph.D. in mathematics. Please arrange for vita, transcripts, and at least three letters of reference to be sent to Chair of Search Committee, Department of Mathematics, University of Central Florida, Orlando, FL 32816-1364. In order to receive full consideration, applications should be postmarked by December 15, 1996.

The university is an Equal Opportunity Affirmative Action Employer. Women and minorities are strongly urged to apply. As an agency of the State of Florida,
Subject to administrative approval, the department anticipates having available a tenure-track position, starting in fall 1997, at the rank of assistant professor. We especially encourage women and minorities to apply. Preference will be given to those areas currently represented in the department. The principal qualification is excellence in teaching and research. Salary will be commensurate with ability and experience. To apply, send vita and four letters of recommendation to Kevin Clancey, Head, at the above address. The deadline for applications is January 1, 1997. The University of Georgia is an Equal Opportunity/Affirmative Action Employer.

Applications are invited for one or more full-time faculty positions (rank open) to commence August 21, 1997. The department will consider applicants in all fields of mathematics, but we intend to show preference in applied mathematics, differential equations, mathematical physics, probability theory, number theory, and combinatorics. Salary and teaching load are competitive. Applicants should send a letter of application, curriculum vitae and publication list, and arrange to have three letters of reference sent directly to the address below. We encourage use of the application cover sheet provided by the American Mathematical Society.

Philippe Tondeur, Chair
Department of Mathematics
University of Illinois at Urbana-Champaign
1409 West Green Street
Urbana, IL 61801
tel. 217-333-3352
e-mail: search@math.uiuc.edu

All materials, including letters of reference, should be received by December 6, 1996. All completed applications received by that date will receive full consideration. Candidates must have completed the Ph.D. (or equivalent) by the time the appointment begins and are expected to present evidence of excellence in research and teaching. Applications from women and minority candidates are especially encouraged. The University of Illinois is an Affirmative Action/Equal Opportunity Employer.

Applications are invited for a tenure-track faculty position in actuarial science starting August 1997. Although the appointment is planned for the assistant professor level, exceptional candidates will be considered regardless of rank. Specialties in either life or casualty are welcome. Applicants must be committed to excellence in both teaching and creative research. They should have earned (or be close to completing) both a Ph.D. degree and either an associateship or fellowship in a professional actuarial society. The selection process begins on December 2, 1996, and continues until the position is filled. Women and minorities are encouraged to apply. The University of Iowa is an Affirmative Action, Equal Opportunity Employer. Please send a curriculum vitae, and have three letters of reference sent to Professor James D. Broffitt, Actuarial Search Committee, Dept. of Statistics & Actuarial Science, Univ. of Iowa, Iowa City, IA 52242. E-mail: broffitt@stat.uiowa.edu, http://www.stat.uiowa.edu/.

The Department of Mathematics of The University of Iowa invites applications for the following positions:

1. Tenure-track beginning or early assistant professorship, starting in August 1997, in the broadly interpreted area of computational mathematics. Expertise is desired in areas such as numerical parallel computing, computer graphics, or computational geometry. Extraordinary candidates at higher rank may be considered. Selection will be based on evidence of outstanding research accomplishments or potential, and teaching ability. A Ph.D. or equivalent training is required.

2. Pending availability of funds, one or more visiting positions for all or part of the 1997-98 academic year. Selection will be based on research expertise and teaching ability. Preference will be given to applicants whose scholarly activity is of particular interest to members of the current faculty.

Women and minority candidates are especially urged to apply for the above positions. The University of Iowa welcomes the employment of professional couples on its faculty and staff, permits the appointment of faculty couples within the same department, and permits the sharing of a single appointment by a faculty couple.

Formal screening will begin December 15, 1996; applications will be accepted until the positions are filled. To apply, send a complete vita and have three letters of recommendation sent to:

Professor Bor-Luh Lin, Chair
Department of Mathematics
The University of Iowa
Iowa City, Iowa 52242

The University of Iowa is an Equal Employment Opportunity and Affirmative Action Employer.

Applications are invited for tenure-track and visiting positions commencing August 10, 1997; rank and salary commensurate with qualifications. The department seeks candidates whose research interests mesh well with current faculty. The department has research groups in the areas of analysis, algebra, geometry/topology, and differential equations. Applicants must have strong research credentials and a commitment to excellence in teaching. A Ph.D. in mathematics or a Ph.D. dissertation accepted with only formalities to be completed is required. Letter of application, current vita, description of research, and three letters of recommendation should be sent to:

Louis Pigno
Department of Mathematics
Cardwell Hall 138
Kansas State University
Manhattan, KS 66506

Offers may begin by December 9, 1996, but applications for positions will be reviewed until February 1, 1997, or until positions are closed. AA/EOE.

Applications are invited for a tenure-track assistant professor position in mathematics which will begin on September 1, 1997. Under exceptional circumstances we would consider hiring at a higher level. Necessary requirements include a doctoral degree, demonstrated success or strong potential in research, and a commitment to effective teaching at the undergraduate and graduate levels. At least two years teaching experience beyond the doctoral degree are preferred.

Boston College is a Jesuit university enrolling approximately 8,500 full-time undergraduate students and 4,300 graduate students. The Department of Mathematics has twenty-one full-time faculty. It grants approximately fifty B.A. degrees in mathematics, and approximately ten M.A. degrees and five M.S.T. degrees in the
teaching of mathematics) annually. Current research interests include algebra, analysis, applied mathematics, dynamical systems, geometry, number theory, probability, statistics, and topology.

Applicants should submit a curriculum vitae along with a cover letter, and should arrange to have at least four letters of reference sent to the department. At least one of the letters should focus on teaching effectiveness and potential. Send all materials to:

Search Committee, Chair
Department of Mathematics
Boston College
Chestnut Hill, MA 02167-3806

E-mail inquiries may be directed to: Search Committee. bc.edu. Electronic applications will NOT be accepted. Review of applications will begin on January 1, 1997, and continue until the position is filled. Boston College is an Affirmative Action/Equal Opportunity Employer.

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 $38,000 supplemented by summer research stipend of $5,444 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.

NEW JERSEY

RUTGERS UNIVERSITY-NEWARK
Assistant Professor of Mathematics

The Department of Mathematics and Computer Science invites applications for an anticipated tenure-track assistant professorship in pure mathematics to begin in September 1997. Applications for a higher level appointment may be considered if a position becomes available. Candidates must have a Ph.D. and a strong research record, show outstanding promise for future work in mathematics, and demonstrate a commitment to effective teaching. Preference will be given to candidates with research interests related to those of faculty in the department.

Each candidate should include an AMS cover sheet and a curriculum vitae with the application. At least four letters of recommendation, one of which addresses teaching, should be sent in support of the application. The application and letters should be sent to:

Personnel Committee
Department of Mathematics and Computer Science
Rutgers University
Newark, NJ 07102

Applications received by December 16, 1996, will receive first consideration.

Rutgers University is an Equal Opportunity/Affirmative Action Employer.

NEW YORK

POSTDOCTORAL FELLOWSHIP IN MATHEMATICAL SCIENCES
1997-1998 IBM POSTDOCTORAL FELLOWSHIP IN MATHEMATICAL SCIENCES

The Mathematical Sciences Department of the IBM Thomas J. Watson Research Center invites applications for its 1997-1998 Postdoctoral Fellowship for research in mathematical and computer sciences. This fellowship provides scientists of outstanding ability an opportunity to advance their scholarship as resident department members at the Research Center. The department provides an atmosphere in which basic research is combined with experience on technical problems arising in industry. The program of the Mathematical Sciences Department is organized for research in pure and applied mathematics, and in theoretical and exploratory computer science.

Each candidate must have a doctorate and not more than five years of postdoctoral professional experience when the fellowship commences. The fellowship has a period of one year, and may be extended by another year on mutual agreement. The stipend will be generally in the range of $67,000 to $70,000 per year, depending on experience. In addition, there will be an allowance for moving expenses.

To apply, please submit the following by January 10, 1997: résumé, including thesis summary; reprints of publications based on thesis and other research; a research proposal; and visa status. Citizens of countries as restricted by the U.S. Department of Commerce are required to have a green card or an equivalent visa status. Please indicate where you first learned about the fellowship. Applicants are responsible for requesting that three or more letters of reference, including one from the thesis advisor, arrive before January 10. Direct all material to:

Committee on Postdoctoral Fellowships
Department of Mathematical Sciences
IBM Research Division
T. J. Watson Research Center
P. O. Box 218
Yorktown Heights, NY 10598

One fellowship will be awarded. Each applicant will be notified individually as soon as the committee has reached a decision on the application, no later than March 14, 1997.

NEW YORK UNIVERSITY
Courant Institute of Mathematical Sciences

The Courant Institute anticipates having a small number of faculty positions in mathematics to begin in September 1997. Appointments may be made either at a junior or senior level. Most, but not all, of these positions will be in some area of geometry, analysis, applied mathematics, or scientific computing. In addition, there will be one interdisciplinary position in atmosphere/ocean research, and possibly a second, as well as possible interdisciplinary positions in biosciences and in mathematical finance. Applications should be addressed to: Appointments Committee, Courant Institute of Mathematical Science, 251 Mercer Street, New York, NY 10012. The Courant Institute/New York University is an Equal Opportunity, Affirmative Action Employer.

RENNESLAER POLYTECHNIC INSTITUTE
Department of Mathematical Sciences

Applications are invited for a tenure-track assistant professor position in applied mathematics, to begin in August 1997. Candidates are expected to have demonstrated outstanding research potential, and to have a strong interest and ability in teaching.

Applicants should submit a letter of application, a curriculum vitae, a description of research interests, and arrange to have three letters of recommendation sent directly to: Mark H. Holmes, Chair, Department of Mathematical Sciences, Rensselaer Polytechnic Institute, Troy, NY 12180. Evaluation of applications will begin December 15, 1996.

Rensselaer is an Equal Opportunity/Affirmative Action Employer and strongly encourages applications from women and underrepresented minorities.
Applications are invited for two tenure-track assistant or associate professor positions in applied mathematics effective fall 1997. One associate professor position is available for an exceptional candidate in applied scientific computation. A strong research record and doctorate in mathematics, applied mathematics, or a closely related field is 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. These positions will begin a five-year plan to build a strong group interacting with existing strengths at UNC in mathematics, polymer, and biomedical sciences. For additional information, please see 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. Completed applications received by December 1 are assured of full consideration.

UNIVERSITY OF NORTH CAROLINA AT CHARLOTTE
Mathematics Department
Charlotte, NC 28223

(1) The Department of Mathematics at UNC-Charlotte seeks applications for a professor/associate professor in mathematical statistics/applied statistics. Candidates should have a strong research background, a genuine interest in applications, and experience with statistical software. Candidates with a proven track record of strong external funding and experience in Ph.D. supervision preferred.

(2) Possible visiting and/or postdoctoral positions in areas including statistics, probability, mathematical physics, partial differential equations, operator theory, numerical analysis, and commutative algebra are also available.

Women, disabled persons, and underrepresented minorities are urged to apply. Send vita and a short abstract of current research to Professor Volker Wihstutz, Department of Mathematics, UNC-Charlotte, Charlotte, NC 28223. Also arrange for four letters of recommendation to be sent to the above address. Review of applications will begin October 15, 1996, and continue until the position is filled. AA/EOE.

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 1997. Duties include teaching mathematics at the undergraduate and graduate levels and continuing research. A Ph.D. is required. Only applicants whose research expertise is in topology or geometry will be considered. Women and minorities are encouraged to apply. The department has twenty-four members and offers a B.S. and M.A. in mathematics and a B.S. and M.S. in computer science. 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.

OHIO
THE OHIO STATE UNIVERSITY
Department of Mathematics

The Department of Mathematics of The Ohio State University hopes to have available several positions at both visiting and permanent, effective autumn quarter 1997. Candidates in all areas of applied and pure mathematics are invited to apply. However, for the permanent positions preference will be given to those in applied mathematics and analysis. Significant mathematical research accomplishments or exceptional promise, and evidence of superior teaching ability, will be expected.

Please send credentials and have at least three letters of recommendation sent to Professor Robert Brown, Department of Mathematics, The Ohio State University, 231 W. 18th Avenue, Columbus, Ohio 43210. Review of résumés will begin immediately.

The Ohio State University is an Equal Opportunity/Affirmative Action Employer. Women and minority candidates are encouraged to apply.

OREGON
UNIVERSITY OF OREGON
Department of Mathematics

Assistant professor tenure-track position in pure mathematics or statistics beginning September 1997. Qualifications are a Ph.D. in mathematics or statistics, a strong record of research accomplishment, and evidence of teaching ability. Preference given to candidates with research interests that complement those currently represented. Competitive salary with excellent fringe benefits. Send complete résumé and three letters of recommendation. Closing date is January 3, 1997. Women and minorities are encouraged to apply. An EO/AA/ADA institution committed to cultural diversity. Contact Gary Seitz, Department Head, University of Oregon, Department of Mathematics, Eugene, OR 97403; e-mail: seitz@math.uoregon.edu.

Pennsylvania
UNIVERSITY OF PITTSBURGH
Department of Mathematics

The Mathematics Department of the University of Pittsburgh invites applications for two tenure-track assistant professorships, one in applied analysis and one in scientific computation, to begin fall 1997 (pending budgetary approval). Preference will be given to candidates with interdisciplinary interests in biology, material sciences, imaging and, in the case of the candidate in scientific computation, in the applied aspects of combinatorial and discrete mathematics. Substantial research accomplishments and a dedication to teaching are essential. We particularly encourage applications from minorities and women. The University of Pittsburgh is an Affirmative Action/Equal Opportunity Employer. Send a vita, three letters of recommendation and a research statement by November 15, 1996, to:
Hiring Committee  
Department of Mathematics  
University of Pittsburgh  
Pittsburgh, PA 15260

RHODE ISLAND

BROWN UNIVERSITY

J. D. Tamarkin Assistant Professorship

Three-year nontenure, nonrenewable appointment, beginning July 1, 1997. Teaching load: two courses per semester (6 hours per week). Applicants (regardless of age) should have received the Ph.D. degree before the start of the appointment, but no earlier than January 1, 1995. Applicants should have strong research potential and a commitment to teaching. Field of research interest will be taken into account. A curriculum vitae, a completed application form, and three letters of recommendation should be received by December 31, 1996. Requests for application forms and all other inquiries should be addressed to Tamarkin Search Committee, Department of Mathematics, Brown University, Providence, RI 02912. Brown University is an Equal Opportunity/Affirmative Action Employer and encourages applications from women and minorities.

TEXAS

UNIVERSITY OF TEXAS AT ARLINGTON

Department of Mathematics

The department invites applications for possibly two to three anticipated tenure-track positions beginning with the fall semester, 1997. One of these will be a position of assistant professor in mathematics education. The candidate must show strong potential for excellence in teaching and research in math education. The department is seeking to extend its effectiveness in the area of undergraduate mathematics, mathematics programs for future elementary middle and secondary teachers, and Masters and Ph.D. degrees in mathematics education. For the other positions, we seek candidates in various areas of mathematics, in particular, numerical analysis and differential equations, which are complementary to those of the current faculty and would enhance and support the goals of the department. Application deadline is December 15, 1996, or until positions filled. Salary and rank are commensurate with qualifications which must include the Ph.D. degree (an earned doctorate by Aug. 1997). Candidates must show strong potential for excellence in teaching and research. Please send a résumé and three letters of recommendation to: Chairperson, Faculty Recruiting Committee, University of Texas at Arlington, Department of Mathematics, Box 19408, Arlington, TX 76019-0408. The University of Texas at Arlington is an Affirmative Action/Equal Opportunity Employer.

TEXAS A&M UNIVERSITY

Department of Mathematics

Applications are invited for tenure-track/tenured faculty positions beginning fall 1997. Field is open, but we particularly seek applications from individuals whose mathematical interests would act as a bridge between some of our current research groups, or who add a strong applied or computational component to our existing strengths. For a senior position the applicant should have an outstanding research reputation and would be expected to fill a leadership role in the department. An established research program, including success in attracting external funding and supervision of graduate students, and a demonstrated ability and interest in teaching are required. For an assistant professorship, we seek strong research potential and evidence of excellence in teaching. Research productivity beyond the doctoral dissertation will normally be expected. In order to expedite the application process we request that the "AMS Application Cover Sheet" be used. Applicants should send the completed form, a vita, and arrange to have letters of recommendation sent to:

Faculty Hiring  
Department of Mathematics  
Texas A&M University  
College Station, Texas 77843-3368

Our URL is http://www.math.tamu.edu/.  
Texas A&M University is an EOE/AA employer and the department encourages applications from women and minorities.

TEXAS A&M UNIVERSITY

Visiting Positions in Mathematics

The department expects to have several visiting appointments available beginning fall 1997. Senior positions may be for a semester or year period. Junior positions will be for a two-year period, and are intended for those who have recently received their Ph.D. The expectation is for collaborative efforts with our existing faculty. Candidates should identify in their application those permanent department members or groups with which they have close research interests. Application materials must include an application letter, a vita, and three letters of recommendation. Junior candidates must present evidence of teaching ability and experience and include a statement of research plans. In order to facilitate the process we request that applicants use the "AMS Application Cover Sheet". For full consideration, the complete dossier should be sent by January 15, 1997, to:

Visiting Appointments  
Department of Mathematics  
Texas A&M University  
College Station, Texas 77843-3368

Our URL is http://www.math.tamu.edu/.

There will be two research instructorships that are specifically targeted to geometry, analysis and topology. These will be for a period of two years, carry a two course per year teaching load and a stipend of $36,000 for the academic year. Additional information is available at http://math.tamu.edu/programs/research/GRAT. Applicants for these positions should mark their letters for the attention of the Research Group in Geometry at the above address.

Texas A&M University is an EOE/AA employer and the department encourages applications from women and minorities.

UNIVERSITY OF TEXAS AT ARLINGTON

Department of Mathematics

The department invites applications for a position of assistant professor in mathematics education. The candidates must show strong potential for excellence in teaching and research in math education. The department is seeking to extend its effectiveness in the areas of undergraduate mathematics; mathematics programs for future elementary, middle, and secondary teachers; and Masters and Ph.D. degrees in mathematics education. The University of Texas at Arlington is a comprehensive research institution of over 22,000 students located midway between Dallas and Fort Worth. UT Arlington has an established national program for inservice teachers and serves as host site for T3, Teachers Teaching with Technology.

Please send resumes and three letters of recommendation to: Chairperson, Faculty Recruiting Committee, University of Texas at Arlington, Department of Mathematics, Box 19408, Arlington, TX 76019-0408. Application deadline is January 15, 1997.

The University of Texas at Arlington is an Affirmative Action/Equal Opportunity Employer.

UTAH

UNIVERSITY OF UTAH

Department of Mathematics

The University of Utah, Department of Mathematics, invites applications for the following positions. Availability of positions is contingent upon funding.

1. One full-time tenure-track appointment in the assistant or associate professorial levels. The department is primarily interested in applicants with work in the research areas represented in the department and who received their Ph.D. degrees. 

NOTICES OF THE AMS  
VOLUME 43, NUMBER 11  
1400
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 volumes of *Mathematical Reviews*) of their 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, 1996. 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.

### CANADA

Canada

**UNIVERSITY OF WATERLOO**

Department of Pure Mathematics

The department invites applications for a tenure-track position at the assistant professor level starting July 1, 1997. For details see the web page: [http://math.uwaterloo.ca/PM_Dept/job.html](http://math.uwaterloo.ca/PM_Dept/job.html).

**UNIVERSITY OF ALBERTA**

Department of Mathematical Sciences

Tenure-Track Positions

The Department of Mathematical Sciences at the University of Alberta anticipates approximately eight positions in the next three years with three positions firmly available beginning July 1, 1997. All positions are initially considered at the assistant professor level at a minimum annual salary of $39,230. We are looking for individuals with very strong proven ability or exceptional demonstrated potential in research, excellent communication skills for teaching, and leadership potential. Successful individuals will be expected to establish vigorous and well-funded research programs. Demonstrated or clear evidence of possible interaction with industry will be a definite consideration. Exceptional individuals wishing to complete prestigious Postdoctoral Awards would be considered for deferred appointment. Depending on the outcome of several searches, the positions may be carried over and re-advertised.

**Scientific Computation (SC-1)**

Over three years we expect to fill two positions in scientific computation. Candidates for one of the positions should have theoretical and practical knowledge of numerical methods for partial differential equations, numerical linear algebra and/or multidimensional numerical integration as applied to high performance computing environments in areas such as visualization of fluid flows or geophysical phenomena, numerical simulation for multiphase fluid flows and Monte-Carlo simulations.

The second position in scientific computation also would be open more broadly to include candidates in computational algebra, geometry, number theory, or analysis.

**Fluid Mechanics (FM-1)**

One anticipated position will be for an outstanding scientist in the area of fluid mechanics. This individual should complement the department's strengths in one or more of geophysical fluid dynamics, soliton and nonlinear wave theory, hypersonic and transonic flow, shock waves and computational fluid dynamics, and be able to teach advanced courses in fluid dynamics, hydrodynamic stability theory and geometrical fluid dynamics.

**ODE/PDE (DE-1)**

At least one of the anticipated positions will be in modern areas of ordinary and partial differential equations; for example, nonlinear evolution differential equations and dynamical systems with applications to physical problems.

In accordance with Canadian Immigration requirements, priority will be given to Canadian citizens and permanent residents of Canada. If suitable Canadian citizens and permanent residents cannot be found, other individuals will be considered. Candidates should send a curriculum vitae, including a list of publications, and arrange for at least three letters of reference to be sent to:

S. D. Riemenschneider, Chair Department of Mathematical Sciences University of Alberta Edmonton, Alberta T6G 2G1 Canada

Early applications are encouraged. Closing date for applications is January 6, 1997.

The University of Alberta is committed to the principle of equity in employment. As an employer we welcome diversity in the workplace and encourage applications from all qualified women and men, including aboriginal peoples, persons with disabilities, and members of visible minorities.

**UNIVERSITY OF TORONTO**

The Department of Mathematics, University of Toronto is happy to announce that a generous donation has made possible the establishment of a new endowed Chair: The Ted Mossman Chair in Mathematics.

It is intended for an outstanding mathematician in the early stages of her/his career. The department would welcome nominations (contact Steve Halperin, department chair, halper@math.toronto.edu).
UNIVERSITY OF TORONTO
Tenure-Stream Appointment in Applied Probability

The University of Toronto solicits applications for a tenure-stream appointment in applied probability. The position is subject to budgetary approval.

The appointment is at the downtown (St. George) campus at the level of assistant professor, to begin July 1, 1997. This will be a joint appointment (50/50) between the Departments of Mathematics and Statistics. Candidates are expected to have demonstrated excellence in both teaching and research past their Ph.D.; in particular, a candidate’s research record should clearly show the ability to make significant original and independent research contributions. Salary commensurate with experience.

Applicants should send their complete C.V., including a list of publications, a short statement describing their research program, and all appropriate material about their teaching. They should also arrange to have at least four letters of reference sent directly to Professor V. Ivrii, Associate Chair, Department of Mathematics, University of Toronto, Toronto, Canada M5S 3G3. At least one letter should be primarily concerned with the candidate’s teaching. In addition, it is recommended that applicants submit the electronic application form which is available from our World Wide Web Employment Opportunities page: http://www.toronto.edu/math/jobs/. To insure full consideration, this information should be received by December 31, 1996.

In accordance with its Employment Equity Policy, the University of Toronto encourages applications from qualified women or men, members of visible minorities, aboriginal peoples, and persons with disabilities. In accordance with Canadian immigration requirements, this advertisement is directed to Canadian citizens and permanent residents.

UNIVERSITY OF TORONTO
Tenure-Stream Appointment in Geometry

The department solicits applications for a tenure-stream appointment in geometry at the level of assistant professor. Preference will be given to researchers in the areas of algebraic geometry, arithmetic algebraic geometry, and differential geometry.

The appointment is at the downtown (St. George) campus, to begin July 1, 1997. Candidates are expected to have at least three years experience in teaching and research after the Ph.D., and to be able to demonstrate excellence in each. In particular, a candidate's research should clearly establish the ability to make significant original and independent contributions to mathematics at the highest level. Salary is commensurate with experience.

Applicants should send their complete C.V., including a list of publications, a short statement describing their research program, and all appropriate material about their teaching. They should also arrange to have at least four letters of reference sent directly to Professor V. Ivrii, Associate Chair, Department of Mathematics, University of Toronto, Toronto, Canada M5S 3G3. At least one letter should be primarily concerned with the candidate’s teaching. In addition, it is recommended that applicants submit the electronic application form which is available on our World Wide Web Employment Opportunities page: http://www.toronto.edu/math/jobs/. To insure full consideration, this information should be received by December 31, 1996.

In accordance with its Employment Equity Policy, the University of Toronto encourages applications from qualified women or men, members of visible minorities, aboriginal peoples, and persons with disabilities.

UNIVERSITY OF TORONTO
Tenure-Stream Appointment in Algorithmic Mathematics and Theoretical Computer Science

The University of Toronto solicits applications for a tenure-stream appointment in the field of algorithmic mathematics and theoretical computer science, including complexity and effective methods in scientific computation. The position is subject to budgetary approval.

The appointment is at the downtown (St. George) campus at the level of assistant professor, to begin July 1, 1997. This will be a joint appointment between the Department of Mathematics (75%) and the Department of Computer Science (25%). Candidates are expected to have demonstrated excellence in both teaching and research after the Ph.D.; in particular, a candidate’s research record should clearly show the ability to make significant original and independent contributions to mathematics. Salary commensurate with experience.

Applicants should send their complete C.V., including a list of publications, a short statement describing their research program, and all appropriate material about their teaching. They should also arrange to have at least four letters of reference sent directly to Professor V. Ivrii, Associate Chair, Department of Mathematics, University of Toronto, Toronto, Canada M5S 3G3. At least one letter should be primarily concerned with the candidate’s teaching. In addition, it is recommended that applicants submit the electronic application form which is available from our World Wide Web Employment Opportunities page: http://www.toronto.edu/math/jobs/. To insure full consideration, all information should be received by December 31, 1996.

In accordance with Canadian immigration requirements, this advertisement is directed to Canadian citizens and permanent residents of Canada. In accordance with its Employment Equity Policy, the University of Toronto encourages applications from qualified women or men, members of visible minorities, aboriginal peoples, and persons with disabilities.

LEBANON
AMERICAN UNIVERSITY OF BEIRUT
Department of Mathematics

The Department of Mathematics at the American University of Beirut in Beirut, Lebanon (AUB), invites applications for faculty positions in the fields of (a) statistics, (b) graph theory, (c) combinatorics, and (d) algebraic and differential geometry, starting October 1, 1997. The completed doctorate is required, with postdoctoral teaching and/or research experience required. Rank will normally be assistant professor, usual contract is for three years.
The department offers both Bachelor’s and Master’s degrees, with a research thesis required for the Master’s degree. Candidates will be expected to engage in research, to be qualified to teach on the undergraduate and graduate levels, and to be qualified to supervise student research and thesis writing. The language of instruction is English.

Interested candidates should send a letter of application (with a copy to the Director of Personnel, c/o AUB New Office) and a C.V., and should arrange for three letters of reference to be sent before November 15, 1996, to: Dean, Faculty of Arts and Sciences, American University of Beirut, c/o New York Office, 850 Third Avenue, 18th Floor, New York, NY 10022-6297, USA. Incomplete and/or late applications will not be considered.

AUB is an Equal Opportunity, Affirmative Action Employer.

U.S. passports are presently invalid for travel to, in, or through Lebanon, and for residence in Lebanon, by order of the Department of State, and therefore applications from individuals who would travel to or reside in Lebanon on a U.S. passport cannot at this time be considered.

WEST INDIES

UNIVERSITY OF THE WEST INDIES

Cave Hill Campus

Barbados

Applications are invited for the post of Senior Lecturer in Mathematics and Statistics in the Department of Computational, Mathematical and Physical Sciences, Faculty of Science and Technology, at the Cave Hill Campus of the University of the West Indies, Barbados. Applicants for this post should be competent to teach mathematical statistics. The successful applicant will be expected to assume duties by August 1, 1997. Salary Scales:

Senior Lecturer: BDS $60,216 x 1,956-71,752 x 2,112-78,288 (Bar) x 2,112-82,512 per annum.

Lecturer: BDS $45,372 x 1,956-57,108 (Bar) x 1,956-68,844 per annum.

Detailed applications (three copies) giving full particulars of qualifications and experience, and the names and addresses of three (3) referees should be sent to the Campus Registrar, University of the West Indies, P.O. Box 64, Bridgetown, Barbados. The university will send further particulars for this post to all applicants.

American Mathematical Society

Fundamental Groups of Compact Kähler Manifolds

J. Amorós, I-UPC, ETSEIB, Barcelona, Spain,
M. Burger, Université de Lausanne, Switzerland,
K. Corlette, University of Chicago, IL, D. Kotschick,
Universität Basel, Switzerland, and D. Toledo,
University of Utah, Salt Lake City

This book is an exposition of what is currently known about the fundamental groups of compact Kähler manifolds. This class of groups contains all finite groups and is strictly smaller than the class of all finitely presentable groups. For the first time ever, this book collects together all the results obtained in the last few years which aim to characterize these infinite groups which can arise as fundamental groups of compact Kähler manifolds.

The methods and techniques used form an attractive mix of topology, differential and algebraic geometry, and complex analysis. The book would be useful to researchers and graduate students interested in any of these areas, and it could be used as a textbook for an advanced graduate course. One of its outstanding features is a large number of concrete examples.

Mathematical Surveys and Monographs, Volume 44; 1996; 140 pp.; Hardcover; ISBN 0-8218-0498-7; List $39, All AMS members $31; Order code SURV/44NA

Introduction to Intersection Theory in Algebraic Geometry

William Fulton, University of Chicago, IL

This book presents expository lectures from the CBMS regional conference held at George Mason University during the summer of 1983. This volume has been reprinted by the AMS with updates and corrections. In the work, Fulton gives references to many further developments in the field.

CBMS Regional Conference Series in Mathematics, Number 54; 1994; 83 pp.; Softcover; ISBN 0-8218-0704-8; List $24; All individuals $14; Order code CBMS/54NA

Topology of Real Algebraic Varieties and Related Topics

V. Kharlamov, University Louis Pasteur, Strasbourg Cedex, FR, A. Korchagin, Brooklyn, NY, G. Polotovsii, Gorky State University, Russia, and O. Viro, University of California, Riverside, Editors

This volume is dedicated to the memory of the Russian mathematician D. A. Gudkov. It contains papers written by his friends, students, and collaborators and is devoted mainly to the areas where D. A. Gudkov made important contributions. The main topic is the topology of real algebraic varieties. Several papers include new results on the topology of real plane algebraic curves (the Hilbert 16th problem).


All prices subject to change. Charges for delivery are $3.00 per order, or for air delivery outside of the continental U.S., please include $6.50 per item. Prepayment required. Order from: American Mathematical Society, P.O. Box 6004, Boston, MA 02106-0904. Or for credit card orders, fax (401) 331-3942 or call toll free 800-321-4AMS (4267) in the U.S. and Canada, (401) 455-4300 worldwide. Residents of Canada, please include 7% GST.
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BIRKHÄUSER MATHEMATICS

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A. Visintin, Università degli Studi di Trento, Italy

This book offers an introduction to modeling and analysis of phase transition and ferromagnetic problems that is accessible to the non-specialist. It also presents a number of research problems that will appeal to the specialist in these fields.

The book consists of three parts dealing with some classes of nonlinear parabolic PDEs, phase transitions, and ferromagnetism. Although each part has its own independent structure, a common thread joins them: nonlinear parabolic PDE’s occurring as models of phase transitions, and solid-liquid and ferromagnetic systems exhibiting the physical and mathematical analogies that form the main theme of the book.

1996 250 pp. Hardcover $64.50 (tent.)
ISBN 0-8176-3766-0

PROGRESS IN NONLINEAR DIFFERENTIAL EQUATIONS AND THEIR APPLICATIONS

HANDBOOK OF BROWNIAN MOTION
Facts and Formulae
A. Borodin, St. Petersburg, Russia & P. Salminen, Åbo Akademi University, Turku, Finland

The purpose of this book is to give an easy reference to a large number of facts and formulae associated to Brownian motion. The book consists of two parts: (1) theory — is devoted primarily to properties of linear diffusions and Brownian motion and (2) formula — is a table of distributions of functionals of Brownian motion and related processes. The collection contains more than 1500 numbered formulae. This book is of value as a basic reference to researchers, graduate students, and people doing applied work with Brownian motion and diffusions.

Probability and Its Applications

SUB-RIEMANNIAN GEOMETRY
A. Bellaiche, Université de Paris VII-Denis Diderot, Paris, France & J.-J. Risler, Université Pierre et Marie Curie, Paris, France (Eds.)

This book provides an introduction to sub-Riemannian geometry and presents the state of the art and open problems in the field. It consists of five original articles by the leading specialists: The tangent space in sub-Riemannian geometry/ A. Bellaiche * Carnot-Carathéodory spaces seen from within/M. Gromov * Survey of singular geodesics/R. Montgomery * A cornucopia of four-dimensional abnormal sub-Riemannian minimizers/H.J. Sussmann * Stabilization of controllable systems/I.-M. Coron

PROGRESS IN MATHEMATICS, VOLUME 144

LINEAR INTEGRAL EQUATIONS
Second Edition
R.P. Kanwal, Pennsylvania State University

Many physical problems that are usually solved by differential equation methods can be solved more effectively by integral equation methods. Such problems abound in applied mathematics, theoretical mechanics, and mathematical physics. The second edition of this widely used book continues the emphasis on applications and presents a variety of techniques with extensive examples. Additional material has been added throughout the book. The chapters dealing with differential equations and singular integral equations have been considerably expanded. Thus the book is ideal as a text for a beginning graduate level course. Its treatment of boundary value problems and an extended and up-to-date bibliography will also make the book useful to research workers in many applied fields.


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Two New Titles in Knot Theory —
KNOT THEORY AND ITS APPLICATIONS
K. Murasugi, Professor Emeritus, University of Toronto
(Translated from the Japanese by B. Kurpita)

This book is an introduction to the fascinating study of knots and provides insight into recent applications to such studies as DNA research and graph theory. The author clearly outlines what is known and what is not known about knots. He has been careful to avoid advanced mathematical terminology and intricate techniques in algebraic topology and group theory. There are numerous diagrams and exercises which relate to the material. Developments over the past ten years are described, in particular the study of Jones polynomials.

1996 250 pp. Hardcover $69.50

A SURVEY OF KNOT THEORY
A. Kawachi, Osaka City University, Japan

The present volume, written by a well-known specialist, gives a complete survey of knot theory from its very beginnings to today’s most recent research results. The topics include Alexander polynomials, Jones type polynomials, and Vassiliev invariants. With its appendix containing many useful tables and an extended list of references with over 3,500 entries, it is an indispensable book for everyone concerned with knot theory.


VARIATIONAL METHODS FOR DISCONTINUOUS STRUCTURES
R. Serapioni & F. Tomarelli, Politecnico di Milano, Italy (Eds.)

In recent years many researchers in material science have focused their attention on the study of composite materials, equilibrium of crystals and crack distribution of continual subject to loads. Several new issues in computer vision and image processing have been studied in depth. Some of the topics discussed include: differential or variational modeling of image segmentation, domain partitions, surface flow by mean curvature, homogenization of composite materials, phase transformations, crystals, metastability of martensite, interaction between fracture and damage, and magnetostriuctive materials.

1996 204 pp. Hardcover $89.50 ISBN 3-7643-5273-6
PROGRESS IN NONLINEAR DIFFERENTIAL EQUATIONS AND THEIR APPLICATIONS, VOLUME 25

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Young Tableaux
With Applications to Representation Theory and Geometry
William Fulton
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Jaakko Hintikka
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A First Course in the Numerical Analysis of Differential Equations
Arieh Iserles
The point of departure is mathematical but the exposition strives to maintain a balance among theoretical, algorithmic and applied aspects of the subject. Cambridge Texts in Applied Mathematics 15 1996 396 pp. 55655-4 Paperback $27.95

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Showing the link between commutative ring theory and algebraic geometry, this book contrasts the methods and ideology of modern abstract algebra with concrete applications in algebraic geometry and number theory. London Mathematical Society Student Texts 29 1996 167 pp. 45889-7 Paperback $18.95

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A Student Introduction
P. Wilmott, S. Howison, and J. Dewynne
The authors describe the modelling of financial derivative products from an applied mathematician’s viewpoint, from modeling to analysis to elementary computation. 1995 333 pp. 49789-2 Paperback $24.95

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Finsler Geometry

David Bao, University of Houston, TX, Shing-shen Chern, University of California, Berkeley, and Zhongmin Shen, Indiana-Purdue University at Indianapolis, Editors

This volume features proceedings from the 1995 Joint Summer Research Conference on Finsler Geometry (Seattle, WA), chaired by S.S. Chern and co-chaired by D. Bao and Z. Shen.

The editors of this volume have provided comprehensive and informative "capsules" of presentations and technical reports. This was facilitated by classifying the papers into the following 6 separate sections:

- Finsler Geometry over the reals
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ALGEBRA AND ALGEBRAIC GEOMETRY

Cogroups and Co-rings in Categories of Associative Rings
George M. Bergman, University of California, Berkeley, and Adam O. Hausknecht, University of Massachusetts at Amherst

This book studies representable functors among well-known varieties of algebras. All such functors from associative rings over a fixed ring R to each of the categories of abelian groups, associative rings, Lie rings, and to several others are determined. The book includes a "Symbol index", which serves as a glossary of symbols used and a list of the pages where the topics so symbolized are treated, and a "Word and phrase index". The authors have strived—and succeeded—in creating a volume that is very user-friendly.

Mathematical Surveys and Monographs, Volume 65; 1996; 388 pp.; Hardcover; ISBN 0-8218-0495-2; List $79; Individual member $47; Order code SURV/65NA

Enveloping Algebras
Jacques Dixmier, Paris, France

For the graduate student, this is a masterpiece of pedagogical writing, being succinct, wonderfully self-contained and of exceptional precision.

—Mathematical Reviews

The above citation is taken from the review of the first English edition of Dixmier’s book. The book, which is the first systematic exposition of the algebraic approach to representations of Lie groups via representations of (co)modules over the corresponding universal enveloping algebras, turned out to be so well written that even today it remains one of the main textbooks and reference books on the subject. In 1992, Jacques Dixmier was awarded the Leroy P. Steele Prize for expository writing in mathematics. The Committee’s citation mentioned Enveloping Algebras as one of Dixmier’s “extraordinary books”. For the 1996 printing the author updated the status of open problems and added some relevant references.

Graduate Studies in Mathematics, Volume 11, 1996; 379 pp.; Hardcover; ISBN 0-8218-0560-4; List $99; All AMS members $47; Order code GSM/11NA

Tight Closure and Its Applications
Craig Huneke, Purdue University, West Lafayette, IN

This monograph deals with the theory of tight closure and its applications. The contents are based on talks given at a CBMS conference held at North Dakota State University in June 1995.

Tight closure is a method to study rings of equicharacteristic by using reduction to positive characteristic. In this book, the basic properties of tight closure are covered, including various types of singularities, e.g., F-regular and F-rational singularities. Several applications of the theory are given. These include the existence of big Cohen-Macaulay algebras and various uniform Artin-Rees theorems.

CBMS Regional Conference Series in Mathematics, Number 86, 1996; 137 pp.; Softcover; ISBN 0-8218-0412-X; List $29; All individuals $23; Order code CBMS/86NA

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Introduction to Measure and Integration

Elliott H. Lieb, Princeton University, NJ, and Michael Loss, Georgia Institute of Technology, Atlanta

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The book covers measure and integration, theory of $L^p$ spaces, distribution theory, Fourier analysis, potential theory, Sobolev spaces, and more. Analysis is a unique, practical book that everyone—from the graduate student, to the professional mathematician, to the physicist or engineer using analytical methods—will find interesting, stimulating, and useful.

About the authors: Elliott Lieb is Professor of Mathematics and Theoretical Physics at Princeton University and is a member of several US, Austrian, and Danish Academies of Science. He is also the recipient of several prizes including the 1998 AMS/SIAM Birkhoff prize. Michael Loss is Professor of Mathematics at the Georgia Institute of Technology. Co-published in the Colloquium Series on Mathematics, Volume 14; November 1996; approximately 300 pages; Hardcover; ISBN 0-8218-0632-7; List $35; All AMS members $28; Order code GSM/14NA

The Way I Remember It

Walter Rudin, University of Wisconsin, Madison

Walter Rudin’s memoirs should prove to be a delightful read specifically to mathematicians, but also to historians who are interested in learning about his colorful history and ancestry. Characterized by his personal style of elegance, clarity, and brevity, Rudin presents in the first part of the book his early memories about his family history, his boyhood in Vienna throughout the 1920s and 1930s, and his experiences during World War II.

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 12; October 1996; 191 pages; Hardcover; ISBN 0-8218-0633-5; List $29; All AMS members $23; Order code HMATH/12NA

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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 $93; for those whose annual professional income is $45,000 or more, the dues are $124.

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 $97; for those whose annual professional income is above $45,000, the dues are $105.

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 $186.

For either students or unemployed individuals, dues are $31, and annual verification is required. The annual dues for reciprocity members who reside outside the U.S. and Canada are $62. 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 ($93 or $124).

The annual dues for category-S members, those who reside in developing countries, are $16. Members can choose only one privilege journal. Please indicate your choice below.

Members can purchase a multi-year membership by prepaying their current dues rate for either two, three, four or five years. This option is not available to category-S, unemployed, or student members.

1997 Dues Schedule (January through December)

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<th>Category</th>
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<td>Multi-year membership</td>
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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. My unemployment status is not a result of voluntary resignation or of retirement from my last position.

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.

4 send NOTICES

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Reciprocating Societies

- Allahabad Mathematical Society
- Asociación Matemática Española
- Australian Mathematical Society
- Azerbaijan Mathematical Society
- Berliner Mathematische Gesellschaft e.V.
- Calcutta Mathematical Society
- Croatian Mathematical Society
- Danske Matematikforening
- Deutsche Mathematiker-Vereinigung e.V.
- Edinburgh Mathematical Society
- Egyptian Mathematical Society
- Gesellschaft für Angewandte Mathematik und Mechanik
- Glasgow Mathematical Association
- Hellenic Mathematical Society
- Indian Mathematical Society
- Iranian Mathematical Society
- Irish Mathematical Society
- Israel Mathematical Union
- János Bolyai Mathematical Society
- 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
- Nigerian Mathematical Society
- Norsk Matematisk Forening
- Österreichische Mathematische Gesellschaft
- Palestine Society for Mathematical Sciences
- Polskie Towarzystwo Matematyczne
- Punjab Mathematical Society
- Ramanujan Mathematical Society
- Real Sociedad Matemática Española
- Saudi Association for Mathematical Sciences
- Sociedad Colombiana de Matemáticas
- Sociedad de Matemáticas de Chile
- Sociedad Matemática de la República Dominicana
- Sociedad Matemática Mexicana
- Sociedade Brasileira Matemática
- Sociedade Brasileira de Matemática Aplicada e Computacional
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- Société Mathématique de Belgique
- Société Mathématique de France
- Société Mathématique Suisse
- Society of Associations of Mathematicians & Computer Science of Macedonia
- Society of Mathematicians, Physicists, and Astronomers of Slovenia
- South African Mathematical Society
- Southeast Asian Mathematical Society
- Suomen Matemaattinen Yhdistys
- Svenska Matematikersamfundet
- Union Mathematica Argentina
- Union of Bulgarian Mathematicians
- Union of Czech Mathematicians and Physicists
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Members of the Society who move or change positions are urged to notify the Providence Office as soon as possible.

Journal mailing lists must be printed four to six weeks before the issue date. Therefore, in order to avoid disruption of service, members are requested to provide the required notice well in advance.

Besides mailing addresses for members, the Society's records contain information about members' positions and their employers (for publication in the Combined Membership List). In addition, the AMS maintains records of members' honors, awards, and information on Society service.

When changing their addresses, members are urged to cooperate by supplying the requested information. The Society's records are of value only to the extent that they are current and accurate.

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| Recent honors and awards | | |
Meetings & Conferences of the AMS

Columbia, Missouri
University of Missouri
November 1-3, 1996

Meeting #916
Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of Notices: September 1996
Issue of Abstracts: Volume 17, Issue 4

Deadlines
For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired

Registration and Meeting Information
Registration is on the second floor of the General Classroom Building (GCB) outside of Room 209; Friday, November 1, 2:30 p.m. to 5:00 p.m.; Saturday, November 2, 8:00 a.m. to 5:00 p.m.; and Sunday, November 3, 9:00 a.m. to 11:00 a.m. Registration fees (payable on site only): $30/AMS members; $45/nonmembers; and $10/emeritus members, students, or unemployed mathematicians. Fees are payable by cash, check, VISA, MasterCard, Discover, or American Express.

Invited addresses: Allen Auditorium, Arts and Sciences Building (A&S); other sessions: GCB and A&S.

Pasadena, California
California Institute of Technology
November 16-17, 1996

Meeting #917
Western Section
Associate secretary: William A. Harris Jr.
Announcement issue of Notices: September 1996
Program issue of Notices: November 1996
Issue of Abstracts: Volume 17, Issue 4

Deadlines
For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired

Registration and Meeting Information
Registration is in the North Lobby of the Sloan Laboratory: Saturday, November 16, 8:00 a.m. to 5:00 p.m.; and Sunday, November 17, 8:00 a.m. to 1:00 p.m. Registration fees (payable on site only): $30/AMS members; $45/nonmembers; and $10/emeritus members, students, or unemployed mathematicians. Fees are payable by cash, check, VISA, MasterCard, Discover, or American Express.

Invited Addresses: East Bridge Lab (201); other sessions: Downs and Sloan Labs.
Meetings & Conferences

1. Alumni Club
2. Arts & Science/Allen Auditorium
3. Brady Commons
4. General Classroom Building
5. Math Building
6. Parking
7. Parking Garage
8. Visitor Parking

UNIVERSITY OF MISSOURI
San Diego, California  
*San Diego Convention Center*  
January 8–11, 1997

**Meeting #918**  
Joint Mathematics Meetings, including 103rd Annual Meeting of the AMS, 80th Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM), the National Association of Mathematicians (NAM), and winter meeting of the Association for Symbolic Logic (ASL).  
Associate secretary: Lesley M. Sibner  
Announcement issue of *Notices*: October 1996  
Program issue of *Notices*: January 1997  
Issue of *Abstracts*: Volume 18, Issue 1

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**Deadlines**  
For organizers: Expired  
For consideration of contributed papers in Special Sessions: Expired  
For abstracts: Expired  
For summaries of papers to MAA organizers: To be announced

**Program Updates**  
**AMS-MAA Sessions**  
The presentation on *Maximizing Your Job Search Success* on Friday morning will review effective strategies for locating career positions. Specific techniques for responding to posted positions, applying directly with possible employers, and developing a supportive personal job search network will be discussed. Participants will learn how to apply a variety of successful approaches toward attainment of desired career objectives.

**MAP**

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**CALTECH**  
33. E. Bridge  
37. Sloan Laboratory  
47. Downs Laboratory  
61. Athenaeum - Caltech Faculty Club
MAA Sessions
Undergraduate Mathematics Education: Visions for the Future: Thursday, 2:15. Frank Wattenberg, Weber State University is an additional panelist.

Orientation and Supervision of Part-Time Instructors: Thursday, 2:15 p.m. Additional panelists are Bettye Anne Case, Florida State University, and Richard D. Ringelstein, East Carolina University.

Teaching at a College or University—Advice About Preparing for and Securing Such Positions: Thursday, 7:00 p.m. to 9:00 p.m., sponsored by the MAA Task Force on Graduate Students, and moderated by Thomas W. Rishel, Cornell University, and James R. C. Leitzel, University of New Hampshire. Panelists include Richard Cleary, St. Michael’s College; John Meier, Lafayette College; Teresa Moore, Ithaca College; and Nikhil Shah, Cornell University, who will discuss the job interview process from the institution’s perspective, what teaching at such institutions actually entails, the ingredients of a “good” vita and cover letter, and programs on teaching designed for graduate students and how they affect the job search process. The session is directed toward graduate students anticipating such employment in the future and faculty from institutions at all levels.

Women and Mathematics: Case Studies of Intervention Programs, Friday 9:30 a.m., has been cancelled.

A Chair’s Survival Guide: Friday, 7:30 p.m., sponsored by the Committee on the Teaching of Undergraduate Mathematics. The panelists will be Carol Congleton, Mira Costa College; Larry Copes, Augsburg College; Paul Duvall, University of North Carolina at Greensboro; and Robert Olin, Virginia Polytechnic Institute and State University.

Scientific Visualization in Undergraduate Mathematics: Saturday, 1:00 p.m. A partial list of panelists includes Bev Baartman, Michigan Technological University; Thomas Banchoff, Brown University; and James King, University of Washington, Seattle; and Joan Ferrini-Mundy, MSEP and University of New Hampshire.

Advanced Placement Statistics: Saturday, 1:00 p.m. Panelists include Duane Hinders, Gunn High School, Palo Alto, CA.

Art, Literature, Music, and Mathematics: Saturday, 2:30 p.m. Leonard Gillman, University of Texas, Austin, is also a presenter.

Report on the Eighth International Congress on Mathematics Education (ICME-8): Saturday, 4:00 p.m. The Eighth International Congress on Mathematics Education (ICME-8) was held in Seville, Spain, July 14-21, 1996. In this session a panel of U.S. participants in the Congress, including Victor J. Katz, University of the District of Columbia; Mark Saul, Bronxville Schools, New York; Joanne Rossi Becker, San Jose State University; Lynnell S. Matthews, Howard Community College; and Jack Alexander, National Academy of Sciences, will report their observations about the substance of the scientific program and other aspects of the Congress and give their personal reactions and observations. There will be an opportunity for questions/discussion with the members of the audience. Organized by Jerry P. Becker, Southern Illinois University.

Other Organizations
Association for Women in Mathematics
An additional panelist in Wednesday’s panel discussion at 3:30 p.m. is Audrey Terras, University of California, San Diego.

Joint Policy Board on Mathematics
Math Awareness Week (MAW) 1997—Mathematics and the Internet: 9:30 a.m. to 10:55 a.m., Friday. The session chair is Robert M. Fossum, University of Illinois, Urbana-Champaign. Participants include Gene Klotz, The Math Forum (host of the MAW web site). This session will feature case studies of 1996 MAW activities presented by representatives of sponsoring institutions, presentation of the 1997 MAW theme poster and supporting materials, an overview of mathematics on the Internet, and uses of the 1997 MAW WWW site.

What’s New(s) in Mathematics? 2:15 p.m. to 3:45 p.m., Thursday. The chair is Steven Weintraub, Louisiana State University. Participants include Ivars Peterson, Science News. This session will feature presentations from working journalists in both the general and trade press, an analysis and discussion of “news” in mathematics from the perspective of practitioners in the field, and tips on using the academic public information office.

Registration Information
The deadline for EARLY registration is October 31.

Memphis, Tennessee
University of Memphis
March 21–22, 1997

Meeting #919
Southeastern Section
Associate secretary: Robert J. Daverman
Announcement issue of Notices: January 1997
Program issue of Notices: March 1997
Issue of Abstracts: Volume 18, Issue 2

Deadlines
For organizers: Expired
For consideration of contributed papers in Special Sessions: October 19, 1996
For abstracts: December 14, 1996

Invited Addresses
Keith Ball, Texas A&M University, Title to be announced.
Nikolai I. Chernov, University of Alabama at Birmingham, Title to be announced.
Richard Martin Hain, Duke University, Title to be announced.
Allen R. Tannenbaum, University of Minnesota, Title to be announced.
Special Sessions

Approximation in Mathematics (Code: AMS SS A1), George A. Anastassiou, University of Memphis.

Chaotic Dynamics (Code: AMS SS I1), Nikolai I. Chernov and Serge Troubetzkoy, University of Alabama at Birmingham.

Complex Analysis in One and Several Variables (Code: AMS SS F1), Dmitry Khavinson, University of Arkansas.

Convergence and Recurrence in Ergodic Theory. (Code: AMS SS E1), James T. Campbell and Mate Wierdl, University of Memphis.

Dynamical Systems and Fractal Geometry (Code: AMS SS C1), Fernanda Botelho, University of Memphis.

Graph Theory (Code: AMS SS M1), Ralph J. Faundree Jr. and Richard H. Schelp, University of Memphis.

Harmonic Analysis and Convexity. (Code: AMS SS G1), Eric A. Carlen, Georgia Institute of Technology, Erwin Lutwak, Polytechnic University, and Elisabeth Werner, Case Western Reserve University.

Invariants of 3-Manifolds (Code: AMS SS H1), Stavros Garofalidis, Brown University, and Richard Martin Hain and Jun Yang, Duke University.

Mathematical Methods in Computer Vision (Code: AMS SS J1), Benjamin B. Kimia, Brown University.

Numerical Solutions for Partial Differential Equations (Code: AMS SS D1), Xiaobing Feng and Obannes Karakashian, University of Tennessee.

Partial Differential Equations (Code: AMS SS P1), Gisele Ruiz Goldstein and Jerome A. Goldstein, University of Memphis.

Random Graphs (Code: AMS SS N1), Bela Bollobas and Cecil C. Rousseau, University of Memphis.

Recurrence Neural Networks and Applications (Code: AMS SS K1), Fernanda Botelho and Max H. Garzon, University of Memphis.

Symbolic Dynamics (Code: AMS SS B1), Paul B. Trow, University of Memphis.

Topology of Manifolds and Singular Spaces (Code: AMS SS L1), Bruce Hughes, Vanderbilt University, and Andrew A. Ranicki, Edinburgh University.

College Park, Maryland

University of Maryland, College Park

April 12–13, 1997

Meeting #920

Eastern Section

Associate secretary: Lesley M. Sibner

Announcement issue of Notices: February 1997

Program issue of Notices: April 1997

Issue of Abstracts: Volume 18, Issue 2

Deadlines

For organizers: Expired

For consideration of contributed papers in Special Sessions: November 18, 1996

For abstracts: January 13, 1997

Invited Addresses

Lisa Claire Jeffrey, McGill University, Title to be announced.

Alexandre Kirillov, University of Pennsylvania, Merits and demerits of the orbit method.

Jian-Shu Li, University of Maryland, College Park, Title to be announced.

Richard Pollack, Courant Institute of Mathematical Sciences, New York University, Title to be announced.

Special Sessions


Analysis of Spatial Stochastic Models (Code: AMS SS E1), A. M. Kagan and Eric V. Slud, University of Maryland.

Automorphism Groups of Geometric Structures (Code: AMS SS J1), Alessandra Iozzi and Garrett James Stuck, University of Maryland.

Groupoids and their Applications (Code: AMS SS F1), Alan T. Paterson, University of Mississippi.

Harmonic Analysis and Applications (Code: AMS SS N1), Stephen D. Casey, American University, and David F. Walnut, George Mason University.

Hyperbolic Equations (Code: AMS SS L1), Manoussos Grillakis and Matel Macheden, University of Maryland.


Lie Groups and Automorphic Forms (Code: AMS SS C1), Jian-Shu Li, University of Maryland, and Gordan Savin, University of Utah.


Numerical Solution of Differential Equations (Code: AMS SS M1), Ricardo H. Nochetto and John E. Osborn, University of Maryland.

Partial Differential Equations (Code: AMS SS K1), Jonathan Adam Poritz, University of Maryland.

Representation Theory (Code: AMS SS D1), Alexandre A. Kirillov, University of Pennsylvania.

Symplectic Geometry, Moduli Spaces and Integrable Systems (Code: AMS SS B1), Lisa Claire Jeffrey, McGill University, and Eyal Markman, University of Michigan.
Topological Dynamics (Code: AMS SS 11), Joseph Auslander and Kenneth R. Berg, University of Maryland.

Corvallis, Oregon
Oregon State University
April 19-20, 1997

Meeting #921
Western Section
Associate secretary: William A. Harris, Jr
Announcement issue of Notices: February 1997
Program issue of Notices: April 1997
Issue of Abstracts: Volume 18, Issue 2

Deadlines
For organizers: Expired
For consideration of contributed papers in Special Sessions: November 18, 1996
For abstracts: January 13, 1997

Detroit, Michigan
Wayne State University
May 2-4, 1997

Meeting #922
Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of Notices: March 1997
Program issue of Notices: May 1997
Issue of Abstracts: Volume 18, Issue 2

Deadlines
For organizers: Expired
For consideration of contributed papers in Special Sessions: December 9, 1996
For abstracts: February 3, 1997

Invited Addresses
Harold P. Boas, Texas A&M University, Title to be announced.
Carlos E. Kenig, University of Chicago, Title to be announced.
Ernest E. Shult, Kansas State University, Title to be announced.
A. L. Volberg, Michigan State University, Title to be announced.

Special Sessions
Algebraic Combinatorics (Code: AMS SS K1), Devadatta M. Kulkarni, Oakland University.

Algebraic Topology (Code: AMS SS D1), Robert R. Bruner and David Handel, Wayne State University.
Analysis and Geometry (Code: AMS SS J1), Carlos E. Kenig, University of Chicago, and Tatiana Toro, University of Washington.
C* Algebras (Code: AMS SS H1), Jerry Kaminker, Indiana University-Purdue University at Indianapolis, and Claude L. Schochet, Wayne State University.
Differential Geometry and Its Applications (Code: AMS SS C1), Daniel S. Drucker and Chong-Shi Houh, Wayne State University.
Groups and Geometries (Code: AMS SS E1), Daniel E. Frohardt and Kay Magaard, Wayne State University, and Robert L. Griess, Jr., University of Michigan.
Optimization and Variational Analysis (Code: AMS SS L1), Boris S. Mordukhovich, Wayne State University, and Jay S. Treiman and Qiji Zhu, Western Michigan University.
Recent Advances in Noncommutative Ring Theory (Code: AMS SS F1), Peter Malcolmson and Frank Okoh, Wayne State University.
Representation Theory of Finite Groups and Related Topics (Code: AMS SS B1), David Howard Gluck, Wayne State University.
Stochastic Processes in Finance and Control (Code: AMS SS G1), Raoul LePage, Michigan State University, and Bert M. Schreiber, Wayne State University.
VOA’s monstrous moonshine and related topics (Code: AMS SS I1), Chongying Dong, University of California Santa Cruz, and Robert L. Griess Jr., University of Michigan.
Wavelets and Applications (Code: AMS SS M1), Gregory F. Bachelis and Tze-Chien Sun, Wayne State University, and Grant Gerhart, Tardec, Tacoma, Army.

Pretoria, Republic of South Africa
University of Pretoria

Meeting #923
Associate secretary: Susan J. Friedlander
Announcement issue of Notices: To be announced
Program issue of Notices: To be announced
Issue of Abstracts: To be announced
Deadlines
For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Invited Addresses
Hyman Bass, Columbia University, Title to be announced.
Percy Alec Deift, Courant Institute of Mathematical Sciences, New York University.
Doron Lubinsky, University of Witwatersrand, South Africa, Title to be announced.
Peter Sarnak, Princeton University, Title to be announced.

Special Sessions
Algebraic K-Theory (Code: AMS SS F1), Eric M. Friedlander, Northwestern University, and Remi Kuku, ICTP, Trieste, Italy.

Dynamical Systems and Ergodic Theory (Code: AMS SS B1), Harvey B. Keynes, University of Minnesota, and Michael Sears, University of Witwatersrand, South Africa.

Dynamical Systems and Ergodic Theory (Code: AMS SS B1), Harvey B. Keynes, University of Minnesota, and Michael Sears, University of Witwatersrand, South Africa.

Fluid Dynamics (Code: AMS SS D1), Susan J. Friedlander, University of Illinois at Chicago, Andrew Gilbert, University of Exeter, United Kingdom, and David Mason, University of Witwatersrand, South Africa.

Geometry, Topology and Physics (Code: AMS SS A1), Steven B. Bradlow, University of Illinois-Urbana, George Ellis, University of Cape Town, South Africa, Nigel J. Hitchin, University of Cambridge, England, and Joao Rodrigues, University of Witwatersrand, South Africa.

Invariant Subspaces and Collections of Operators (Code: AMS SS G1), Peter Rosenthal, University of Toronto, and Graeme Philip West, University of Witwatersrand.

Number Theory (Code: AMS SS E1), John Knopfmacher, University of Witwatersrand, South Africa, and Peter Sarnak, Princeton University.

Secondary and Postsecondary Curriculum Reform (Code: AMS SS C1), Johann Engelbrecht, University of Pretoria, South Africa, Deborah Hughes Hallet, Harvard University, and Harvey B. Keynes, University of Minnesota.

Montreal, Quebec, Canada
University of Montreal
September 26–28, 1997

Meeting #924
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 10, 1997
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Special Sessions
Set-Theoretic Techniques in Topology and Analysis (Code: AMS SS A1), Gary F. Gruenhage and Piotr Koszmider, Auburn University.

Milwaukee, Wisconsin  
*University of Wisconsin*  
October 24-26, 1997

**Meeting #926**  
Central Section  
Associate secretary: Susan J. Friedlander  
Announcement issue of *Notices*: August 1997  
Program issue of *Notices*: October 1997  
Issue of *Abstracts*: To be announced

**Deadlines**  
For organizers: January 4, 1997  
For consideration of contributed papers in Special Sessions: May 7, 1997  
For abstracts: July 9, 1997

**Invited Addresses**  
Spencer J. Bloch, University of Chicago, *Title to be announced.*  
Henri Moscovici, Ohio State University, *Title to be announced.*  
Wei Ming Ni, University of Chicago, *Title to be announced.*  
Andrei Susin, Northwestern University, *Title to be announced.*

**Special Sessions**  
*Computability Theory* (Code: AMS SS A1), Steffen Lempp, University of Wisconsin, Madison, and Robert I. Soare, University of Chicago.  
*Concentration Phenomena in Differential Equations* (Code: AMS SS E1), Lia Bronsard, McMaster University, and Wei-Ming Ni, University of Minnesota.  
*Geometric Topology and Geometric Group Theory* (Code: AMS SS H1), Fredric Davis Ancel and Craig R. Guilbault, University of Wisconsin-Milwaukee.  
*Harmonic Analysis and Its Applications* (Code: AMS SS F1), Lung-Kee Chen, Oregon State University, Dashan Fan, University of Wisconsin-Milwaukee, and Yi-Biao Pan, University of Pittsburgh.  
*Low Dimensional Dynamics* (Code: AMS SS C1), Karen M. Brucks, University of Wisconsin-Milwaukee, and Beverly E. J. Diamond, University of Charleston.  
*Operator Theory and Function Spaces* (Code: AMS SS G1), Zeljko Cuckovic, University of Toledo.

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Rings and Modules (Code: AMS SS I1), Karl Andrew Kosler and Shubhangi S. Stalder, University of Wisconsin Centers-Waukesha.

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Albuquerque, New Mexico  
*University of New Mexico*

**Meeting #927**  
Western Section  
Associate secretary: William A. Harris, Jr  
Announcement issue of *Notices*: August 1997  
Program issue of *Notices*: October 1997  
Issue of *Abstracts*: To be announced

**Deadlines**  
For organizers: January 4, 1997  
For consideration of contributed papers in Special Sessions: To be announced  
For abstracts: To be announced

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Oaxaca, Mexico  
*Oaxaca, Mexico*  
December 4-7, 1997

3rd Joint Meeting of the American Mathematical Society and the Sociedad Mathematica Mexicana.  
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: To be announced  
For consideration of contributed papers in Special Sessions: To be announced  
For abstracts: To be announced

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Baltimore, Maryland  
*Baltimore Convention Center*  
January 7-10, 1998

Joint Mathematics Meetings including the 104th Annual Meeting of the AMS, 81st Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the
The Emergence of the American Mathematical Research Community, 1876-1900:
J. J. Sylvester, Felix Klein, and E. H. Moore
Karen Hunger Parshall, University of Virginia, Charlottesville, and David E. Rowe,
University of Mainz, Germany

...a fine and extensive account of the growth of mathematics in the United States...completed by a fine bibliography and index...Professional research-level mathematics...came late to the United States; however, once inaugurated...it rose more like a liftoff than a takeoff. This book admirably records the countdown and launch.

—Isis

In an excellent way this book gives an incredible amount of details never losing sight of the whole. Thirteen tables and a subject index make information easy...many photos, some of them being published for the first time...a sound and high quality investigation.

—Zentralblatt für Mathematische

This fascinating book is a contribution to the history of American science...For those of us who have made our careers in American mathematics and are interested in understanding our intellectual heritage, it is essential reading.

—Mathematical Reviews

This volume traces the transformation of the United States from a mathematical backwater to a major presence during the quarter-century from 1876 to 1900. Presenting a detailed study of the major figures involved in this transformation, it focuses on the three most influential individuals and the principal institutions with which they were associated: British algebraist James Joseph Sylvester, Johns Hopkins University; German standard-bearer Felix Klein, Göttingen University; and American mathematician Eliakim Hastings Moore, University of Chicago. This book further analyzes the research traditions these men and institutions represented, and the impact these had on the second generation of American mathematical researchers, and the role of the American Mathematical Society in these developments. This is the first work ever written on the history of American mathematics during this period and one of the few books that examines the historical development of American mathematics from a wide perspective. By placing the development of American mathematics within the context of broader external factors affecting historical events, the authors show how the character of American research was decisively affected by the surrounding scientific, educational, and social contexts of the period. Aimed at a general mathematical audience and at historians of science, this book contains an abundance of unpublished archival material, numerous rare photographs, and an extensive bibliography.

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Meetings & Conferences

National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL). Associate secretary: Robert J. Daverman
Announcement issue of Notices: October 1997
Program issue of Notices: January 1998
Issue of Abstracts: To be announced

Deadlines
For organizers: April 10, 1997
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

Invited Addresses
Edward Witten, Institute for Advanced Study (AMS Josiah Willard Gibbs Lecture).

Louisville, Kentucky

University of Louisville
March 20-21, 1998
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: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Special Sessions

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.

Real Analysis (Code: AMS SS G1), Udayan B. Darji and Lee Larson, University of Louisville.

Manhattan, Kansas

Kansas State University
March 27-28, 1998
Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of Notices: January 1998
Program issue of Notices: March 1998
Issue of Abstracts: To be announced

Deadlines
For organizers: June 26, 1997
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Special Sessions


Philadelphia, Pennsylvania

Temple University
April 4-5, 1998
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: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
Presenters of Papers

Columbia, Missouri; November 1-3, 1996

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Program of the Sessions
Columbia, Missouri, November 1-3, 1996

Friday, November 1

Invited Address

3:00 PM - 3:50 PM Arts and Science Building, Allen Auditorium

(1) Mathematical problems related to superconductivity.
Patricia E. Bauman, Purdue University (916-35-46)

Special Session on Partial Differential Equations and Mathematical Physics, I

4:00 PM - 6:50 PM Room 109, General Classroom Building

Organizer: Mark S. Ashbaugh, University of Missouri, Columbia

4:00PM

(2) Pointwise Fourier inversion and the wave equation.
Mark A. Pinsky*, Northwestern University, and Michael E. Taylor, University of North Carolina (916-42-245)

4:30PM

(3) Embeddings of weighted Sobolev spaces, Poincaré inequalities, and applications. Preliminary report.
Richard C. Brown*, University of Alabama, David E. Edmunds, University of Sussex, and William D. Evans, University of Wales (916-35-164)

5:00PM

(4) Spectral gaps and rates to equilibrium for diffusions in convex domains.
Robert G. Smits, Purdue University (916-35-261)

5:30PM

(5) On the Payne-Pólya-Weinberger Conjecture on the n-dimensional Sphere.
Mark S. Ashbaugh, University of Missouri, and Rafael D. Benguria*, P. Universidad Catolica de Chile (916-58-131)

6:00PM

Carlo Morpurgo, University of Texas at Austin (916-35-231)

6:30PM

(7) Periodic solutions of a second order superquadratic Hamiltonian system where the potential changes sign. Preliminary report.
Andrés I. Ávila, University of Missouri-Columbia (916-58-137)

Special Session on Harmonic Analysis and Probability, I

4:00 PM - 5:50 PM Room 221, General Classroom Building

Organizers: Nakhle Habib Asmar, University of Missouri, Columbia
Stephen John Montgomery-Smith, University of Missouri, Columbia

4:00PM

(8) Some new wavelets in n-dimensions.
Guido Weiss, Washington University (916-42-243)

4:30PM

(9) Product formulas and measure algebras associated with radial oblate spheroidal wave functions. Preliminary report.
William C. Connett*, University of Missouri, St. Louis, Clemens Markett, Rhein. West. Tech. Hoch., Germany, and Alan L. Schwartz, University of Missouri - St. Louis (916-43-54)

5:00PM

Chi Gu and Mitchell H. Taibleson*, Washington University (916-43-203)

5:30PM

(11) Asymptotic behavior of moments of weighted sums of certain iid symmetric random variables.
Pawel Hitczenko, NC State University (916-60-25)

Special Session on Differential Geometry, I

4:00 PM - 5:50 PM Room 114, General Classroom Building

Organizers: John Kelly Beem, University of Missouri, Columbia
Adam D. Helfer, University of Missouri, Columbia

The time limit for each contributed paper in the sessions is ten minutes. In the Special Sessions the time limit varies from session to session and within sessions. To maintain the schedule, time limits will be strictly enforced.

For papers with more than one author, an asterisk follows the name of the author who plans to present the paper at the meeting.

Papers flagged with a solid triangle (•) have been designated by the author as being of possible interest to undergraduate students.

Abstracts of papers presented in the sessions at this meeting will be found in the issue of Abstracts of papers presented to the American Mathematical Society, ordered according to the numbers in parentheses following the listings. The middle two digits, e.g., 897-20-1136, refer to the Mathematical Reviews subject classification assigned by the individual author. Groups of papers for each subject are listed chronologically in the Abstracts. The last one to four digits, e.g., 897-20-1136, refer to the receipt number of the abstract; abstracts are further sorted by the receipt number within each classification.
Special Session on Differential Equations and Dynamical Systems, I

4:00 PM - 6:50 PM  Room 204, General Classroom Building

Organizers: Carmen C. Chicone, University of Missouri, Columbia
Yuri D. Latushkin, University of Missouri, Columbia
Gary H. Meisters, University of Nebraska, Lincoln

4:00PM  A Melnikov method for homoclinic orbits with many pulses.
(16) Roberto Camassa,
Theoretical Division, Los Alamos National Laboratory, Gregor Kovacic*
Rensselaer Polytechnic Institute, and Siu-Kei Tin
University of Michigan

5:00PM  Center manifolds for invariant sets.
(18) S.N. Chow, Georgia Tech. University, Y. Yi*, Georgia Tech.,
and W. Liu, Brown University

5:30PM  On an integral equation for central manifolds: A direct proof for nonautonomous differential equations on Banach spaces.
(20) Yuri Latushkin, University of Missouri-Columbia

6:00PM  Invariant manifolds associated to non-resonant subsets of the spectrum.
(21) Rafael de la Llave, University of Texas, Austin

Special Session on Commutative Algebra, I

4:00 PM - 6:20 PM  Room 105, General Classroom Building

Organizers: Steven Dale Cutkosky, University of Missouri, Columbia
Hema Srinivasan, University of Missouri, Columbia

4:00PM  Infinite collapsing under separable base change.
(22) Preliminary report.
Roger A. Wiegand*, University of Nebraska, Lincoln

5:00PM  Stability bounds. Preliminary report.
(23) Susan E. Morey, University of Texas at Austin

Special Session on Commutative Algebra, II

4:00 PM - 5:30 PM  Room 205, General Classroom Building

Organizers: Steven Dale Cutkosky, University of Missouri, Columbia
Hema Srinivasan, University of Missouri, Columbia

4:00PM  Invariant Gorenstein dimension and complete resolutions.
(12) Robert Brooks, University of Southern California, and
Gornet Ruth* and Bill Gustafson, Texas Tech University

5:30PM  Depth formulas and intersection theorems.
(23) Preliminary report.
John R. Johnson, University of Wisconsin, Madison

Special Session on Gauge Theory and Its Interaction With Holomorphic and Symplectic Geometry, I

4:00 PM - 6:20 PM  Room 117, General Classroom Building

Organizers: Stamatis A. Dostoglou, University of California, Santa Barbara
Jan Segert, University of Missouri, Columbia
Shuguang Wang, University of Missouri, Columbia

4:00PM  Links of singularities and the relation between
(27) Donaldson and Seiberg-Witten invariants of smooth 4-manifolds.
Paul M. N. Feehan, Harvard University

4:30PM  Low order reducibles in the moduli space of SO(3)
monopoles. Preliminary report.
(28) Thomas G. Leness, Michigan State University

5:00PM  Minimal genus embedding in S^2–bundle over surfaces.
(29) BangHe Li, Institute of System Science, PRC, and
Tian-Jun Li*, Yale University

5:30PM  Simple type is not a boundary phenomenon.
(30) Lorenzo A. Sadun, University of Texas

6:00PM  A mixed boundary value problem for the full
(31) Yang-Mills equations in dimensions three and four.
Antonella Marini, Universita' di L'Aquila/University of Utah

Special Session on Spectral Theory and Completely Integrable Systems, I

4:00 PM - 6:20 PM  Room 208, General Classroom Building

Organizer: Fritz Gesztesy, University of Missouri, Columbia

4:00PM  Recent results on trace formulas.
(32) Helge Holden, Norwegian University of Science and Technology

4:30PM  Nonsubordinacy and a class of Jacobi equations.
(33) Preliminary report.
Stephen L. Clark, University of Missouri at Rolla

5:00PM  A differential operator on a tree. Preliminary report.
(34) Yoshimi Saito, University of Alabama at Birmingham

5:30PM  Localization for Schrödinger operators with effective barriers.
(35) Günter Stolz, University of Alabama at Birmingham

6:00PM  Correlated Wegner estimates and localization.
(36) Preliminary report.
Peter Hislop, University of Kentucky
Program of the Sessions – Columbia, MO, Friday, November 1 (cont’d.)

Special Session on Lie Groups and Physics, I

4:00 PM – 9:50 PM  Room 210, General Classroom Building

Organizers: Victor A. Ginzburg, University of Chicago
Yan Soibelman, Kansas State University

4:00PM
(37) Characteristic cycles on the loop Grassmannian.
Sam Evans*, University of Illinois-Chicago, and Ivan Mirkovic, University of Massachusetts, Amherst
(916-22-277)

4:50PM
(38) Double loop groups, double affine Hecke algebras and elliptic curves.
Victor Ginzburg, University of Pennsylvania
(916-22-285)

5:40PM
(39) Deformation of Virasoro and \( \mathfrak{w} \) algebras and their application to physics.
Hidetoshi Awata, University of Chicago
(916-14-127)

6:20PM Break

7:30PM The quotient realizations for the groups of double loops.
Boris Khesin, (916-22-278)

8:20PM Flat connections on Riemann surfaces.
Lisa Claire Jeffrey, McGill University (916-58-178)

9:10PM Riemann-Roch from Duistermaat-Heckman.
Scott Axelrod, Massachusetts Institute of Technology (916-22-286)

Special Session on Algebraic Geometry, I

4:00 PM – 6:50 PM  Room 223, General Classroom Building

Organizers: Dan Edidin, University of Missouri
Qi Zhang, University of Missouri

4:00PM
(40) Determinant line bundles over moduli of vector bundles. Preliminary report.
Zhenbo Qin, Oklahoma State University (916-14-74)

4:30PM
(41) Singular hermitian metrics on holomorphic vector bundles.
Mark Andrea A. de Cataldo, Washington University in St. Louis (916-14-119)

5:00PM
(42) Vector bundles on projective Spaces.
Mohan N Kumar, University of Pennsylvania in St. Louis (916-14-127)

5:30PM
(43) Variety of linear systems on double covering curves.
Changho Keem*, Seoul National University, and Edoardo Ballico, University of Trento, Italy (916-14-17)

6:00PM
(44) Reduced Gorenstein codimension three subschemes of projective space.
Anthony V. Geramita, Queen’s University, and Juan C. Migliore*, University of Notre Dame (916-14-221)

6:30PM
Meeyoung Kim* and Andrew J. Sommese, University of Notre Dame (916-14-246)

Special Session on Algebraic Geometry, II

4:00 PM – 5:50 PM  Room 219, General Classroom Building

Organizers: Peter G. Casazza, University of Missouri, Columbia
N. J. Kalton, University of Missouri, Columbia

4:00PM
(46) Tensor products and independent sums of \( L^p \)-spaces, \( 1 < p < \infty \).
Dale E. Alspach, Oklahoma State University (916-46-133)

4:30PM Functions that strictly govern the isomorphically polyhedral Banach spaces. Preliminary report.
George Androulakis, University of Texas, Austin (916-46-198)

5:00PM Polynomials on \( \mathbb{Q} \). Preliminary report.
Richard M. Aron, Kent State University (916-46-139)

5:30PM Characterizing Hilbert space frames with the subframe property.
Peter G. Casazza, University of Missouri (916-46-187)

Saturday, November 2

Special Session on Commutative Algebra, II

8:00 AM – 10:50 AM  Room 105, General Classroom Building

Organizers: Steven Dale Cutkosky, University of Missouri, Columbia
Hema Srinivasan, University of Missouri, Columbia

8:00AM
(53) Remarks on the parametric decomposition of monomial ideals.
Kishor M. Shah, Southwest Missouri State University (916-13-219)

8:30AM
(54) Coefficient and stable ideals in polynomial rings. Preliminary report.
William J. Heinzer, Purdue University (916-13-124)

9:00AM
(55) Poincaré series of monomial quotient rings.
Hara Charalambous, SUNY-Albany (916-13-234)

9:30AM
(56) Formulas for the Betti numbers of monomial ideals. Preliminary report.
John A. Eagon, University of Minnesota (916-13-194)

10:00AM
Daniel Katz, University of Kansas, and Heath Martin*, University of Central Florida (916-13-132)

10:30AM
(58) How to shell a monoid. Preliminary report.
Victor Reiner, University of Minnesota, Irena Peeva* and Bernd Sturmfels, University of California, Berkeley (916-13-196)

Special Session on Differential Equations and Dynamical Systems, II

8:30 AM – 10:50 AM  Room 204, General Classroom Building

Organizers: Carmen C. Chicone, University of Missouri, Columbia
Yuri D. Latushkin, University of Missouri, Columbia

8:30AM
(59) Coevolution and fast-slow dynamics. Preliminary report.
Alexander I. Khbik*, Theory Center, Cornell University, and Alexey S. Kondrashov, Section of Ecology and Systematics, Cornell University (916-58-176)

9:00AM
(60) Asymptotic method in the stability of multiple waves.
Xiao-Biao Lin, North Carolina State University (916-35-28)

9:30AM
(61) Dynamics of weakly coupled map lattices. Preliminary report.
Miaohua Jiang, Georgia Institute of Technology (916-58-79)

10:00AM
(62) Traveling waves in lattice dynamical systems.
W. A. Shen*, Auburn University, S.-N. Chow, Georgia Tech, and J. Mallet-Paret, Brown University (916-34-40)
10:30AM Stable chaotic waves for nonlinear hyperbolic PDEs.
(63) Leonid Bunimovich, Georgia Institute of Technology (916-33-42)

**Special Session on Lie Groups and Physics, II**

8:30 AM – 10:50 AM Room 210, General Classroom Building
Organizers: Victor A. Ginzburg, University of Chicago
Van Soibelman, Kansas State University

8:30AM A braid group action on invariant forms.
(64) Ben Cox, Lulea University, Lulea, Sweden S-971 87 (916-22-276)

9:20AM Infinite wedge representations and combinatorics.
(65) Eugene Stern, University of California, Berkeley (916-22-272)

10:10AM Canonical basis and cohomologies of local systems.
(66) Alexander Kirillov, Massachusetts Institute of Technology (916-22-274)

**Special Session on Algebraic Geometry, II**

8:30 AM – 10:50 AM Room 223, General Classroom Building
Organizers: Dan Edidin, University of Missouri
Qi Zhang, University of Missouri

8:30AM Buchsbaum-Rim sheaves and Gorenstein algebras.
(67) Juan C. Migliore and Chris S. Peterson*, University of Notre Dame (916-14-244)

9:00AM Vanishing theorems and syzygies for algebraic surfaces, Calabi-Yau threefolds and Fano varieties.
Francisco J. Gallego, Universidad Complutense de Madrid, and Bangere P. Purnaprajna*, Oklahoma State University (916-14-191)

9:30AM Reider-type theorems on normal surfaces.
(69) Vladimir Mašek, Washington University in St. Louis (916-14-93)

10:00AM Rigid curves in Quintic threefolds.
(70) Holger P. Kley, University of Utah (916-14-143)

10:30AM On the Clifford sequence of a general k-gonal curve.
Seonja Kim, Chungnam Sanup University, Korea (916-14-47)

**Special Session on Partial Differential Equations and Mathematical Physics, II**

9:00 AM – 10:50 AM Room 109, General Classroom Building
Organizer: Mark S. Ashbaugh, University of Missouri, Columbia

9:00AM Isoperimetric bounds for solutions of the heat equation and integrals of Green's functions.
Rodrigo Bañuelos, Purdue University (916-31-68)

9:30AM On the optimal placement of boundary conditions.
Steven J. Cox* and Paul X. Uhlig, Rice University (916-35-77)

10:00AM Some further results on gradient maximum principles.
(74) L. E. Payne, Cornell University (916-35-50)

10:30AM Trace identities and universal eigenvalue estimates.
(75) Evans M. Harrell, III*, Georgia Institute of Technology, and Joachim Stubbe, Forschungsinstitut für Mathematik, ETH, Zürich (916-47-259)

**Special Session on Harmonic Analysis and Probability, II**

9:00 AM – 10:50 AM Room 221, General Classroom Building
Organizers: Nakhle Habib Asmar, University of Missouri, Columbia
Stephen John Montgomery-Smith, University of Missouri, Columbia

9:00AM Recent developments in Littlewood-Paley theory.
(76) Kathryn E. Hare, University of Waterloo (916-42-35)

Alan L. Schwartz*, University of Missouri-St. Louis, and Olivier Gebuhrer, Université Louis Pasteur (916-43-242)

10:00AM Characterizations of the Khinchin's inequalities for multilinear forms.
Niandi Xiang, University of Illinois, Chicago (916-60-211)

10:30AM Sharp inequalities for orthogonal martingales under differential subordination.
Gang Wang, DePaul University (916-60-45)

**Special Session on Differential Geometry, II**

9:00 AM – 10:50 AM Room 114, General Classroom Building
Organizers: John Kelly Beem, University of Missouri, Columbia
Adam D. Helfer, University of Missouri, Columbia

9:00AM Casimir energies and heat kernel asymptotics.
(80) Preliminary report.
Matt Visser, Washington University (916-83-49)

9:30AM Quantum ergodic theory and non-commutative geometry. Preliminary report.
Gerard Emch, University of Florida (916-53-63)

10:00AM Homogeneous non-linear sprays and connections.
(82) Preliminary report.
Lilia Del Riego*, Zona Universitaria, Mexico, and Phillip E. Parker, Wichita State University (916-53-115)

10:30AM Examples of planar sprays. Preliminary report.
Phillip E. Parker*, Wichita State University, and Lilia Del Riego, Zona Universitaria, Mexico (916-53-115)

**Special Session on Gauge Theory and Its Interaction With Holomorphic and Symplectic Geometry, II**

9:00 AM – 10:50 AM Room 117, General Classroom Building
Organizers: Stamatios A. Dostoglou, University of California, Santa Barbara
Jan Segert, University of Missouri, Columbia
Shuguang Wang, University of Missouri, Columbia

9:00AM A topological method to compute spectral flow.
(84) Dave R. Auckly, University of California, Berkeley (916-53-210)

9:30AM The SU(3) generalized Casson's invariants for 3-manifolds. Preliminary report.
Hans U. Boden, McMaster University (916-57-255)

10:00AM Flat SL2C-connections and the Kauffman Bracket Skein module I.
(86) Doug Bullock, Boise State University (916-57-258)

10:30AM Flat SL2C-connections and the Kauffman Bracket Skein Module II.
Charles D. Frohman, University of Iowa (916-57-257)
Program of the Sessions – Columbia, MO, Saturday, November 2 (cont’d.)

Special Session on Spectral Theory and Completely Integrable Systems, II

9:00 AM – 10:50 AM Room 208, General Classroom Building
Organizer: Fritz Gesztesy, University of Missouri, Columbia
9:00AM KdV and Magri bracket. Preliminary report.
(88) Thomas Kappeler* and Mihail Makarov, Ohio-State University (916-35-33)
9:30AM Bisppectral Darboux transformations.
(89) Alex Kasman*, Concordia University, and Mitchell Rothstein, University of Georgia (916-58-61)
10:00AM On complete integrability of generalized Toda flows. Preliminary report.
(90) Michael I. Gekhtman*, University of Michigan, and Michael Z. Shapirol, Royal Institute of Technology (916-51-60)
10:30AM Some classes of solutions to the Toda lattice hierarchy.
(91) Harold Widom, University of California, Santa Cruz (916-35-91)

Special Session on Classifying Spaces and Cohomology of Finite Groups, I

9:00 AM – 10:50 AM Room 119, General Classroom Building
Organizers: Alejandro Adem, University of Wisconsin
Stewart B. Priddy, Northwestern University
9:00AM Sporadic geometries and homology approximations. Preliminary report.
(92) Stephen D. Smith, University of Illinois at Chicago (916-55-233)
9:30AM Applications of eigenvalues and Möbius functions to classifying spaces. Preliminary report.
(93) John R. Martino*, Western Michigan University, and Stewart B. Priddy, Northwestern University (916-55-209)
10:00AM On the cohomology of split extensions of elementary abelian 2-groups.
(94) Stephen F. Siegel, University of Mass. (916-20-205)
(95) Ran Levi, Northwestern University (916-55-293)

Special Session on Banach Spaces and Related Topics, II

9:00 AM – 10:20 AM Room 219, General Classroom Building
Organizers: Peter G. Casazza, University of Missouri, Columbia
N. J. Kalton, University of Missouri, Columbia
9:00AM Copies of C0 and asymptotically isometric copies of C0 in Banach spaces.
(96) Patrick N Dowling, Miami University (916-46-208)
9:30AM On Banach spaces that contain d1. Preliminary report.
(97) S. J. Dilworth, Maria Girardi*, University of South Carolina, and W. B. Johnson, Texas A&M University (916-46-183)
10:00AM Unconditional bases in C0-products. Preliminary report.
(98) Nigel J. Kalton* and Peter G. Casazza, University of Missouri (916-46-154)

Invited Address

11:00 AM – 11:50 AM Arts and Science Building, Allen Auditorium
(99) Recent developments in the cohomology of finite groups.
Alejandro Adem, University of Wisconsin (916-20-217)

Invited Address

1:30 PM – 2:20 PM Arts and Science Building, Allen Auditorium
(100) Function theory and geometry on covering spaces.
David E. Barrett, University of Michigan (916-30-216)

Special Session on Partial Differential Equations and Mathematical Physics, III

2:30 PM – 5:50 PM Room 109, General Classroom Building
Organizer: Mark S. Ashbaugh, University of Missouri, Columbia
2:30PM A rearrangement inequality for integrals involving volumes of simplices.
(101) Albert Baernstein, II*, Washington University, Eric Carlen and Michael Loss, Georgia Institute of Technology (916-26-181)
3:00PM The essential spectrum of relativistic multi-particle operators.
(102) Roger T. Lewis*, University of Alabama, Birmingham, Heinz Siedentop, Universiteit I Oslo, Norway, and Sinem Vugalter, Radiophysical Research Inst. Russia (916-81-186)
3:30PM Optimal smoothing and decay estimates for the two dimensional Navier-Stokes equation.
(103) Eric Carlen and Michael Peter Loss*, Georgia Tech (916-35-129)
4:00PM Buckling eigenvalues for a clamped plate embedded in an elastic medium and related questions.
(104) Bernhard Kawohl, University of Cologne, Cologne, Germany, Howard A. Levine*, Iowa State University, and Waldemar Velte, University of Wurzburg, Germany (916-35-37)
4:30PM Zeta functions of Laplacians under mass normalization. Preliminary report.
(105) Richard Snyder Laugesen, Johns Hopkins University (916-35-182)
5:00PM On hydrodynamic models of semiconductor devices.
(106) Dehua Wang, University of Chicago (916-35-64)
5:30PM Entire large solutions of semilinear elliptic problems.
(107) Alan V. Lair, Air Force Institute of Technology, and Aihua W. Shaker*, Air Force Institute of technology (916-35-06)

Special Session on Commutative Algebra, III

2:30 PM – 5:50 PM Room 105, General Classroom Building
Organizers: Steven Dale Cutkosky, University of Missouri, Columbia
Hema Srinivasan, University of Missouri, Columbia
2:30PM Some recent progress in the monomial conjecture. Preliminary report.
(108) Sankar P. Dutta, University of Illinois, Mathematics Department (916-13-71)
3:00 PM  Factorizations over finite fields.  
(109) Shreeram S. Abhyankar, Purdue University  
(916-14-16)

3:30 PM  Generalized Puiseux expansions and their Galois groups.  
(110) Sanju Vaidya, Mount Saint Mary College  
(916-13-55)

4:00 PM  A relative filtration index for finite ring extensions.  
(111) Phillip Griffith, Queen’s University  
(916-13-232)

4:30 PM  Deformations of chains of modules.  
(112) Keith Pardue, Queen’s University  
(916-13-200)

5:00 PM  Extremal properties of Hilbert functions. Preliminary report.  
(113) Vesselin Gasharov, University of Michigan  
(916-13-195)

5:30 PM  Cofinite modules and local cohomology.  
(114) Donatella Delfino, University of Michigan, and  
Thomas Marley*, University of Nebraska Lincoln  
(916-13-65)

Special Session on Lie Groups and Physics, III  
2:30 PM – 9:50 PM  Room 210, General Classroom Building  
Organizers: Victor A. Ginzburg, University of Chicago  
Yan Soibelman, Kansas State University  

2:30 PM  Geometric singularities and enhanced Gauge symmetries.  
(115) Michael Bershadsky, Harvard University  
(916-22-287)

3:00 PM  Generating functional and effective action in CFT on higher genus Riemann surfaces.  
(116) Leon Takhtajan, SUNY, Stony Brook  
(916-22-281)

4:00 PM  On the proof of the mirror conjecture for flag manifolds and complete intersections.  
(117) A. Givental, University of California, Berkeley  
(916-22-283)

5:00 PM  Quantum Schubert polynomials and Gromov-Witten invariants.  
(118) Alex Postnikov, Massachusetts Institute of Technology  
(916-22-275)

5:50 PM  Break  
7:30 PM  Vertex operator algebras, quantum field theory and geometry.  
(119) Andrei Radul, Howard University  
(916-22-279)

8:00 PM  Deformation quantization and [Q, R] = 0 theorem.  
(120) Boris Tsygan, (916-22-268)

9:10 PM  Elliptic quantum groups and Bethe ansatz.  
(121) Aleksandr Varchenko, University of North Carolina  
(916-22-288)

Special Session on Harmonic Analysis and Probability, III  
3:00 PM – 4:50 PM  Room 221, General Classroom Building  
Organizers: Nakhle Habbas Asmar, University of Missouri, Columbia  
Stephen John Montgomery-Smith, University of Missouri, Columbia  

3:00 PM  The Bergman projection of unimodular functions.  
(122) Richard Rochberg, Washington University  
(916-46-212)

3:30 PM  The martingale structure of the n-dimensional Beurling-Ahlfors transform.  
J. Lindeman, II, Purdue University  
(916-60-70)

4:00 PM  On the exact rate of decay of eigenfunctions in horn-shaped domains.  
(124) Michael C. Cranston*, University of Rochester, and  
Yi Li, University of Rochester (916-35-207)

4:30 PM  Inequalities for randomly stopped continuous time processes.  
(125) Victor H. de la Peña, Columbia University  
(916-60-85)

Special Session on Differential Geometry, III  
3:00 PM – 5:50 PM  Room 114, General Classroom Building  
Organizers: John Kelly Beem, University of Missouri, Columbia  
Adam D. Helfer, University of Missouri, Columbia  

3:00 PM  Totally geodesic lightlike hypersurface of spacetime.  
(126) Krishan Duggal, University of Windsor  
(916-53-106)

3:30 PM  Volume comparison theorems on Lorentzian manifolds. Preliminary report.  
(127) Seon-Bu Kim, Chonnam National University, Korea  
(916-53-48)

4:00 PM  A local version of topological censorship.  
(128) Gregory J. Galloway, University of Miami  
(916-53-235)

4:30 PM  Regularity of the cosmological time function.  
(129) Lars Andersson, Royal Institute of Technology, Sweden, Gregory J. Galloway, University of Miami, and Ralph Howard*, University of South Carolina.  
(916-53-88)

5:00 PM  Naked strong curvature singularities in Scherkes space-times. Preliminary report.  
(130) Andzej Krolak, Polish Academy of Sciences, Poland  
(916-53-116)

5:30 PM  Curvature homogeneous metrics and the redshift of light from remote sources.  
(131) Victor Patrangenaru, Indiana University, Bloomington  
(916-83-87)

Special Session on Differential Equations and Dynamical Systems, III  
3:00 PM – 5:50 PM  Room 204, General Classroom Building  
Organizers: Carmen C. Chicone, University of Missouri, Columbia  
Yuri D. Latushkin, University of Missouri, Columbia  

3:00 PM  On the spectrum of the Euler equation.  
(132) Susan Friedlander*, University of Illinois-Chicago, and Misha Vishik, University of Texas (916-76-59)

3:30 PM  Regularity in hydrodynamics of an ideal incompressible fluid.  
(133) Misha Vishik, University of Texas at Austin  
(916-34-169)

4:00 PM  Spectral analysis of photonic band-gap structures.  
(134) Peter Kuchment*, Alex Figotin, Leonid Kunyansky and Igor Rodnianski, Kansas State University (916-35-146)

4:30 PM  Does a quantum particle know the time?  
(135) Lev Kapitanski*, and Igor Rodnianski, Kansas State University  
(916-35-207)

5:00 PM  Vibrations of fractal drums and differential equations. Preliminary report.  
(136) Michel L. Lapidus, University of California, Riverside (916-34-202)

5:30 PM  Bifurcation to Lorenz attractors. Preliminary report.  
(137) Clark Robinson, Northwestern University  
(916-34-228)
Special Session on Gauge Theory and Its Interaction With Holomorphic and Symplectic Geometry, III

3:00 PM - 5:50 PM  Room 117, General Classroom Building

Organizers: Stamatis A. Dostoglou, University of California, Santa Barbara
Jan Segert, University of Missouri, Columbia
Shuguang Wang, University of Missouri, Columbia

3:00PM  Essential surfaces in bounded 3-manifolds.
(138)  D. Cooper, D. D. Long*, University of California, Santa Barbara, and A. W. Reid, University of Texas, Austin (916-58-250)
3:30PM  Floer homology of connect sums of Brieskorn spheres. Preliminary report.
(139)  Christopher M. Herald, Swarthmore College (916-58-188)
4:00PM  Symplectic invariants and Floer homology.
(140)  Darko Milinkovic*, University of Wisconsin, Madison, and Yong-Geun Oh, University of Wisconsin, Madison (916-58-252)
4:30PM  Stability properties of monopoles. Preliminary report.
(141)  David M. Stuart, (916-35-213)
5:00PM  Discussion-W. Li
5:30PM  Computation formulas for monopole invariants for 3-manifolds.
(142)  Rongguang Wang, HKUST, Hong Kong (916-53-266)

Special Session on Spectral Theory and Completely Integrable Systems, III

3:00 PM - 5:50 PM  Room 208, General Classroom Building

Organizer: Fritz Gesztesy, University of Missouri, Columbia

3:00PM  Wave invariants and inverse spectral problems.
(143)  Preliminary report.
  Steve Zelditch, Johns Hopkins Univ. (916-81-151)
3:30PM  Scattering for a generalized Schrödinger equation.
(144)  Tuncay Aktosun, North Dakota State University (916-34-123)
4:00PM  The second periodic eigenvalue and the Aliakasos-Fusco conjecture.
(145)  Vassilis George Papanicolaou, Wichita State University, Department of Mathematics and Statistics (916-34-07)
4:30PM  On a theorem of Hochstadt. Preliminary report.
(146)  Rudi Weikard, University of Alabama at Birmingham (916-34-73)
5:00PM  Coupling constant thresholds for perturbed periodic operators. Preliminary report.
(147)  Martin Klaus* and Silvestro Fassari, Virginia Tech (916-34-215)
5:30PM  Inverse spectral problems for sectorial Stieltjes functions and nonselfadjoint Schrödinger operators on half-line. Preliminary report.
(148)  Eduard R. Tsekanovskii, (916-47-05)

Special Session on Classifying Spaces and Cohomology of Finite Groups, II

3:00 PM - 4:50 PM  Room 119, General Classroom Building

Organizers: Alejandro Adem, University of Wisconsin
Stewart B. Priddy, Northwestern University

3:00PM  A remark on homological localization. Preliminary report.
(149)  Guido Mislin, Ohio State University (916-55-159)
3:30PM  The braid group of a graph.
(150)  Henry H. Glover, Ohio State University (916-55-218)
4:00PM  Cohomology of central extensions of elementary abelian 2-groups. Preliminary report.
(151)  Dirk B. Karagueuzian, University of Wisconsin, Madison (916-20-263)
4:30PM  Classifying spaces and mod p cohomology of some central extensions.
(152)  Jill Dietz, St. Olaf College (916-55-199)

Special Session on Algebraic Geometry, III

3:00 PM - 6:45 PM  Room 223, General Classroom Building

Organizers: Dan Edidin, University of Missouri
Qi Zhang, University of Missouri

3:00PM  Symmetries of Littlewood-Richardson coefficients for flag varieties and Schubert polynomials.
(153)  Frank Sottile*, MSRI and University of Toronto, and Nantel Bergeron, York University, Ontario, and UQAM, Montreal (916-14-103)
3:30PM  On extensions of the infinitesimal invariant of normal functions. Preliminary report.
(154)  Xian Wu, University of South Carolina (916-14-147)
4:00PM  Equivariant intersection theory.
(155)  Dan Edidin, University of Missouri, and William A. Graham*, Institute for Advanced Study (916-14-223)
4:20PM  Break
4:45PM  Affine lines fibered by affine lines over the projective line. Preliminary report.
(156)  David L Wright, Washington University in St. Louis (916-14-134)
5:15PM  Dimension of the Hilbert scheme of space curves.
(157)  Kyungho Oh, and Prabhakar Rao*, UM-St.Louis (916-14-121)
5:45PM  Hilbert functions of "fat points".
(158)  Karen A. Chandler, University of Notre Dame (916-14-237)
6:15PM  Homogeneous basis for an ideal. Preliminary report.
(159)  Tie Luo* and Erol Yilmaz, University of Texas at Arlington (916-14-158)

Special Session on Banach Spaces and Related Topics, III

3:00 PM - 5:50 PM  Room 219, General Classroom Building

Organizers: Peter G. Casazza, University of Missouri, Columbia
N. J. Kalton, University of Missouri, Columbia

3:00PM  A few more reasons for calculating the Fourier transform of a norm.
(160)  Alexander Kolodolsky, University of Texas at San Antonio (916-46-53)
3:30PM  Ultrapowers, duality and semigroups of operators.
(161)  Preliminary report.
  Antonio Martinez-Abejon*, University of Texas, Austin, and Manuel Gonzalez, University Cantabria, Spain (916-46-135)
4:00PM  The existence of shape-preserving operators with a given action.
(162)  Michael Patrick Prophet, Murray State University (916-46-256)
4:30PM  Contractive projections in symmetric spaces.
(163)  Beata Randrianantoanina, University of Texas, Austin (916-46-135)
12:20

NOVEMBER 1996 NOTICES OF THE

Special Session on Partial Differential Equations and Mathematical Physics, IV

10:00 AM - 12:20 PM Room 109, General Classroom Building

Organizer: Mark S. Ashbaugh, University of Missouri, Columbia

10:00AM Spectra of Schrodinger operators on planar domains with ends with unbounded cross-section. Julian K Edward, Florida International University (916-35-83)

10:30AM The stochastic flow of a Dirichlet eigenvalue. Preliminary report. Steven J. Fromm, University of Wyoming, Kimberly K. J. Knizteder, Wright State University, and Patrick T. McDonald*, New College of the University of South Florida (916-35-238)

11:00AM Resonances of the stratified wave equation. David W. Pravica, East Carolina University (916-35-187)

11:30AM Spectral operators generated by damped hyperbolic equations. Marianna A. Shubov, Texas Tech University (916-49-136)

NOON Upper bounds for spontaneous bifurcations with sublinear growth functions. Yaping Liu, Pittsburg State University (916-35-36)

Contributed Papers

3:00 PM - 3:55 PM Room 217, General Classroom Building

3:00PM Fifth Hilbert problem and infinite - dimensional groups. Preliminary report. Boris S. Khots, (916-22-69)

3:15PM Loop algebras, gauge invariants and a new completely integrable system. Stephanie F. Singer*, Haverford College, and Malcolm Quinn, (916-22-19)

3:30PM initially deformed systems. Preliminary report. Ronald A. Knight, Truman State University (916-54-39)

3:45PM Weighted Poincaré type inequalities. Preliminary report. Ritva M. Hurri-Syrjanen, University of Helsinki (916-46-58)

Sunday, November 3

Invited Address

9:00 AM - 9:50 AM Arts and Science Building, Allen Auditorium

[170] Algebra and geometry of quantum groups. Yan Soibelman, Kansas State University (916-22-04)

Special Session on Differential Equations and Dynamical Systems, IV

10:00 AM - 12:20 PM Room 204, General Classroom Building

Organizers: Carmen C. Chicone, University of Missouri, Columbia

Yuri D. Latushkin, University of Missouri, Columbia

10:00AM Commuting analytic maps and linearizability. Preliminary report. David A. DeLatte, University of North Texas (916-34-204)

10:30AM Convergence of the transfer operator for rational maps. Nicolai T. A. Haydn, University of Southern California (916-58-172)

11:00AM Extremal rotation numbers for torus shear homeomorphisms. Erik Doff*, Montana State University, Bozeman, and Michal Misiurewicz, IUPUI (916-58-118)

11:30AM The geometry of continued fractions. Mariusz Urbanski* and Daniel Mauldin, Department of Mathematics, University of North Texas, Denton, Texas. (916-34-197)

NOON Which interval maps are unstable? Michal Misiurewicz*, Indiana University - Purdue University, Indianapolis, and Alexander Blokh, University of Alabama at Birmingham (916-58-189)

Special Session on Commutative Algebra, IV

10:00 AM - 1:20 PM Room 105, General Classroom Building

Organizers: Steven Dale Cutkosky, University of Missouri, Columbia
Special Session on Lie Groups and Physics, IV

11:00 AM - 12:30 PM
11:00 AM
Ideals generated by quadratics exhibiting double exponential degrees.
Jee Heub Koh, Indiana University (916-13-92)

11:30 AM
The zero cycle subgroup.
NOON
Satyagopal Mandal, University of Kansas (916-13-226)

12:30 PM
Tight closure and base change.
Douglas J. McCulloch, University of Michigan (916-13-227)

1:00 PM
1-forms on Artin local rings.
Mohan N. Kumar, Washington University in St. Louis. (916-13-128)

Special Session on Lie Groups and Physics, IV

10:00 AM - 3:00 PM
Room 210, General Classroom Building

Organizers: Victor A. Ginzburg, University of Chicago Yan Soibelman, Kansas State University

10:00 AM
Semi-induced representations and universal string theory. Preliminary report.
Alexander A. Voronov, Massachusetts Institute of Technology (916-13-31)

10:30 AM
Representations of groups in BRST cohomology.
GREGG J. ZUCKERMAN*, Yale University, and BONG H. LIAN, Brandeis University (916-22-180)

11:00 AM
Tensor ideals for tilting modules.
HANS WENZL, (916-22-282)

12:20 PM
Break

1:30 PM
Quantum affine algebras and Dorey's rule.
V. CHARI, (916-22-290)

2:20 PM
Cohomology of Poisson structures.
J.-H. Lu, (916-22-284)

Special Session on Banach Spaces and Related Topics, IV

10:00 AM - 11:50 AM
Room 219, General Classroom Building

Organizers: Peter G. Casazza, University of Missouri, Columbia N. J. Kalton, University of Missouri, Columbia

10:00 AM
Compact operators on injective tensor product of spaces.
Paulette Saab, University of Missouri (916-46-174)

10:30 AM
The Pelczynski property.
Scott Sacone, Northwestern University (916-46-262)

11:00 AM
Banach spaces failing the almost isometric universal extension property.
DARRIN M. Speegle, Texas A&M University (916-46-165)

11:30 AM
Extrinsic homeomorphisms of null subsets of Euclidean sets with an application to extensible isometries of linear subspaces of C(Δ). Preliminary report.
STEPHEN J. DILWORTH, University of South Carolina (916-46-236)

Special Session on Harmonic Analysis and Probability, IV

10:30 AM - 12:00 PM
Room 221, General Classroom Building

Organizers: Nakhl Habib Asmar, University of Missouri, Columbia
Stephen John Montgomery-Smith, University of Missouri, Columbia

10:30 AM
A dimension free weak-type estimate for maximal conjugate series of vector-valued functions.
Brian P. Kelly, Truman State University (916-43-38)

11:00 AM
Γ-analytic functions and inductive limits.
Suren A. Grigorian, Higher Institute of Energy, Kazan, Russia, and Thomas V. Tonev*, The University of Montana - Missoula (916-46-09)

11:30 AM
Holomorphic flows, cocycles and coboundaries.
Farhad Jafari, University of Wyoming, Thomas Tonev, Elena Toneva and Keith Yale*, University of Montana (916-30-254)

Special Session on Gauge Theory and Its Interaction With Holomorphic and Symplectic Geometry, IV

10:30 AM - 12:00 PM
Room 117, General Classroom Building

Organizers: Stamatis A. Dostoglou, University of California, Santa Barbara
Jan Segert, University of Missouri, Columbia
Shuguang Wang, University of Missouri, Columbia

10:30 AM
Charles P. Boyer, University of New Mexico (916-55-14)

11:00 AM
Vanishing theorems in the Pontrjagin ring of moduli spaces.

11:30 AM
Symplectic structure on the moduli space of flat connections over surfaces with boundary.
Ambar N. Sengupta, Louisiana State University (916-53-76)

12:00 PM
Discussion-Weitsman

Special Session on Spectral Theory and Completely Integrable Systems, IV

10:30 AM - 12:00 PM
Room 203, General Classroom Building

Organizer: Fritz Gesztesy, University of Missouri, Columbia
Program of Sessions

10:30AM  Implications for non-integrable systems of the
      (211)  lessons of complete integrability.
      Jerry L. Bona, University of Texas, Austin
      (916-35-248)

11:00AM  The 1st theory of the inverse square potential.
      (212)  Preliminary report.
      Jerome A. Goldstein, University of Memphis
      (916-47-240)

11:30AM  Degenerate parabolic problems and analytic
      (213)  semigroups. Preliminary report.
      Gisèle Ruiz Goldstein*, Jerome A. Goldstein,
      University of Memphis, and Silvia Romanelli,
      Universita di Bari (916-35-241)

NOON    Nonlinear stability of solitary waves of a
      (214)  generalized Kadomtsev-Petviashvili equation.
      Preliminary report.
      Yue Liu*, University of Texas, Austin, and Xiao-Ping
      Wang, Hong Kong University (916-35-152)

12:30PM  Large-time asymptotic behavior of solutions of
      (215)  Burgers' equation.
      Daniel B. Dix, University of South Carolina
      (916-35-153)

Susan J. Friedlander
Associate Secretary
Chicago, Illinois

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Program of the Sessions
Pasadena, California, November 16-17, 1996

Saturday, November 16

Special Session on Hopf Algebras and Their Representations, I
8:00 AM - 10:50 AM Room 107, Downs Laboratory
Organizers: Davida Fischman, California State University, San Bernardino
M. Susan Montgomery, University of Southern California

8:00AM Brauer groups of quantum groups and braided categories. Preliminary report.
Fred Van Oystaeyen, University of Antwerp, Belgium (917-16-132)

8:30AM Galois extensions for co-Frobenius Hopf algebras.
Margaret Beattie*, Mount Allison University, Canada, Sorin Dascalescu and Serban Raianu, University of Bucharest, Romania (917-16-135)

9:00AM Hopf algebras over noncommutative rings.
Peter C. Schauenburg, Universitat Munchen, Germany (917-16-116)

9:30AM Weak and strong structure theorems.
Claudia Menini, Universita degli Studi di Ferrara, Italy (917-16-102)

9:30AM Isomorphic galois extensions.
Robert G. Underwood, Auburn University at Montgomery (917-13-106)

10:00AM The R/k-bialgebra of trees and differential algebra.
Richard G. Larson, University of Illinois at Chicago (917-16-41)

Special Session on History of Mathematics, I
8:30 AM - 10:50 AM Room 151, Sloan Laboratory
Organizers: Shawnee L McMurrin, Pomona College
James J. Tattersall, Providence College

8:30AM Pythagoras and the crisis over incommensurability.
Samuel S. Kutler, CSHPM (917-01-95)

Special Session on Group Actions and Noncommutative Algebra, I
8:40 AM - 10:50 AM Room 103, Downs Laboratory
Organizers: Zinovy Reichstein, Oregon State University
Nikolaus Vosessen, University of Montana

8:40AM Actions of Picard groups on graded rings.
Jeremy Haefner*, University of Colorado, and Angel del Rio, Universidad de Murcia (917-16-94)

Yi Hu, University of California, Berkeley (917-14-115)

9:50AM Actions of algebraic groups on the spectrum of rational ideals.
Nikolaus Vosessen, University of Montana (917-16-73)

10:25AM Multiplicative actions of finite groups.
Martin W. Lorenz, Temple University, Philadelphia (917-16-46)

The time limit for each contributed paper in the sessions is ten minutes. In the Special Sessions the time limit varies from session to session and within sessions. To maintain the schedule, time limits will be strictly enforced.

For papers with more than one author, an asterisk follows the name of the author who plans to present the paper at the meeting.

Papers flagged with a solid triangle (►) have been designated by the author as being of possible interest to undergraduate students.

Abstracts of papers presented in the sessions at this meeting will be found in the November issue of Abstracts of papers presented to the American Mathematical Society, ordered according to the numbers in parentheses following the listings. The middle two digits, e.g., 897-20-1136, refer to the Mathematical Reviews subject classification assigned by the individual author. Groups of papers for each subject are listed chronologically in the Abstracts. The last one to four digits, e.g., 897-20-1136, refer to the receipt number of the abstract; abstracts are further sorted by the receipt number within each classification.
Special Session on Analysis on Singular and Noncompact Spaces, I

9:00 AM - 10:50 AM  Room 159, Sloan Laboratory
Organizers: Xianzhe Dai, University of Southern California
Rafe R. Mazzeo, Stanford University

9:00AM Adiabatic limits of the Seiberg-Witten equations on Seifert manifolds.
(16) Liviu I. Nicolaescu, University of Michigan Ann Arbor (917-58-45)
9:40AM Seiberg-Witten Floer Theory.
(17) Matilde Marcolli, The University of Chicago (917-57-52)
(18) John M. Lee*, University of Washington, and Rafe Mazzeo, Stanford University (917-53-98)

Special Session on Dynamical Systems, I

9:00 AM - 10:50 AM  Room 153, Sloan Laboratory
Organizers: Rafael de la Llave, University of Texas at Austin
Maciej P. Wojtkowski, University of Arizona

9:00AM Perturbations of Hamiltonian normal forms.
(19) Jerrold E. Marsden, Caltech (917-58-55)
9:30AM The Equichordal Point Problem and the existence of heteroclinic and homoclinic connections.
(20) Marek R. Rychlik, University of Arizona (917-39-47)
10:00AM The dynamics of contact structures. Preliminary report.
(21) Robert W. Ghrist and John B. Etnyre, University of Texas, Austin (917-57-53)
(22) Michael Rudnev, Caltech (917-34-84)

Special Session on Probability, I

9:00 AM - 10:55 AM  Room 114, E. Bridge Laboratory
Organizer: Thomas M. Liggett, University of California, Los Angeles

9:00AM The asymmetric random cluster model and comparisons among Potts models. Preliminary report.
(23) Kenneth S. Alexander, University of Southern California (917-60-50)
9:40AM A strict inequality between site and bond critical probabilities.
(24) Alan M Stacey, University of Cambridge (917-60-70)
10:20AM Mixing and determinism in random fields. Preliminary report.
(25) Robert M. Burton, Oregon State University (917-60-75)

Invited Address

11:00 AM - 11:50 AM  Room 201, E. Bridge Laboratory
(26) Geometric microlocal analysis and its applications.
Rafe Mazzeo, Stanford University (917-58-24)

Invited Address

2:00 PM - 2:50 PM  Room 201, E. Bridge Laboratory
(27) The Ising model in recent years: Wulff droplets, metastability and strong mixing properties.
Roberto Henrique Schonmann, University of California, Los Angeles (917-60-10)

Special Session on Analysis on Singular and Noncompact Spaces, II

3:00 PM - 5:30 PM  Room 159, Sloan Laboratory
Organizers: Xianzhe Dai, University of Southern California
Rafe R. Mazzeo, Stanford University

3:00PM Gluing self-dual 4-orbifolds.
(28) Jian Zhou, UC at Santa Barbara (917-53-96)
3:40PM Shifted $L^2$-invariants.
(29) John W. Lott, University of Michigan, Ann Arbor (917-53-99)
4:20PM Gluing constant mean curvature surfaces.
(30) Preliminary report.
Daniel Polack, University of Washington (917-58-111)
5:00PM Higher spectral flow.
(31) Xianzhe Dai*, USC, and Weiping Zhang, Nankai Institute of Mathematics, Tianjing, PRC (917-58-64)

Special Session on Dynamical Systems, II

3:00 PM - 4:50 PM  Room 153, Sloan Laboratory
Organizers: Rafael de la Llave, University of Texas at Austin
Maciej P. Wojtkowski, University of Arizona

3:00PM Denjoy minimal sets are far from affine.
(32) Alec Norton, University of Texas, Austin (917-58-48)
3:30PM Non-invertible piecewise continuous mappings and subshifts of finite type.
(33) Areek J. Goetz, Boston University (917-58-74)
4:00PM Periodic orbits and complexity for billiards in polygons.
(34) Eugene Gutkin, University of Southern California (917-58-57)
4:30PM Topics in holomorphic dynamics.
(35) Ricardo Perez-Marcos, Univ of Cal, Los Angeles (917-58-113)

Special Session on Group Actions and Noncommutative Algebra, II

3:00 PM - 5:45 PM  Room 103, Downs Laboratory
Organizers: Zinovy Reichstein, Oregon State University
Nikolaus Vonessen, University of Montana

3:00PM Near subgroups of finite groups. Preliminary report.
(36) Michael Aschbacher, Caltech (917-20-19)
3:35PM Crossed products of restricted enveloping algebras.
(37) Mark C. Wilson, University of Auckland (917-16-56)
4:10PM Torsion in the class group of a noncommutative curve. Preliminary report.
(38) Christopher J. Pappacena, University of Southern California (917-16-68)
### Special Session on History of Mathematics, II

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<td>Organizers: Shawnee L. McMurrin, Pomona College</td>
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<td>James J. Tattersall, Providence College</td>
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<td>3:00 PM</td>
<td>P.A.M. Dirac, Preliminary report.</td>
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<td>3:30 PM</td>
<td>Solution to an ancient combinatorial riddle.</td>
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<tr>
<td>4:00 PM</td>
<td>Cubic curves, coordinates and classification:</td>
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<td>John D. Andersen, Institute for History and Philosophy of Science</td>
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<td>and Technology, University of Toronto (917-01-109)</td>
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<td>4:30 PM</td>
<td>The number theoretic legacy of Sophie Germain.</td>
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<tr>
<td>5:00 PM</td>
<td>Report on the Institute in the History of Mathematics and its use in</td>
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<td>teaching.</td>
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<td>5:30 PM</td>
<td>Cocycle deformations of quantum matrix bialgebras.</td>
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<tr>
<td>6:00 PM</td>
<td>Injective comodules for the quantized function coalgebra of SL(2) at</td>
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<td>a root of 1. Preliminary report.</td>
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### Sunday, November 17

#### Special Session on Hopf Algebras and Their Representations, II

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<td>Special Session on Hopf Algebras and Their Representations, II</td>
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<td>Organizers: Davida Fischman, California State University, San Bernardino</td>
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<td>M. Susan Montgomery, University of Southern California</td>
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<tr>
<td>3:00 PM</td>
<td>Cocycle deformations of quantum matrix bialgebras.</td>
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<td>3:30 PM</td>
<td>Quasi-discrete quantums.</td>
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<td>4:00 PM</td>
<td>Quantum coalgebras. Preliminary report.</td>
</tr>
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<td>4:30 PM</td>
<td>Quantum convolution when $q$ is not a root of unity.</td>
</tr>
<tr>
<td>5:00 PM</td>
<td>Quantum determinant and Dieudonne determinant.</td>
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<tr>
<td>5:30 PM</td>
<td>Normal elements in braided bialgebras. Preliminary report.</td>
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#### Special Session on Group Actions and Noncommutative Algebra, III

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<th>Time</th>
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<td>8:05 AM - 10:50 AM</td>
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<td>Special Session on Group Actions and Noncommutative Algebra, III</td>
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<tr>
<td></td>
<td>Organizers: Zinovy Reichstein, Oregon State University, Nikolaus Vonessen, University of Montana</td>
</tr>
<tr>
<td>8:45 AM</td>
<td>Imbeddings of topological groups into linear spaces. Preliminary report.</td>
</tr>
<tr>
<td>8:50 AM</td>
<td>Imbeddings of topological groups into linear spaces. Preliminary report.</td>
</tr>
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Program of the Sessions - Pasadena, CA, Sunday, November 17 (cont'd.)

8:40AM  Primitive ideals in the enveloping algebra of the Lie superalgebra osp(1, 2r).  
(63) Ian M Musson, University of Wisconsin-Milwaukee  
(917-17-103)

9:15AM  Quantum P^0's which embed Quantum Quadrics.  
(64) Michaela Vancliff*, University of Oregon, and Kristel Van Rompay, University of Antwerp, U.I.A.  
(917-16-27)

9:50AM  Quadratic algebras of global dimension three.  
(65) Preliminary report.  
Darin R. Stephenson, University of California, San Diego (917-16-114)

10:25AM  On the trace of graded automorphisms  
(66) James J. Zhang, University of Washington  
(917-16-40)

Special Session on History of Mathematics, III

8:30 AM - 10:50 AM  Room 151, Sloan Laboratory  
Organizers: Shawnee L. McMurran, Pomonia College  
James J. Tattersall, Providence College

8:30AM  Charles Babbage and cryptography.  
(67) James J. Tattersall, Providence College (917-01-72)

9:00AM  Early voyages into logarithmic seas.  
(68) Barnabas B. Hughes, California State University, Northridge (917-01-18)

9:30AM  Historical pi calculations via the student project.  
(69) C. Ara Pehlivanian, U.S. Military Academy, West Point (917-01-101)

10:00AM  Debeaune's commentary on Descartes' geometry.  
(70) Preliminary report.  
C. Edward Sandifer, Western Connecticut State University (917-01-97)

Gary G. Cochell, Culver-Stockton College (917-01-107)

Special Session on Analysis on Singular and Noncompact Spaces, I

9:00 AM - 10:50 AM  Room 159, Sloan Laboratory  
Organizers: Xianzhe Dai, University of Southern California  
Rafe R. Mazzeo, Stanford University

9:00AM  The heat kernel for manifolds with conic singularities.  
(72) Edith A. Moore, UCLA (917-35-44)

9:40AM  Singular curves and a Sard theorem in subRiemannian geometry. Preliminary report.  
(73) Richard W. Montgomery, USCS Santa Cruz (917-58-65)

10:20AM  Discussion

Special Session on Dynamical Systems, III

9:00 AM - 10:50 AM  Room 153, Sloan Laboratory  
Organizers: Rafael de la Llave, University of Texas at Austin  
Maciej P. Wojtkowski, University of Arizona

9:00AM  Dynamical systems with some hyperbolic properties. Preliminary report.  
Lai-Sang Young, UCLA (917-58-63)

9:30AM  Convergence of densities for piecewise affine approximations of interval maps.  
(75) Nicolai Haydn, University of Southern California (917-58-61)

10:00AM  Properties of solutions of complex differential equations.  
(76) Alberto Candel, Caltech (917-58-87)

10:30AM  Extremal rotation numbers for torus shear homeomorphisms.  
(77) Erik Doeff*, Montana State University - Bozeman, and Michal Misiurewicz, IUPUI (917-58-32)

Invited Address

11:00 AM - 11:50 AM  Room 201, E. Bridge Laboratory  
(78) Essential dimension of reductive groups.  
Zinovy Reichstein, Oregon State University (917-16-03)

Invited Address

2:00 PM - 2:50 PM  Room 201, E. Bridge Laboratory  
(79) Hamiltonian systems with hyperbolic properties.  
Maciej P. Wojtkowski, University of Arizona (917-58-133)

Special Session on Analysis on Singular and Noncompact Spaces, I

3:00 PM - 4:50 PM  Room 159, Sloan Laboratory  
Organizers: Xianzhe Dai, University of Southern California  
Rafe R. Mazzeo, Stanford University

3:00PM  Inverse scattering problems for the Schrödinger operators with external Young-Mills potentials.  
(80) Gregory Eskin* and James Ralston, UCLA (917-35-66)

3:40PM  Invariant Gibbs measures for 2D nonlinear wave equations.  
(81) Jean Bourgain, Institute for Advanced Study, Arthur Jaffe, Harvard University, and Wensheng Wang*, USC, Los Angeles (917-35-76)

4:20PM  Regularity of fourth order equation in conformal geometry. Preliminary report.  
Sun-Yung A. Chang, UCLA, Matthew J. Gursky, Indiana University, and Paul C. Yang*, USC (917-53-134)

Special Session on Dynamical Systems, IV

3:00 PM - 4:50 PM  Room 153, Sloan Laboratory  
Organizers: Rafael de la Llave, University of Texas at Austin  
Maciej P. Wojtkowski, University of Arizona

3:00PM  The integral manifold of the three-body problem.  
(83) Preliminary report.  
Qiudong Wang, UCLA (917-34-59)

3:30PM  Arnold diffusion-issues and recent results.  
(84) Preliminary report.  
Stephen Wiggins, Caltech (917-58-62)

4:00PM  Strange attractors in dynamical systems.  
(85) Bjorn Birnir, University of California, Santa Barbara (917-58-112)

4:30PM  On spectra of flows given by differential equations on the torus. Preliminary report.  
Oliver R. Knill, University of Arizona, Tucson (917-58-37)
### Special Session on History of Mathematics, IV

**3:00 PM - 4:50 PM**  
Room 151, Sloan Laboratory  
Organizers: Shawnee L. McMurrnan, Pomona College  
James J. Tattersall, Providence College

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<td>Charles L. Dodgson's contributions to linear algebra and to the theory of parallels.</td>
<td>Francine F. Abeles, Kean College of New Jersey</td>
<td>(917-01-81)</td>
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<td>3:30PM</td>
<td>Alfred Tarski comes to the USA: The hard years. Preliminary report.</td>
<td>Anita Burdman Feferman, Stanford University</td>
<td>(917-01-117)</td>
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<tr>
<td>4:00PM</td>
<td>When Tarski met Gödel. Preliminary report.</td>
<td>Solomon Feferman, Stanford University</td>
<td>(917-01-118)</td>
</tr>
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### Special Session on Hopf Algebras and Their Representations, IV

**3:00 PM - 5:50 PM**  
Room 107, Downs Laboratory  
Organizers: Davida Fischman, California State University, San Bernardino  
M. Susan Montgomery, University of Southern California

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<tbody>
<tr>
<td>3:00PM</td>
<td>Indecomposable modules of reduced enveloping algebras.</td>
<td>Rolf Farnsteiner, University of Wisconsin-Milwaukee</td>
<td>(917-16-90)</td>
</tr>
<tr>
<td>3:30PM</td>
<td>Finite stratification of spectra, the Dixmier-Moeglin equivalence, and q-skew polynomial algebras. Preliminary report.</td>
<td>Kenneth R. Goodearl, University of California, Santa Barbara, and Edward S. Letzter*, Texas A &amp; M University</td>
<td>(917-16-100)</td>
</tr>
<tr>
<td>4:00PM</td>
<td>Invariants of skew derivations. Preliminary report.</td>
<td>Jeffrey Bergen*, DePaul University, and Piotr Grzeszczuk, University of Warsaw</td>
<td>(917-16-128)</td>
</tr>
<tr>
<td>4:30PM</td>
<td>Crossed products, Goldie rings, and rings of quotients.</td>
<td>Dmitriy Rumynin, University of Massachusetts at Amherst</td>
<td>(917-16-43)</td>
</tr>
<tr>
<td>5:00PM</td>
<td>Irreducible representations of crossed products.</td>
<td>Sarah J. Witherspoon*, University of Toronto and University of California, Berkeley, and Susan Montgomery, University of Southern California</td>
<td>(917-16-13)</td>
</tr>
</tbody>
</table>

### Contributed Papers, I

**3:00 PM - 3:40 PM**  
Room 103, Downs Laboratory

<table>
<thead>
<tr>
<th>Time</th>
<th>Title</th>
<th>Speaker(s)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>3:00PM</td>
<td>Rate of convergence of some neural network operators to the unit-univariate case. Preliminary report.</td>
<td>George A. Anastassiou, The University of Memphis</td>
<td>(917-41-07)</td>
</tr>
<tr>
<td>3:15PM</td>
<td>Induced embeddings in Steinhaus graphs.</td>
<td>Franz A. Delahan, University of California.Irvine</td>
<td>(917-05-54)</td>
</tr>
</tbody>
</table>
Conferences

Joint Summer Research Conferences in the Mathematical Sciences

University of Washington, Seattle, Washington
June 22–July 31, 1997

The 1997 Joint Summer Research Conferences in the Mathematical Sciences will be held at the University of Washington, Seattle, June 22–July 31, 1997. The topics and organizers for the seven conferences were selected by the AMS, the Institute of Mathematical Statistics (IMS), and the Society for Industrial and Applied Mathematics (SIAM) Committee on Joint Summer Research Conferences in the Mathematical Sciences. The selections were based on suggestions made by the members of the committee and individuals submitting proposals. The committee considered it important that the conferences represent diverse areas of mathematical activity, with emphasis on areas currently especially active, and that careful attention be paid to subjects in which there is important interdisciplinary activity at present.

It is anticipated that the series of conferences will be supported by grants from the National Science Foundation and other agencies. If supported, funding will be available for a limited number of participants in each conference. In addition to those funded, others will be welcome, within the limitations of the facilities of the campus. In the spring, a brochure of information will be mailed to all who are requesting to attend the conferences. The brochure will include information on room and board rates, the residence and dining hall facilities, travel, local information, and a Residence Housing Form to request on-campus accommodations. Information on off-campus housing will also be included in the brochure. Participants will be responsible for making their own housing and travel arrangements. Each participant will be required to pay a conference fee.

Those interested in attending one of the conferences should send the following information to the Summer Research Conference Coordinator, Conferences Department, American Mathematical Society, P.O. Box 6887, Providence, RI 02940; phone: 401-455-4142; e-mail: rgc@ams.org.

Please type or print the following:
1. Title and dates of conference desired
2. Full name
3. Mailing address
4. Area code and phone number for office, home, and FAX
5. E-mail address
6. Scientific background relevant to the topic of the conference
7. Financial assistance requested (or indicate if support is not required)

The deadline for receipt of requests for information is March 1, 1997.

After the deadline of March 1, requests to attend will be forwarded to the Organizing Committee for each conference for consideration. All applicants will receive a formal invitation, brochure of information, notification of financial assistance, and a tentative scientific program (if the chair has prepared one in advance; otherwise, programs will be distributed at on-site registration) from the AMS by May 1. Funds available for these conferences are limited, and individuals who can obtain support from other sources should do so. The allocation of grant funds is administered by the AMS office, and the logistical planning for the conferences is also done by the AMS. However, it is the responsibility of the chair of the Organizing Committee of each conference to determine the amount of support participants will be awarded. This decision is not made by the AMS. Women and minorities are encouraged to apply and participate in these conferences.

Any questions concerning the scientific portion of the conference should be directed to the chair or any member of the Organizing Committee. For further information supplied by organizers on individual sites, see web sites on e-math, where available.

The Joint Summer Research Conferences in the Mathematical Sciences are under the direction of the AMS-IMS-SIAM Committee on Joint Summer Research Conferences in the Mathematical Sciences. The following committee members chose the topics for the 1997 conferences: Katalin Bencsath, Mary Ellen Bock, Percy Deift, Alan F. Karr, Barbara Keyfitz (chair), Andre Manitius, Bart Ng, Douglas Simpson, John Stembridge, Clifford Taubes, and Sue Whitesides.

N.B. Lectures begin on Sunday morning and run through Thursday. Check-in for housing begins on Saturday. No lectures are held on Saturday.

Statistics in Molecular Biology

Sunday, June 22–Thursday, June 26

François Seillier-Moiseiwitsch, University of North Carolina, chair

Peter Donnelly, University of Chicago, co-chair

Michael Waterman, University of Southern California, co-chair

The major recent technological advances in molecular biology have brought with them an explosion of molecular data. Scientific progress has in many cases already depended on the development and application of novel statistical and mathematical methodology. As the underlying
technology changes, and the realms to which it is applied expand, much future progress will depend crucially on statistical developments. These in turn must be closely informed by the underlying science. One major goal of the meeting is to bring together leading researchers from several relevant fields in order to facilitate cross-disciplinary collaborations. Another, more traditional, goal is to provide a forum for the dissemination and discussion of recent and ongoing work in the field. Specific examples illustrate how statistical techniques have had a great impact in different areas of molecular biology.

Much effort is being spent on localizing disease-associated genes in the human genome. Typically, attempts are made, on the basis of familial data, at the disease to a marker on a chromosome by estimating the frequency of inheriting both the disease and the marker together. The closer the gene is to the marker the smaller the chance of having a crossover between the two loci. If the proportion of recombinants is 1/2, then the loci are either located on different chromosomes or far apart on the same one. The estimation of the genetic distance, a function of the recombination fraction, is essentially a statistical problem. Assumptions as to the genetic model and the type of data guide the choice of statistical technique. Correlations in familial data and the latency of the genotypes render fitting even simple probability models arduous. Maximizing the likelihood function is not straightforward and better algorithms are based upon the Markov-chain Monte-Carlo procedure. However, the workings of this procedure are not completely understood. Advances in molecular techniques have generated a slew of new markers, which leads to the possibility of utilizing the information on several markers simultaneously in the mapping process (multipoint mapping). Further, efficient techniques for identifying genomic portions which are identical by descent are being developed. Also, data generated from radiation hybrids yield maps with a higher level of resolution than the traditional procedure. These latest developments render the earlier methods of data analysis obsolete.

The Human Genome Project is concerned with producing a genetic map of closely-spaced markers spanning the whole genome as well as a physical map of the chromosomes. The latter consists of the actual sequence of bases forming each chromosome. Direct sequencing can only be achieved on relatively small DNA segments. Chromosomes, therefore, first need to be broken up into portions of more manageable lengths. Once the sequencing is performed, the pieces are assembled by calculating the likelihood of overlap between all pairs and joining those with the highest probability of overlap. This likelihood is computed on the basis of a probability model for the sequencing output. Hence, the assembly is essentially a statistical problem. Automatic, fast, efficient sequencing technology is now on the market. Designing effective experiments would save researchers valuable resources. The computational task of aligning multiple sequences is rendered even more difficult by errors in the automatic sequencing and need to take into account models for this process. The genome of the human immunodeficiency virus mutates very quickly. Some regions undergo more mutations than others. Viral DNA sequences from a single infected individual show great variability, which fluctuates over time, with the original strains being replaced by new ones. It has been discovered that some mutations are linked, i.e. mutations at a particular position are highly statistically correlated to mutations at an other position. This finding could be attributed to the phylogenetic relationships among sequences. It is of great interest to find true linkages, that is those resulting from a parallel evolution. From a biological viewpoint, linked pairs may be close in space and therefore may lead to clues as to protein structures (and to the yet unknown function of some genes). Novel statistical procedures are being developed to address this problem as are tests to compare the variability among sets of sequences. However, much remains to be worked out: the assumptions underlying the statistical methodology utilized currently are not valid in this context.

These are but three examples where statistical methodology plays a major role in providing answers to important problems in molecular biology. We intend to bring together researchers in molecular biology, statistics, probability theory, computer science and computational biology to facilitate this important interdisciplinary work. It is hoped that this meeting will provide a forum where biological scientists will convey their greatest statistical needs and point to the important problems. With the implementation of faster and cheaper sequencing techniques, vast amounts of information will soon be available, together with new lines of inquiry (regarding, for instance, human genomic variability). Summarizing and analyzing large volumes of data is the natural realm of statistics. DNA sequences, in view of their structure and the information they encode and the evolutionary processes by which they are generated, require more sophisticated statistical treatments than the data statisticians usually deal with. For instance, the common statistical summaries are grossly inadequate in this context. There is therefore a great need for novel methodology to be developed.

A number of eminent biologists will present a global view of the present situation and the (short-term and long-term) directions in molecular biology, genetics and the Human Genome Project. The time is ripe for the mathematical community to become better acquainted with these innovations as they shape the future of molecular biology.

The following topics will be discussed:
1. Genetic Mapping: Mathematical properties of mapping functions, probability models for multilocus recombination, multipoint linkage, computational issues for likelihood-based inferences (Markov chain Monte-Carlo methods), affected-pedigree-member methods (in particular, recent developments for technology identifying regions identical by descent).


6. Computing Resources: Presentations about software packages on multiple alignments, statistical analysis for genetic epidemiology, regressive models for genetic epidemiology, LINKAGE, phylogenetic analysis using parsimony, MENDEL, FISHER, PHYLIP, SIMEX.

Graphical Markov Models,
Influence Diagrams, and
Bayesian Belief Networks

Sunday, June 29–Thursday, July 3

David Madigan, University of Washington, co-chair

Michael D. Perlman, University of Washington, co-chair

Perhaps the most central idea of statistical science is the assessment of dependencies among a set of statistical variables. The familiar concepts of correlation, regression, and prediction are manifestations of this idea in various forms, and many, if not most, aspects of causal relationships ultimately rest on representations of multivariate dependence.

In statistics, graphical Markov models represent statistical dependencies by combining two simple yet powerful mathematical concepts: graphs and conditional independence (CI). A graphical Markov model is constructed by specifying local dependencies for each node of the graph in terms of its immediate neighbors, yet can represent a highly varied and complex system of multivariate dependencies by means of the global structure of the graph. Nonetheless, the local specification of a graphical model permits efficiencies in modelling, inference, and probabilistic calculations. This has been greatly facilitated by the parallel development of Bayesian methodology and high-speed computational techniques, in particular, Markov chain Monte-Carlo methods.

Separate but convergent developments of these ideas occurred in computer science, decision analysis, and philosophy, where graphical Markov models are called Influence Diagrams, Belief Networks, or Bayesian Networks, and are used for the construction of expert systems and for causal modelling. In particular, directed acyclic graphs (DAGs) have proved to be well-suited for describing causal relations among stochastic variables in complex systems and for revealing their statistical implications; once a set of assumed local dependencies are depicted by arrows to construct the skeleton of the system, all their global implications can be revealed and traced through the network structure by means of the d-separation criterion.

Graphical Markov models determined by DAGs admit especially simple statistical analyses. In particular, the likelihood function associated with a DAG model admits a convenient recursive factorization which, for categorical or multivariate normal data, allows explicit maximum likelihood estimates, likelihood ratio tests, etc. When used for the construction of expert systems, DAG models allow efficient computational algorithms for exact probability calculations in complex networks defined by local dependencies, as well as efficient updating algorithms for Bayesian analysis.

An interesting, although complicating, feature of DAG models is the non-uniqueness of the DAG associated with the model. Unlike undirected graphs, two or more DAGs may determine the same graphical Markov model. This non-uniqueness can lead to computational inefficiency in model selection and to inaccurate specification of prior distributions in Bayesian model averaging. A fundamental characterization of Markov-equivalent DAGs allows one to determine whether two specified DAGs determine the same graphical Markov model. The Markov-equivalence class [D] containing a given DAG D may be exponentially large, however, so this does not resolve these difficulties. Recently it has been discovered that a single graph, the so-called essential graph D*, simultaneously represents the entire class [D], and can be constructed in polynomial time. Markov Chain Monte-Carlo schemes based on this construction have been developed to overcome the problems of computational efficiency and specification of priors in Bayesian model averaging and model selection.

In the late 1980s, DAG models were generalized to "chain graphs", which are "mixed" graphs (both directed and undirected edges) that contain no (partially) directed cycles. Loosely speaking, chain graph models attempt to simultaneously represent dependencies some of which are causal and some associative. Very recently, it has been noted that a chain graph may admit different Markov interpretations, hence may simultaneously represent different statistical models. The study of these competing Markov properties and the assessment of their relative applicability in practice is currently under intensive study. The non-uniqueness property of DAGs is shared by chain graphs, and the questions associated with the Markov equivalence of chain graphs are substantially more complex than those associated with DAGs.

Acyclic directed graphs and chain graphs generally model recursive relationships that exclude feedback and causal cycles. Recent studies of nonrecursive graphical Markov models based on directed cyclic graphs and "rec-
iprocal graphs", have begun to reveal their relations to nonrecursive simultaneous equations models in econometrics. The Markov-equivalence question for nonrecursive graphical Markov models promises to be even more challenging than those for DAGs and chain graphs.

Graphical Markov models may be particularly well suited for identifying latent variates. Given a set of hypothesized dependencies among a set of observable variates, it may be possible to characterize a minimal set of latent variates and an associated minimal graphical model that incorporates these dependencies and variates, thus bypassing the nonidentifiability problem that often occurs with other latent variate methods. Additional challenges for new research on graphical Markov models include the development of diagnostic tools for model selection, sensitivity analysis for local misspecification of a graphical model, computational methods for massive data sets and/or missing data, and the extension of present theory and methodology to graphical systems whose topology evolves with time.

Principal Speakers:
STEEN A. ANDERSSON, Indiana University. Alternative Markov properties for chain graphs (tentative)
DAVID COX, Oxford University. Multivariate dependencies models, analysis, and interpretation (tentative)
DANIEL GEIGER, The Technion, Israel, and the Microsoft Corporation. Laplace approximations for likelihood computations (tentative)
DAVID HECKERMAN, The Microsoft Corporation, Seattle. Learning Bayesian networks from incomplete data (tentative)
JAN T. A. KOSTER, Erasmus University, Rotterdam. Reciprocal graphs.
STEFFEN L. LAURITZEN, U. Aalborg, Denmark. Graphical association models (tentative)
JUDEA PEARL, UCLA. Causality, interventions, and counterfactuals (tentative)
THOMAS RICHARDSON, Carnegie-Mellon University/University of Washington. Nonrecursive graphical models and structural equations (tentative)
DAVID SPIEGELHALTER, University of Cambridge, UK. Bayesian graphical models (tentative)
PETER SPIRITES, Carnegie-Mellon University. Directed cyclic graphs (tentative)
MILAN STUDENY, Acad. Sciences, Czech Republic. Semantics, separation, and completeness for chain graphs (tentative)
NANNY WERMUTH, University of Mainz, Germany. Summary graphs for multivariate dependencies (tentative)

New Developments and Applications in Experimental Design

Sunday, June 29–Thursday, July 3

Timothy O'Brien, University of Georgia, co-chair
William Rosenberger, University of Maryland, co-chair

Focus, Importance, and Timeliness of Topic

The validity and practicality of scientific research in experimental fields such as agriculture, medicine, engineering, psychology, and many others, depend upon the efficiency of designs for experimentation. Optimal design theory provides researchers with the means to select an efficient design for their experiment, requiring few replications while giving accurate results. Given the limited resources of many researchers today, finding an optimal design is very important, as experiments are costly and time-consuming. New developments in experimental design have improved our ability to solve difficult design problems for practical applications. However, the usual problem of bridging theory and practice is omnipresent.

To date, most optimal design theory has been based on linear models (e.g., Pukelsheim, 1993). In many cases, however, nonlinear models are more appropriate. Nonlinear models are important in the life sciences and engineering, to name just a couple of fields. Dette and Wong (1996a) considered linear models where errors have variances which vary across the design space. However, in practice, the heteroscedasticity structure is not completely known and additional nonlinear parameters are required in the model. Consequently the resulting model is nonlinear and, as Dette and Wong (1996a, 1996b) demonstrated, there are many applications of such a model to problems in quality control and growth models.

Because most optimal designs, in particular nonlinear problems, depend on unknown parameters, one must often rely on prior knowledge and/or accruing information on the parameters in order to implement them. Bayesian methods and sequential methods are particularly relevant here, as prior information can be used to estimate the unknown parameter, and this estimate can be updated by sequential experimentation. Sequential experimentation has a long history, beginning in psychology (von Bekesy, 1947) and weapons testing (Anderson, McCarthy, and Tukey, 1946). Stochastic approximation methods were introduced by Robbins and Monro (1951). Chernoff's (1972) groundbreaking monograph linked the discussions of sequential methods and optimality. Recent progress has been made in sequential designs for quantile estimation by Durham and Flournoy (1994) and from a Bayesian sequential perspective by Watson and Pell (1983) for psychophysics applications (e.g., determining aural thresholds) and O'Quigley, Pepe and Fisher (1990) for biomedical studies.
Sequential clinical trials have been done since 1948; recent development has been on designing clinical trials which “adapt” to favor treatments which are performing better during the course of the trial. Such designs control the ethical cost of introducing patients to less effective therapies (e.g., Wel and Durham, 1978; Rosenberger and Lachin, 1993; Rosenberger, 1993). Such designs have additional application in engineering (e.g., Hughes-Oliver, 1994), where cost is measured in financial expenditure, rather than in human terms. Again the link between theory and practice has been tenuous.

Sequential designs have also been proposed for random processes, which have applications in the analysis of spatial environmental data. Optimal procedures are computationally difficult and depend on uncertainty in process parameters. Sequential methods for the location of extrema of the process have been discussed by Cox and John (1992) and Kushner (1964). Bayesian techniques have been developed by Mockus (1989). In addition, sequential designs have found applications in computer experiments, which are increasingly important tools in virtually all fields of scientific research (Sacks, et al. (1989), Currin, et al. (1991), and Morris, Mitchell, and Ylvisaker (1993)). Still another emerging strategy to designing problems in high dimensional settings is space filling (see Budne (1959) and McKay, Conover, and Beckman (1979) for alternative approaches).

The focus of this conference is to discuss recent developments in experimental designs for biomedical, industrial and other applications. The broad emphasis will be on applications. Each speaker will exhibit a specific application, and mathematics will be applications-driven. Our goal is to bridge the gap between theory and practice and to introduce statisticians working on diverse problems to current methodological developments.

Representation Theory of Real and p-adic Reductive Groups

Sunday, July 6–Thursday, July 10

Jeffrey Adams, University of Maryland, co-chair
Dan Barbasch, Cornell University, co-chair
Allen Moy, University of Maryland, co-chair

Representation theory of Lie groups has its roots in the work of Lie, Killing, Frobenius, and Cartan in the late nineteenth century. In the last 50 years it has been understood to deal with representations of groups such as real Lie groups, p-adic groups, finite Chevalley groups, as well as finite and infinite dimensional Lie algebras. By its nature it uses techniques from many fields: analysis, algebra, geometry, and algebraic geometry; and finds applications in areas such as harmonic analysis, combinatorics, number theory, and mathematical physics. This conference plans to cover a few of the areas that have seen recent development, and to put this progress in perspective.

Character Theory

The importance of character theory for finite groups has been well known since the work of Frobenius. It generalizes to compact groups in the form of the Peter-Weyl theorem, and is given explicitly by the Weyl character formula. In the 1950s Harish-Chandra began a systematic study of harmonic analysis on reductive Lie groups. For this he developed the theory of infinite dimensional representations of a noncompact Lie group $G$. One of Harish-Chandra’s seminal results is that the character of an irreducible admissible representation is a distribution given by a locally integrable function which is analytic on the regular set. This result was fundamental for Harish-Chandra’s subsequent work, the culmination of which was his classification of the discrete series, i.e. the irreducible subspaces of $L^2(G)$, and the determination of the Plancherel formula of $G$.

Real Groups

The result quoted above suggests that one may treat infinite dimensional representations of arbitrary reductive groups in the same way as representations of finite groups. However the technical difficulties in obtaining an explicit formula analogous to Weyl’s character formula are daunting. One explicit result is the so-called Casselman-Osborne formula, which expresses the character on each Cartan subgroup in terms of Lie algebra cohomology. This was proved by Hecht-Schmid in the 1970s. An explicit combinatorial formula was conjectured by Kazhdan-Lusztig (in terms of standard modules whose characters are known) and proved by Brylinski-Kashiwara, Beilinson-bernstein and Lusztig-Vogan. This required the introduction of techniques from algebraic geometry (intersection homology), and partial differential operators (D-modules). Of particular recent interest has been a conjecture (come to be known as the Barbasch-Vogan conjecture) that relates the analytic character expansion at the origin with the algebraic structure of the corresponding $(g, K)$ module. This was recently solved by Schmid-Vilonen, using results of Rossman and Chang and some new techniques based on microlocal analysis.

$p$-adic Groups

It was natural for Harish-Chandra and others, most notably in the context of the Langlands program, to conjecture analogous results for reductive $p$-adic groups. In certain cases these generalizations have been established. In particular Harish-Chandra showed that the character of an irreducible admissible representation of a reductive $p$-adic group is a locally integrable function which is locally constant on the regular set. However the proof of $p$-adic statements generally require techniques quite different from those used in the real case, and the $p$-adic theory is not as mature as the real theory. This reflects the deeper arithmetic content of the $p$-adic case, e.g. in contrast with the real case the absolute Galois group of a $p$-adic field is infinite.

After a rather long quiet period, the last six years has seen extremely interesting developments in the character theory of reductive $p$-adic groups. Important results as well as new insights have been obtained. For example, Mur-
naghan has shown that the characters of certain supercuspidal representations are the Fourier Transforms of invariant measures. Hales, Kottwitz, and Shelstad have done major work in endoscopy. Waldspurger and Barbasch-Moy have done work in local expansions of characters. And Schneider-Stuhler have made connections of characters and the Bruhat-Tits building of the group.

Representations

Dual Pairs and Exceptional Groups

Representation theory has contributed to automorphic forms in two ways. First of all the Langlands program conjectures, and in some cases establishes, deep connections between representations of a connected reductive algebraic group $G$ and automorphic forms. Secondly theta series give relations between automorphic forms on different groups. The second topic has undergone considerable growth in recent years.

The "classical" theory relates the representations of a dual pair of subgroups $G$ and $G'$ of the metaplectic group $\text{Mp}$ (i.e. $G$ and $G'$ are each other's centralizers in $\text{Mp}$). These correspondences are now understood to be "functorial" in some sense, and compatible with the Langlands program (and Arthur's refinement of it). The conjectures of Gross and D. Prasad, and of Kudla, have stimulated interest in this area.

This theory has also been extended to dual pairs in groups besides the metaplectic groups. Significantly this includes the exceptional groups, which do not appear in $\text{Mp}$. There has been substantial progress, by Kazhdan, Savin, and others, in understanding small representations of these groups, including some information on their characters and the resulting dual pair correspondence. There is currently a lot of activity in this area, but a picture is only beginning to emerge. One key question is how much of the metaplectic theory will carry over—certainly some but not all of it.

Preliminary List of Speakers

Benedict Gross, Harvard. Dual pairs and exceptional groups

Bertram Kostant, MIT. Real groups

Robert Kottwitz, University of Chicago. $p$-adic groups

Jian-Shu Li, University of Maryland. Dual pairs and exceptional groups

Fiona Murnaghan, University of Toronto, $p$-adic groups

Jordan Savin, University of Utah. Dual pairs and exceptional groups

Wilfried Schmid, Harvard. Real groups

Diana Shelstad, Rutgers. $p$-adic groups

Kari Vilonen, Brandeis. Real groups

David Vogan, MIT. Real groups

Algebraic K-Theory

Sunday, July 13–Thursday, July 24

Wayne Raskind, University of Southern California, co-chair

Charles Weibel, Rutgers University, co-chair

Algebraic $K$-theory is a subject which has undergone a rapid change in direction during the last five years. However, there are still some important common themes which pervade the whole subject. We hope to bring these new developments together, presenting the subject as a whole to the next generation.

Algebraic $K$-Theory, Arithmetic and Algebraic Geometry

Earlier this year (1996), Voevodsky announced a proof of the bijectivity of the Galois symbol:

$$K_n^M(F)/n \rightarrow H^i(G, \mathbb{Z}/n\mathbb{Z}(i)),$$

at least when $n$ is a power of 2. Here $F$ is a field (not of characteristic 2), $K_n^M$ denotes Milnor $K$-theory, $G$ is the absolute Galois group of $F$ and the $i$ on the right denotes Tate twist.

He also announced a proof of two other major results: the Quillen-Lichtenbaum conjecture, which relates the algebraic $K$-theory of $F$ with its étale cohomology, and the Milnor Conjecture that $K_i^M(F)/2 = I/I^{i+1}$, where $I$ is the augmentation ideal of the Witt ring $W(F)$ of quadratic forms.

Much of the machinery Voevodsky used was developed jointly with Suslin, who had already proven the Quillen-Lichtenbaum conjecture for curves and surfaces over $\mathbb{C}$ in 1994. These results are perhaps the greatest advance in this part of the subject in almost 15 years, and they have immediate applications to arithmetic and algebraic geometry.

$K$-Theory and Topology

In the last few years, new and fruitful interactions have arisen between $K$-theory and topology. The most dramatic example of this is the explosion of work in the 1990s on topological cyclic homology. In the last 3 years, this has led to a calculation of the higher $K$-theory of rings like $\mathbb{Z}/p^n$ (McCarthy, Goodwillie, Hesselholt-Madsen). Hesselholt used it in 1995 to give a $K$-theoretic construction of the de Rham-Witt complex on a variety over a field of characteristic $p > 0$, giving a deep connection between the topological and algebrao-geometric aspects of the subject.

The study of "controlled topology," in which one adds the condition that topological operations not move things too far, is another example. The gradual formulation of a controlled $h$-cobordism theorem over the last ten years required the development of controlled $K$-groups. In turn, these controlled $K$-groups have been used to calculate much of the $K$-theory of group rings (Farrell-Jones, Carlsson and Carlsson-Pedersen). It now appears that the Novikov
conjecture about the homotopy invariance of signatures of manifolds is within reach with these tools.

*K*-theory has also proved to be the right tool (in some cases) for solving certain index problems and giving topological generalizations of the Riemann-Roch theorem (Bismut-Lott, Dwyer-Weiss-Williams).

**K-Theory and Operator Algebras**

*K*-groups, sometimes with additional structure, have proved to be important tools in the study of $C^*$-algebras. Within the last few years, evidence has accumulated (due to remarkable work of Elliott, Dādāriat-Loring, Rørdam, Kirchberg and others) that there are several important classes of nuclear $C^*$-algebras which are completely classified by $K$-theoretic invariants. $K$-theory of operator algebras has also been used to study topological invariants related to Reidemeister torsion (Lück-Rørdam, Carey-Mathai). The relation between algebraic and topological $K$-theory of operator algebras is finally beginning to be understood (Karoubi, Higson, Suslin-Wodzicki, Rosenberg), and can now be related to the work of Thomason relating to algebraic and topological $K$-theory for algebraic varieties.

Here are some of the main speakers, with their home institutions, and possible topics (most have agreed to speak).

**Senior Invited Speakers and Possible Topics**

D. Quillen, Oxford. *K*-theory of nonunital rings

A. Suslin, Northwestern. K-theory of varieties

A. Bondal, M.I.T. Motivic cohomology

S. Bloch, University of Chicago. Algebraic geometry, higher Chow groups

S. Lichtenbaum, Brown. Motivic cohomology, number theory

J.-L. Colliot-Thélène, Orsay. Algebraic geometry, quadratic forms

K. Kato, Tokyo. K-theory of elliptic curves/class field theory

H. Esnault, Essen. Algebraic geometry, regulator maps

C. Soulé, I.H.E.S. Hermitian vector bundles

G. Carlsson, Stanford. Homotopy theory, Novikov conjectures

T. Goodwillie, Brown. Topological cyclic homology/geometric topology

A. Connes, Collège de France. Operator algebras

J. Cuntz, Heidelberg. Cyclic homology, operator algebras

V. Voevodsky, Harvard. Quillen-Lichtenbaum/Milnor conjectures

I. Hesselholt, M.I.T. Topological cyclic homology

J. Rognes, Oslo. Waldhausen $K$-theory

M. Weiss, Notre Dame. Topological applications of $K$-theory

N. Higson, Pennsylvania State. $K$-theory of operator algebras

R. McCarthy, University of Illinois-Urbana. Topological cyclic homology

**Trends in the Representation Theory of Finite Dimensional Algebras**

**Sunday, July 20–Thursday, July 24**

Edward L. Green, Virginia Polytechnic Institute, co-chair

Birge Huisgen-Zimmermann, University of California, co-chair

The following three topics will be covered: (1) Interactions between representation theory and algebraic geometry; (2) Homological methods, including Hochschild cohomology, cyclic cohomology, functorial finiteness of categories and Koszul algebras; (3) Applications of representation theory to the study of quantum groups.

While the Auslander-Reiten quiver of a finite dimensional algebra $A$ (a directed graph having as vertices the isomorphism types of the finitely generated indecomposable modules and as arrows the irreducible homomorphisms between them) can be considered the ultimate tool in understanding algebras of finite representation type, in the tame and wild cases geometric as well as homological invariants play a decisive role in solutions to classification problems.

The analysis of representations via algebraic varieties is comparatively young. It goes back to the 1970s, in particular to work of Gabriel, Bernstein, I. M. Gelfand, S. I. Gelfand, and Ponomarev. Their work, based heavily on geometric argumentation, introduced 'Tits forms' (certain quadratic forms that can be associated with algebras from a large class) and proved them to store an enormous amount of representation-theoretic information. Another triggering event consisted of two pivotal papers by Kaz, extending work of Gabriel and Nazarova among others, which completed the description of the dimension vectors of the finite dimensional indecomposable representations of quivers in terms of root systems of Kac-Moody Lie algebras. Since then, a high number of very far-reaching geometric paths have been cut through the subject, such as deformation theory for varieties of representations, to name another example.

Many of the methods and conjectures that come under the heading of homological aspects are well known. We therefore mention only a single specific topic that surfaced comparatively recently, namely approximation theory in the sense of Auslander, Reiten, and Smalø. The idea is to find 'best approximations' of representations by objects from a fixed subcategory enjoying certain functorial finiteness conditions, an approach which permits a analysis of rather general representations via better understood ones.

Much of the interest in quantum groups revolves around algebras such as $U_q(\mathfrak g)$, a deformation of the universal enveloping algebra of a semisimple Lie algebra $\mathfrak g$, and $O_q(\mathfrak g)$, a deformation of the coordinate ring of a semisimple Lie
group $G$. In the case when the parameter $q$ is a root of unity, the irreducible representations of these algebras are finite dimensional, and so the finite dimensional representation theory of the algebras is of key importance. As a consequence, the classification techniques developed for the finite dimensional situation provide powerful tools. Similarly, many open problems about another important class of algebras, that of Sklyanin algebras, could be solved if their (finite dimensional) Koszul duals were better understood. Finally, we mention that Ringel has constructed a Polincaré-Birkhoff-Witt basis for the positive part of $U_q(g)$ in terms of modules over a finite dimensional algebra $\Lambda$ of finite representation type. This approach allows one to use the representation theory of the algebra $\Lambda$, in particular itsAuslander-Reiten quiver, to derive properties of $U_q(g)$. 

Suggested list of principal speakers
The names of those who have tentatively agreed to speak are marked with an asterisk, with possible topics indicated.

Michael Artin*, MIT. Noncommutative algebraic geometry
Raymundo Bautista*, Autonomous National University of Mexico. Finite dimensional algebras
Klaus Bongartz*, University of Wuppertal. Finite dimensional algebras (in particular, algebraic varieties of representations)
Sheila Brenner*, University of Liverpool. Finite dimensional algebras
Kenneth Brown*, Glasgow University. Quantum groups
William Crawley-Boevey*, University of Leeds. Finite dimensional algebras (in particular, geometric aspects)
Jose Antonio de la Pena*, Autonomous National University of Mexico. Finite dimensional algebras (tameness seen from a geometric point of view)
Kent Fuller*, University of Iowa. Finite dimensional algebras
Peter Gabriel, University of Zurich. Finite dimensional algebras and their algebraic varieties
Mark Kleiner*, Syracuse University. Finite dimensional algebras
Hanspeter Kraft, University of Basel. Geometry/invariant theory applied to finite dimensional algebras
Helmut Lenzing*, University of Paderborn. Finite dimensional algebras (geometric aspects)
Claudio Procesi*, University of Rome. Quantum groups and algebraic geometry
Idun Reiten*, University of Trondheim. Finite dimensional algebras
Claus Ringel*, University of Bielefeld. Finite dimensional algebras and quantum groups
Andrzej Skowronski*, University of Torun. Finite dimensional algebras (geometric aspects of tameness)
Sverre Smal*, University of Trondheim. Finite dimensional algebras (homological aspects)
Michel Van den Bergh*, University of Limburg. Noncommutative algebraic geometry and quantum groups
Daniel Zacharia*, Syracuse University. Finite dimensional algebras (homological aspects)

Applications of Curves over Finite Fields

Sunday, July 27, to Thursday, July 31

Michael Fried, University of California, Irvine, chair

Conference Description
The area starts with Galois and Gauss. Group theory and exponential sums were the two main themes then. That tradition continues in this century. The introduction of Chevalley groups over finite fields led to the structure theory of finite simple groups. Wall’s classical result on the Riemann Hypothesis for curves over finite fields is the basis for vital error estimates in combinatorics and number theory.

Two most important and sophisticated modern developments related to finite fields occurred during the last two decades. They are the classification of finite simple groups and the general Riemann Hypothesis over finite fields as proved by Deligne. As recent extensive activities demonstrate, these two deep results provide systematic working tools to a vast number of finite field application problems arising from coding theory, combinatorics and number theory. When one of these tools applies, it is powerful. When both tools apply, it is extraordinary. These tools are not isolated. They are connected, for instance, via monodromy groups of Galois coverings, the Chebatare densities theorem and the Riemann Hypothesis over finite fields.

Unfortunately, due to the depth and technicality of these theories, few people truly understand them well. Even fewer (if any) are experts in both. Our feeling is that there is an urgent need to make these powerful tools more easily accessible, particularly to researchers working in applied areas and to graduate students. At the same time, there is also an urgent need to make important applied problems available to theoretical researchers who may have the necessary tools to attack these problems. Our proposed conference serves such purposes. It also provides an excellent opportunity for high level interactions for different groups of people with rather diverse backgrounds. There will be exposition on advanced research tools as well as deeper illustrations in specific application. The scientific level of most talks would be very high and stimulating.

Topics
The topics to be included are broadly classified as follows.
(a) Galois groups of coverings over finite fields. This includes the inverse Galois problems over finite fields, Abhyankar conjectures, exceptional coverings, applications of the classification of finite simple groups in finite fields.
(b) L-functions and modular curves over finite fields. This includes various consequences of Deligne-Weil estimate for character sums, Dwork’s $p$-adic approach to $L$-functions, construction of varieties over finite fields with
Conferences

many or few rational points, modular curves over finite fields, the theory of algebraic curves over finite fields.
(c) Applications of (a) and (b) in coding theory, graph theory and combinatorics. This includes algebraic geometric codes and Ramanujan graphs.
(d) Effective algorithms over finite fields. This includes factorization of polynomials, construction of generators for finite fields, explicit construction of rational points on a variety, pseudo-random number generators, Galois stratification procedures.

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1-800-321-4267 (401-455-4000 worldwide); Fax 401-331-3842; e-mail cust-serv@ams.org

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Mailing Address __________________________________

Telephone __________________________ Fax __________

Email Address __________________________

**Badge Information**

Affiliation __________________________

Please limit affiliation to 35 characters

Name to appear on badge __________________________

**Registration Fees**

**Joint Meetings**

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<thead>
<tr>
<th>Category</th>
<th>Member AMS, ASL, CMS, MAA, SMM</th>
<th>Nonmember</th>
<th>Grad Student</th>
<th>Undergrad</th>
<th>High School</th>
<th>Unemployed</th>
<th>Temporarily Employed</th>
<th>Third World Fee</th>
<th>Emeritus Member of AMS or MAA</th>
<th>High School Teacher</th>
<th>Librarian</th>
<th>One-day Member</th>
<th>One-day Nonmember</th>
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**Statistical Information:**

☐ I am a mathematics department chair.

**Event Tickets**

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**TOTAL for Event Tickets** $______

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<tr>
<td><strong>TOTAL Amount Due</strong></td>
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**Method of Payment**

☐ Check. Make checks payable to the AMS. Canadian checks must be marked "U.S. Funds".

☐ Credit Card. VISA, MasterCard, AMEX, Discover accepted

Card Number: ____________ Expiration Date: ____________

**Student Activities**

- Mathchats (no charge)
- MAA Student Workshop (no charge)

**MAA Minicourses:** See separate form in October issue.

**Deadlines**

- Room lottery: **October 31, 1996**
- Reservations, listing of resumes/job descriptions in Winter Lists: **November 15, 1996**
- Reservation changes/cancellations through MMSB: **December 9, 1996**
- Advance registration, Employment Register, Short Courses, banquets: **December 20, 1996**
- 50% Refund on banquets: **December 20, 1996**
- 50% Refund on advance registration: **January 3, 1997**

*no refunds after this date*
**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 contracted rates listed. All rates are subject to a 10.5% 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

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<th>Departure Date</th>
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<th>Child □ (give age)</th>
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<th>Quad 2 beds</th>
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</table>

**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.

**Special Housing Requests:**

Priority consideration will be given to all participants with special needs and they will be assigned to properties that are in compliance with the ADA.
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: g_harris@ams.org; 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: g_friedlander@ams.org; telephone: 312-996-3041.

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:

1996
November 1-3 Columbia, Missouri p. 1421
November 16-17 Pasadena, California p. 1421

1997
January 8-11 San Diego, California Annual Meeting p. 1423
March 21-22 Memphis, Tennessee p. 1424
April 12-13 College Park, Maryland p. 1425
April 19-20 Corvallis, Oregon p. 1426
May 2-4 Detroit, Michigan p. 1426
June 26-28 Republic of South Africa p. 1426
September 26-28 Montreal, Canada p. 1427
October 10-12 Atlanta, Georgia p. 1427
October 24-26 Milwaukee, Wisconsin p. 1428
November 8-9 Albuquerque, New Mexico p. 1428
December 4-7 Oaxaca, Mexico p. 1428

1998
January 7-10 Baltimore, Maryland Annual Meeting p. 1428
March 20-21 Louisville, Kentucky p. 1429
March 27-28 Manhattan, Kansas p. 1429

Conferences:

1997:
January 6-7: AMS Short Courses on Applications of Computational Algebraic Geometry and Mathematical Finance, San Diego, CA. See October 1996, pp. 1296-1304, for details.
June 29–July 19: Summer Research Institute, Differential geometry and control, University of Colorado at Boulder. See October 1996, p. 1304, for details.
Instructions for Applicant and Employer Forms

Applicant forms submitted for the Employment Register by the November 15 deadline will be reproduced in a booklet titled *Winter List of Applicants*. Employer forms submitted by the November 15 deadline will be reproduced for the *Winter List of Employers*.

Please use the electronic versions of Applicant and Employer forms ([http://www.ams.org/emp-reg/](http://www.ams.org/emp-reg/)). Paper forms should be submitted only by those who do not have access to e-MATH. See the Employment Register announcement for instructions on accessing e-MATH.

If submitting a paper form, please type carefully. **Do not type outside the box.**

All forms must be received by the Society by **November 15, 1996**, in order to appear in the *Winter List*. If you are attending the meeting, the Advance Registration/Housing Form printed in this issue should accompany the form.

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
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
96 Mathematical education, elementary
97 Mathematical education, secondary
98 Mathematical education, collegiate
EMPLOYER FORM
MATHEMATICAL SCIENCES EMPLOYMENT REGISTER
JANUARY 8-10, 1997
SAN DIEGO, CALIFORNIA

1. Forms should be accessed and submitted electronically if possible. The URL for accessing Employment Register information and forms (as well as other math employment information) is http://www.ams.org/emp-reg.

2. Paper or electronic forms are due, along with payment and your Advance Registration/Housing form, by November 15 (to AMS, P.O. Box 6887, Providence, RI 02940), in order to be included in the Winter List of Employers.

3. Please check if Advance Registration/Housing Form previously sent. □

4. Please list all potential interviewers, for reference by applicants but pay fees only for each separate table.

5. Forms will not be processed until registration and payment of fees have been received.

<table>
<thead>
<tr>
<th>EMPLOYER</th>
</tr>
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<td>Institution __________________________</td>
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| CODE: |
| Department __________________________ |

| CODE: |
| City, State, Zip _________________________ |

| CODE: |
| E-mail address (one only) __________________________ |

| CODE: |
| URL (if applicable) __________________________ |

| CODE: |
| Number of tables needed __________________________ |

| EMPLOYER |
| Name(s) of Interviewer(s) 1. __________________________ |
| 2. __________________________ |
| 3. __________________________ |
| 4. __________________________ |

| EMPLOYER |
| Specialties sought __________________________ |

| EMPLOYER |
| Title(s) of position(s) __________________________ |

| EMPLOYER |
| Number of positions __________________________ |

| EMPLOYER |
| Starting date __________ / __________ |

| EMPLOYER |
| Term of appointment __________ / __________ |

| EMPLOYER |
| Renewal __________ / __________ |

| EMPLOYER |
| Tenure-track position □ Yes □ No |

| EMPLOYER |
| Degree preferred __________________________ |

| EMPLOYER |
| Degree accepted __________________________ |

| EMPLOYER |
| Duties __________________________ |

| EMPLOYER |
| Experience preferred __________________________ |

| EMPLOYER |
| Significant other requirements, needs, or restrictions which will influence hiring decisions __________________________ |

| EMPLOYER |
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**JANUARY 8-10, 1997**

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<table>
<thead>
<tr>
<th>APPLICANT CODE:</th>
<th>Last name</th>
<th>First name</th>
<th>Mailing address (include zip code)</th>
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<tr>
<th>E-mail address (one only)</th>
<th>URL (or other contact info)</th>
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<tbody>
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</table>

- **Specialties** ___________________________________

- **DESIRED POSITION:**
  - Academic: ☐ Research ☐ University Teaching ☐ College Teaching: ☐ 4-year ☐ 2-year
  - Would you be interested in nonacademic employment? ☐ Yes ☐ No
  - Available mo. __ /yr. ___
  - Significant requirements (or restrictions) which would limit your availability for employment

- **PROFESSIONAL ACCOMPLISHMENTS:**
  - Significant achievements, research or teaching interests
  - ______
  - ______

- **Paper to be presented at this meeting or recent publication**
  - ______

- **Degree Year (expected) Institution**
  - ______
  - ______

- **Number of referred papers accepted/published**
  - ______

- **PROFESSIONAL EMPLOYMENT HISTORY:**
  - Employer Position Years
  - 1. ______ ______ ______
  - 2. ______ ______ ______
  - 3. ______ ______ ______

- **References (Name and Institution only)**
  - ______
  - ______

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