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Notices

of the American Mathematical Society

September 2003 **Volume 50, Number 8**

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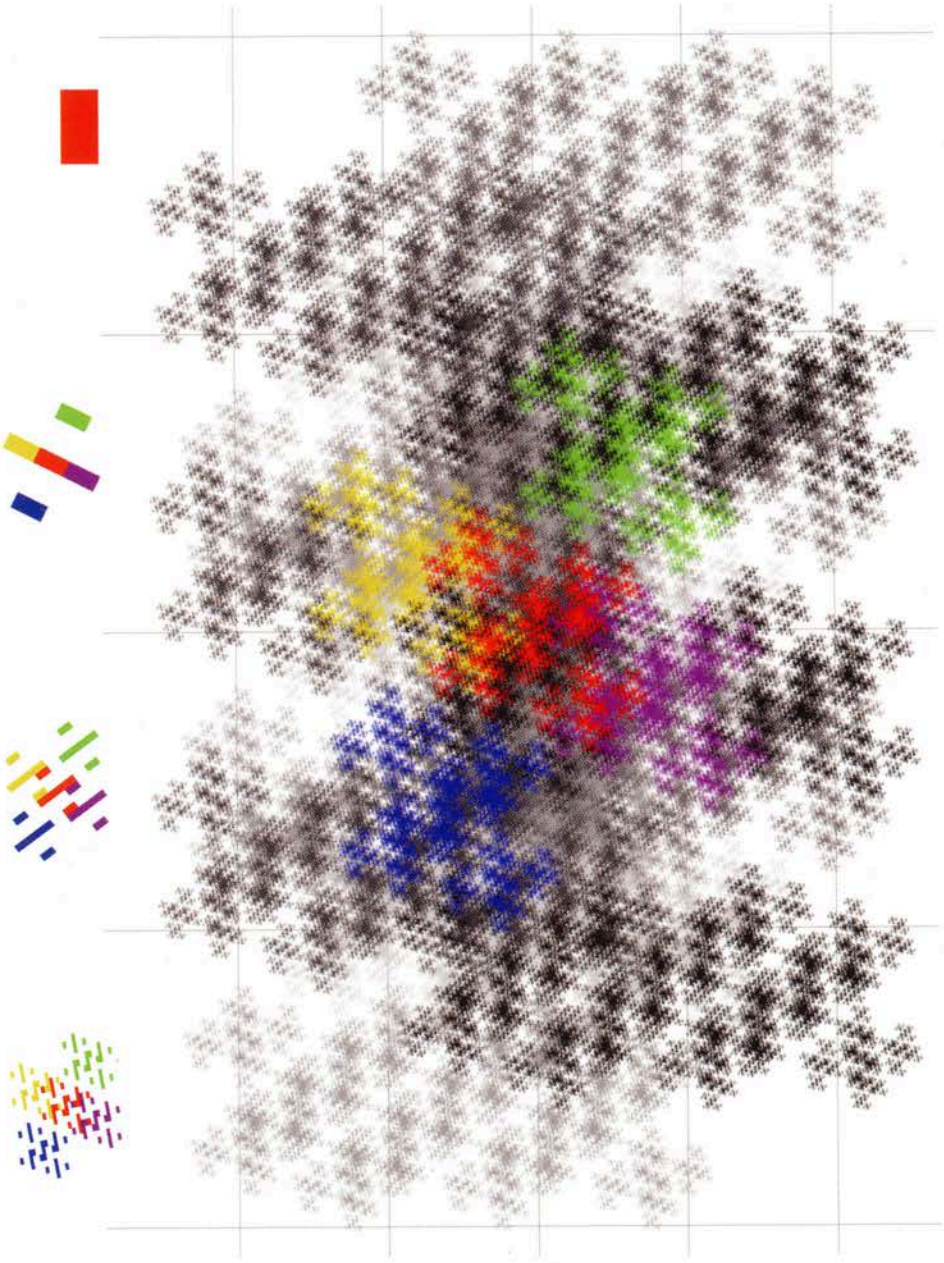

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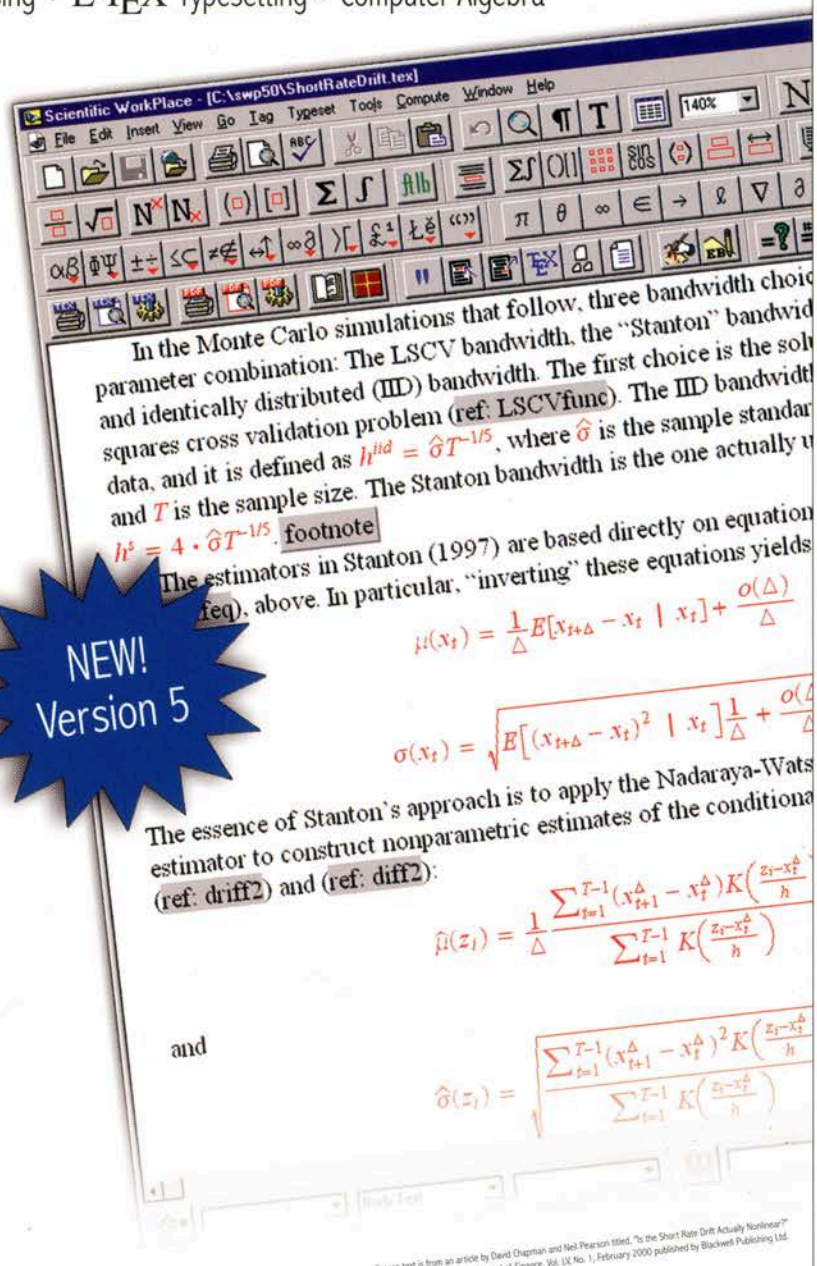

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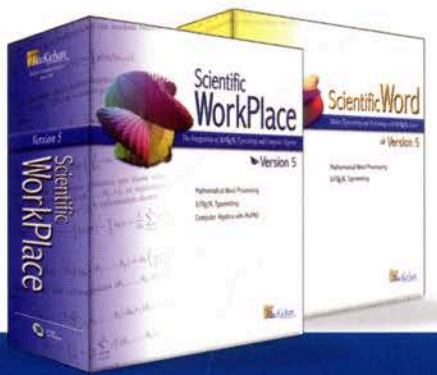

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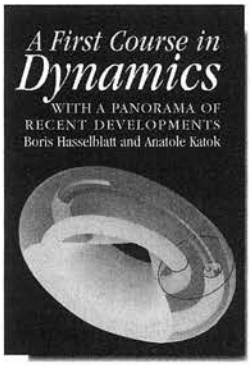

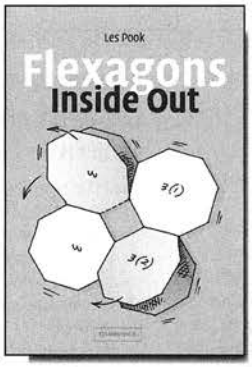

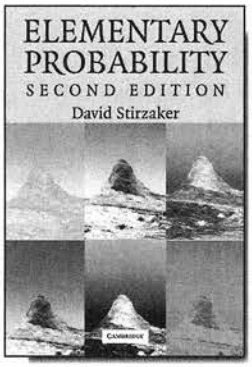

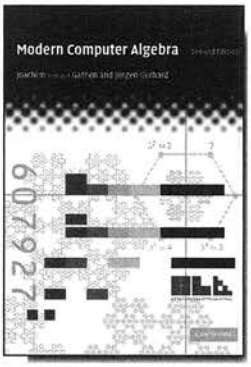

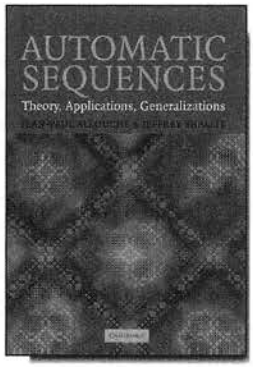

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Notices

of the American Mathematical Society

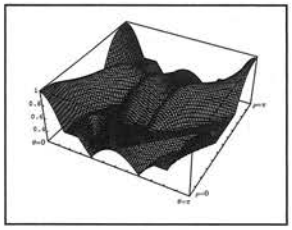
September 2003

Feature Articles

880 Matrix Factorizations, Algorithms, Wavelets

Palle Jorgensen

Wavelets are now about two decades old, and their theory and applications continue to expand. Here the author focuses on understanding families of wavelets through algorithms based on matrix factorizations.



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This article presents the author's views on some critical issues for doctoral education in mathematics in the United States: the goals, the challenges, the promise, and the prospects for change.

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From the AMS Secretary

Special Section—Election of Officers for 2004 965

AMS Standard Cover Sheet 988

Does Your Vote Matter (in AMS Elections)?

Last week my eleven-year-old nephew emailed to ask "about a debate that Mama and I have been having, the question does it matter whether or not you vote? I'm not talking about it ethically since I know it's good to vote and exercise your right as an American citizen; I'm talking about it mathematically. I think that unless the election comes down to 1 vote it really doesn't matter whether you vote or not because you're not changing the outcome of the election." Since this issue of the *Notices* contains information about the annual AMS election (see page 965), I decided to write my reply in the form of this editorial column.

There are certainly examples in history in which a change of one vote could have reversed the outcome. In the 1868 trial of President Andrew Johnson in the U.S. Senate, 35 of 54 senators voted for conviction (one vote fewer than the two-thirds required to remove the president from office). Turning to more recent events, I note that about one-quarter of the cases heard by the U.S. Supreme Court over the past three years were decided by a vote of 5 to 4.

One expects that in an election in which many votes are cast, the likelihood of the outcome depending on a single vote is small. Consider the AMS election, in which typically a few thousand votes are cast. A combinatorial counting argument shows that if voters were to mark their ballots randomly for one or the other of two candidates, the probability that one extra vote could change the outcome is on the order of 1 or 2 percent.

An individual voter does not know ahead of time, though, what the margin of victory will be in the election, so it is impossible to predict whether one's vote would make a difference to the result. Even in an election with millions of eligible voters, where the mathematical probability of a result exactly on the borderline is a fraction of 1 percent, the margin of victory could well be within the margin of error of the vote-counting mechanism. If the citizens registered to vote in Florida had known in advance how close the year 2000 U.S. presidential election would be, no doubt many more of them would have showed up at the polls on election day.

When the result of an election is not in doubt, an individual's vote may nonetheless be valuable. A candidate who wins an election by a large margin is in a strong political position to implement changes, while a losing candidate who makes a strong showing has a good chance of promoting a minority agenda.

Of course one may question whether winning an election by 1,000 votes is significantly different from winning by 1,001 votes. The question may be recast as a version of the ancient *sorites* (or heap) puzzle. A winning margin of one vote is not a landslide, nor is a margin of two votes, nor ...; yet winning an AMS election by 1,000 votes is a landslide. At what size does a margin of victory become a landslide?

Since the sorites paradox has exercised philosophers for two thousand years, I will not try to resolve the puzzle here. I will, however, suggest an analogy to the idea that one individual's vote is valueless in a decisive election. One might just as well say that in a basketball game between unequal teams, there is no motivation for either side to try to score, because any one particular basket is almost certainly not going to decide the game. I say that if there is value in playing the game, there is equally value in voting in the election.

Why then is the turnout low in many elections? According to the Secretary, about 12 percent of the members typically vote in the AMS election. Apparently most members have felt that participating in the affairs of the Society has less value to them than a few minutes of their time and a three-bit stamp. Although this year's new electronic voting option may increase the turnout, I would be surprised if a majority of members cast ballots.

A possible explanation is implicit in the famous 1968 essay by Garrett Hardin, titled "The tragedy of the commons". The essay suggests that if individuals are motivated solely by immediate direct payoffs, then a catastrophe inexorably follows for the whole society, as when overfishing of the oceans results from many individuals seeking to maximize their take of an ever-diminishing resource. The idea is similar to the "prisoner's dilemma" in game theory, in which two persons hoping to maximize their individual returns end up with a result disastrous to both.

The happy news is that (in view of the Archimedean principle) many small actions directed toward the betterment of a Society can collectively achieve a great common good. In my view, this is the significant reason to be involved in the Society's affairs, if only by voting in the election.

—Harold P. Boas, Editor

Letters to the Editor

On Calculus Texts

In all of the U.S. universities where I have taught calculus so far, students are expected to buy what is called a required calculus text. Some of the students (usually the best students in their classes) try to study mathematics, reading the required calculus texts. As far as I know, such reading is a painful experience for those who have tried. I explain this phenomenon in the following way.

To be interesting and useful reading for mathematically oriented students, a calculus text should contain:

1. Accurate, written-for-beginners proofs of the results of the course which do not belong to Foundations of Mathematics, in their logical order. The most well-known examples of the style that I mean are the books: G. H. Hardy, *A Course of Pure Mathematics*; and G. H. Hardy, J. E. Littlewood, and G. Polya, *Inequalities*.

2. Interesting, nonroutine problems of different levels of difficulty, with hints and possibly solutions.

On the other hand, to have a good chance to be adopted as required, a calculus text should contain as much as possible of the following:

3. Understandable-for-an-average-student discussions of all typical problems from all topics usually included in calculus courses at universities of the U.S., pictures and tables that can help average students to use the standard calculus algorithms and to solve typical exam problems, and attractive printing and layout. The discussions are to be written in such a way that one can read them without reading the theoretical part of the text. (The majority of students never reads the theoretical part.)

4. Routine exercises of all natural types and correct answers to odd-numbered exercises at the end of the text. The selection of exercises requires a lot of work, because randomly selected they can lead to very lengthy and complicated (and not so useful and instructive) computations. Also, it is highly desirable to publish a *Student Solution Manual* with properly written correct solutions of all odd-numbered exercises.

It does not seem impossible in principle to produce a calculus text satisfying all of the conditions listed above. I can even imagine a text containing separate theoretical sections, discussion sections, exercise sections, and problem sections. However, I do not know any examples of calculus texts satisfying all of the listed conditions. One of the reasons for this I see in the fact that different tasks (among those listed above) require quite different skills from the author(s). Another reason is that a high level in each of the directions can be achieved only after many "successive approximations" and only if the authors systematically use ideas of their predecessors.

I think that a calculus text satisfying the conditions listed above can be written only as a result of collective efforts of many mathematicians. Also, I think that such a text should not have a fixed, definite list of authors. Instead, the authorship should belong to an authoritative organization of mathematicians, such as the AMS, MAA (Mathematical Association of America), or SIAM (Society for Industrial and Applied Mathematics), or to a funding organization, such as the NSF (National Science Foundation). Since the topic list in calculus is in a state of constant change, the main advantage of collective authorship is that the text could be changed on a regular basis over an indefinite period of time. Also, collective authorship will help to remove (eventually) misprints and errors from the text. To produce a high-quality calculus text, it is important to encourage all users to participate in the text improvement. In this connection it is necessary to develop different forms of sharing some part of the income from the sales of the text with those people whose suggestions are used to improve the text.

—Mikhail I. Ostrovskii
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(Received May 20, 2003)

Peer Review

In the thoughtful series of essays on peer review in the June/July 2003 issue, Steven G. Krantz writes, "A dean whose pedigree is in Celtic history is probably something of a Luddite and is (in my experience) likely to be most comfortable with traditional, hard-copy, refereed journals." The stereotype of the technophobic humanist compared to the e-adept scientist is oversimplified and no longer valid, if indeed it ever was. Humanists have been making electronic texts for nearly as long as there have been computers, and have been publishing peer-reviewed electronic materials since before the creation of the Web (`http://ccat.sas.upenn.edu/bmcr/about.html` notes two journals that started near the end of 1990).

The humanist deans of my experience respect good online work in refereed journals or at refereed publication sites like the Stoa Consortium (`http://www.stoa.org`). While we may not know the relative reputation ranking of journals in mathematics (or any other field but our own), humanists will not immediately assume that all online journals are inferior to all print journals.

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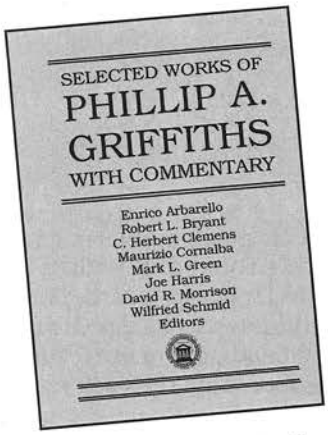
Selected Works of Phillip A. Griffiths with Commentary

IMPORTANT NEW TITLE



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Over the last four decades, Phillip Griffiths has been a central figure in mathematics. During this time, he made crucial contributions in several fields, including complex analysis, algebraic geometry, and differential systems. His books and papers are distinguished by a remarkably lucid style that invites the reader to understand not only the subject at hand, but also the connections among seemingly unrelated areas of mathematics. Even today, many of Griffiths' papers are used as a standard source on a subject. His writings often bring together classical and modern mathematics.

The four parts of *Selected Works—Analytic Geometry*, *Algebraic Geometry*, *Variations of Hodge Structures*, and *Differential Systems*—are organized according to the subject matter and are supplemented by Griffiths' brief, but extremely illuminating, personal reflections on the mathematical content and the times in which they were produced.

Griffiths' *Selected Works* provide readers with a panoramic view of important and exciting mathematics during the second half of the 20th century.

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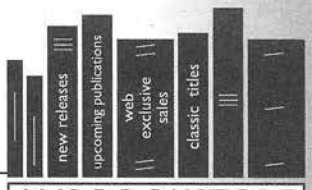

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9/03

Matrix Factorizations, Algorithms, Wavelets

Palle E. T. Jorgensen

with illustrations by Brian Treadway

A math story: When I was little, growing up in Denmark, before kindergarten—only there wasn't any then—so before I heard of *The Tinder Box* or *The Ugly Duckling* from the books of Hans Christian Andersen, my father told me about low-pass and high-pass filters. He was a telephone engineer and worked on the filters used in signals transmitted over long cables, just after World War II. The "high" and "low" part of the story refers to frequency bands of the sound signals. Not that this meant much to me at the time. Rather, I was fascinated by the pictures in the electrical engineering journals that were stacked up on the floor next to me, and I spent hours looking at them (that was all there was, there on the floor!), so these pictures[1] of filter design, some in color, occupied me on long Sundays while my dad was building instruments in the living room. Nothing else for me to do! Then, after going to school I forgot all about my dad's explanation of quadrature mirror filters (no wonder!) and they were out of mind for a very long time. I never had any particular reason to think much about them at all, I mean the low-pass frequency bands and all that, but I am sure they in some strange way created a lasting visual impression on me. If I heard them mentioned later, I might have been slightly amused but no more than that. Perhaps not before wavelet math, or rather my interests in wavelets in the late 1980s, did all of that stuff about frequency bands gradually resurface from out of a mist recalled from the back reaches of my mind.

It was only after I grew up and matured that I realized how these subband filters define operators in Hilbert space which satisfy all kinds of abstract relations, now known as Cuntz and Cuntz-Krieger relations and thought in some circles to have been invented in 1977 by Cuntz or in 1965 by Dixmier. These are tools from math that I had gotten involved with in the late 1970s for completely different reasons. My impression is that the operator relations that are called the Cuntz relations in math go way back, probably back to before I was born, and they are and have been used every day, and twice on Sundays, ever since by signal processing engineers and others I probably don't even know about—in addition to their extensive use in several areas of math! Our matrix functions from math are actually called polyphase matrices by engineers, and they are scattering matrices in other circles, and quantum gates in physics. In fact a lot of the things we do in operator theory are known and used in other fields but are known under different names and in different ways. And important for different reasons! In any case, they *are* really important and for all kinds of good reasons, not least of which is their rediscovery in operator algebras and in wavelets.

Discussions between engineers and mathematicians, both pure and applied, have always seemed to me somewhat surrealistic. Independent lines of thinking fortuitously converge on a common ground of some algorithms and some matrix tricks, but the strands might well come from vastly different vantage points in their approach to a particular subject, reflected in the multiplicity of terminology that is used, i.e., the same mathematical term being assigned different names by the

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[1] *These very same pictures are now popular in wavelet books; see, e.g., [Mal99], [Dau92, pp. 262 and 315], and [StNg96]. The back cover of [StNg96] offers a variant of the diagrams, and the idea they represent is now getting belated recognition in math circles.*

different groups, and yet the discussion is about the same fundamental underlying idea. See an abbreviated dictionary at the end of this paper. The diverse approaches share a common central mathematical concept. I think few of us so far really have made a conscious effort to articulate this in a way that rings bells with all the diverse communities: (1) the telephone engineer who is wondering about signals with discrete time and trying to model the transmission of sound in optical cables and working on filtering out noise in the receiving end; (2) the graphics designer from computer science or from computational geometry who is doing subdivisions; (3) the engineer who is building chips for data compression in his/her attempts at digitizing archives of fingerprints stored in analog form or chips for JPEG 2000 implementations; and, finally, (4) the mathematician, perhaps the last one in the bunch, who is searching for wavelets with the best smoothness or wavelets with a shorter pyramid algorithm. Each one of them, the practitioner from one or the other of the communities, invents his or her tools quite independently of the others; and the connections, those that are understood up to now, are only realized with hindsight, often only much later, after the fact. But we have to first look for these connections, and this present attempt is the tip of the iceberg—a start, at least.

What Is a Wavelet? In its simplest form, it is a function ψ on the real line $\mathbb{R}$ such that the doubly indexed family $\{2^{n/2}\psi(2^n x - k)\}_{n,k\in\mathbb{Z}}$ provides a basis for all the functions in a suitable space such as $L^2(\mathbb{R})$. Since $L^2(\mathbb{R})$ comes with a norm and inner product, it is natural to ask that the basis functions be normalized and mutually orthogonal (but many useful wavelets are not orthogonal). The analog-to-digital problem from signal processing concerns the correspondence

$$f(x) \longleftarrow c_{n,k} \tag{1}$$

for the representation

$$f(x) = \sum_{n\in\mathbb{Z}} \sum_{k\in\mathbb{Z}} c_{n,k} 2^{n/2} \psi(2^n x - k). \tag{2}$$

We will be working primarily with the Hilbert space $L^2(\mathbb{R})$, and we allow complex-valued functions. Hence the inner product $\langle f \mid g \rangle = \int \overline{f(x)}\, g(x)\, dx$ has a complex conjugate on the first factor in the product under the integral sign. If f represents a signal in analog form, the wavelet coefficients $c_{n,k}$ offer a digital representation of the signal, and the correspondence between the two sides in (1) is a new form of the analysis/synthesis problem, quite analogous to Fourier's analysis/synthesis problem of classical mathematics. One reason for the success of wavelets is the fact that the algorithms for the problem (1) are faster than the classical ones in the context of Fourier.

Other efficient algorithms include the fast Fourier transform [Wic94] applied to digitized signals. It is based on dyadic scaling, a feature it shares with the hierarchical wavelet algorithms. But the latter have further advantages related to localization (see, e.g., [Mal99] and [Mey00, §11]): At discontinuities or sharp spikes, the edge effects for wavelet algorithms in the analog-to-digital problem are moderate, and they do not build up as in the Gibbs phenomenon with Fourier-based tools. An intrinsic feature of the subdivision scheme of wavelets is that the edge effects are concentrated in a few large wavelet coefficients, allowing us to neglect the rest; the asymptotic gain compared to Fourier series is exponential. A color picture is usually made up of a few homogeneous chunks of different colors or shades, one separated from the others by edges. It is for this reason that the wavelet algorithm is so much more efficient in digitizing graphics than are the alternative Fourier-based algorithms. Similarly, for signals, wavelet analysis breaks up $f(x)$ into its frequency components, with each component in a resolution in time that is matched to its scale.

Resolution and Detail

Mathematically, a *multiresolution* is a telescoping family of closed subspaces in some Hilbert space, doubly infinite but generated by a single operator U and a single subspace $\mathcal{V}_0$. The operator U represents some scaling, and $\mathcal{V}_0$ some fixed resolution, for example, step functions of step size one; the larger spaces in the family represent a finer resolution, and the smaller spaces coarser resolutions. When applied to signal processing or to optics, each resolution space is assigned a band of frequencies.

Matrix factorizations have a long history as a tool for designing fast algorithms. Factorizations have been used from the beginning in classical algorithms of signal processing and, more recently, in wavelet subdivision schemes. Since algorithms for quantum information are also based on factorization of unitary matrices, it is not surprising that the subdivision-wavelet algorithms have proved to adapt especially well to the realm of qubits in quantum theory: see, for example, [PBK03] in the case of the Grover search algorithm.

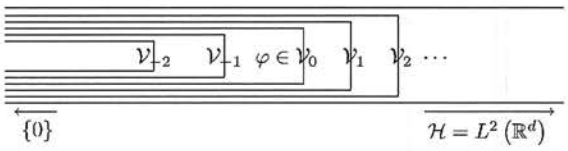
The wavelet algorithms can be cast geometrically in terms of subspaces in Hilbert space which describe a scale of resolutions of some signal or some picture. They are tailor-made for an algorithmic approach that is based upon unitary matrices or upon functions with values in the unitary matrices. Wavelet analysis takes place in some Hilbert space $\mathcal{H}$ of functions on $\mathbb{R}^d$, for example, $\mathcal{H} = L^2(\mathbb{R}^d)$. An indexed family of closed subspaces $\{\mathcal{V}_n\}_{-\infty<n<\infty}$ such that

$$\mathcal{V}_n \subset \mathcal{V}_{n+1}, \qquad \bigcap_{n\in\mathbb{Z}} \mathcal{V}_n = \{0\}, \qquad \text{and}$$

$$\bigvee_{n\in\mathbb{Z}} \mathcal{V}_n = L^2\left(\mathbb{R}^d\right) \tag{3}$$

is said to offer a *resolution.* (To stress the *variety* of spaces in this telescoping family, we often use the word *multiresolution.*) Here the symbol $\bigvee$ denotes the closed linear span. In pictures, the configuration of subspaces looks like:

The subspaces of a resolution

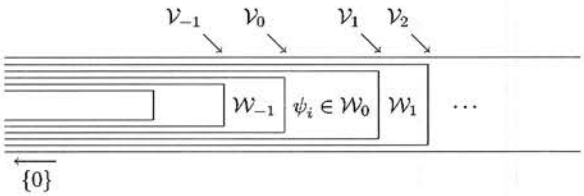


Remember when shopping for a new digital camera: just as important as the resolutions themselves (as given here by the scale of closed subspaces $\mathcal{V}_n$) are the associated spaces of *detail.* As expected, the details of a signal represent the relative complements between the two resolutions, a *coarser* one and a more *refined* one. **Starting with the Hilbert-space approach to signals,** we are led to the following closed subspaces (relative orthogonal complements):

$$\begin{aligned} \mathcal{W}_n &:= \mathcal{V}_{n+1} \ominus \mathcal{V}_n \\ &= \{f \in \mathcal{V}_{n+1} : \langle f \mid h\rangle = 0,\ h \in \mathcal{V}_n\}, \end{aligned} \tag{4}$$

and the signals in these intermediate spaces $\mathcal{W}_n$ then constitute the amount of detail which must be added to the resolution $\mathcal{V}_n$ in order to arrive at the next refinement $\mathcal{V}_{n+1}$. In the diagram below, the intermediate spaces $\mathcal{W}_n$ of (4) represent incremental details in the resolution.

Incremental Detail



The simplest instance of this is the one which Haar discovered in 1910 [Haa10] for $L^2(\mathbb{R})$. There, for each $n \in \mathbb{Z}$, $\mathcal{V}_n$ represents the space of all step functions with step size 2^{-n}, i.e., the functions f on $\mathbb{R}$ which are constant in each of the dyadic intervals $j2^{-n} \le x < (j+1)\,2^{-n}$, $j = 0, \dots, 2^n - 1$, and their integral translates, and which satisfy $\|f\|^2 = \int_{-\infty}^{\infty} |f(x)|^2\, dx < \infty$. The inner product for Haar is the familiar one,

$$\langle f \mid h\rangle = \int_{-\infty}^{\infty} \overline{f(x)}\, h(x)\, dx, \tag{5}$$

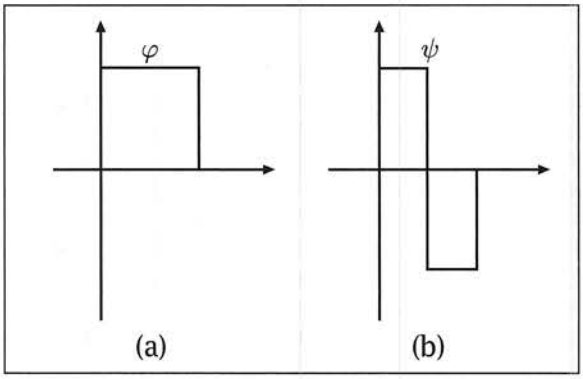


Figure 1. Haar wavelet functions.

and similarly for our present $L^2(\mathbb{R}^d)$, with the modification that the integration is now over $\mathbb{R}^d$.

An operator U in a Hilbert space is *unitary* if it is onto and preserves the norm or, equivalently, the inner product. Unitary operators are invertible, and $U^{-1} = U^*$ where the * refers to the adjoint. Similarly, the orthogonality property for a projection P in a Hilbert space may be stated purely algebraically as $P = P^2 = P^*$. The adjoint * is also familiar from matrix theory, where $(A^*)_{i,j} = \overline{A_{j,i}}$: in words, the * refers to the operation of transposing and taking the complex conjugate. In the matrix case, the norm on $\mathbb{C}^n$ is $\left(\sum_k |x_k|^2\right)^{1/2}$. In infinite dimensions, there are isometries which map the Hilbert space into a proper subspace of itself.

For Haar's case we can scale between the resolutions using $f(x) \mapsto f(x/2)$, which represents a dyadic scaling.

To make it unitary, take

$$U = U_2 : f \longmapsto 2^{-\frac{1}{2}} f\left(\frac{x}{2}\right), \tag{6}$$

which maps each space $\mathcal{V}_n$ onto the next coarser subspace $\mathcal{V}_{n-1}$, and $\|Uf\| = \|f\|$, $f \in L^2(\mathbb{R})$. This can be stated geometrically, using the respective *orthogonal projections* P_n onto the resolution spaces $\mathcal{V}_n$, as the identity

$$UP_nU^{-1} = P_{n-1}. \tag{7}$$

And (7) is a basic geometric reflection of a self-similarity feature of the cascades of wavelet approximations. It is made intuitively clear in Haar's simple but illuminating example, included below. The important fact is that this geometric self-similarity, in the form of (7), holds completely generally. Moreover, it serves as a tool for generating new wavelets and for analyzing them. A crucial observation Haar made in his 1910 paper was that the box-wavelet of Figure 1 is actually singly generated. Without making it explicit, Haar also further noticed a special case of what is now called *multiresolution analysis* (MRA). Haar considered the two functions

$$\varphi = \chi_{[0,1)} \qquad \text{and} \qquad \psi = \chi_{[0,1/2)} - \chi_{[1/2,1)} \tag{8}$$

shown in Figures 1(a) and 1(b), where we use χ to denote the indicator function. With these two functions, φ and ψ, it is clear that

$$\mathcal{V}_0 = \bigvee \{\varphi(\cdot - k) : k \in \mathbb{Z}\} \quad \text{and}$$
$$\mathcal{W}_0 = \bigvee \{\psi(\cdot - k) : k \in \mathbb{Z}\},$$

where $\bigvee$ denotes the closed linear span of the functions inside { }. Similarly, using the translation operators

$$(T_y f)(x) := f(x - y), \qquad f \in L^2(\mathbb{R}),\ y \in \mathbb{R},$$

and the relation

$$UT_yU^{-1} = T_{2y}, \qquad y \in \mathbb{R}, \tag{9}$$

we get

$$\begin{aligned} \varphi(x) &= \varphi(2x) + \varphi(2x-1), \\ \psi(x) &= \varphi(2x) - \varphi(2x-1), \end{aligned} \tag{10}$$

and, for each $n \in \mathbb{Z}$,

$$\mathcal{V}_n = \bigvee_{k\in\mathbb{Z}} \varphi(2^n x - k), \tag{11}$$

representing the closed subspace generated by all the $\mathbb{Z}$-translates as specified, and

$$\mathcal{W}_n = \bigvee_{k\in\mathbb{Z}} \psi(2^n x - k). \tag{12}$$

From Haar to Daubechies

While the identities (10) and the properties sketched in (11) are in fact clear from inspection of the shapes in Figure 1, the first surprise in wavelet theory is that smooth wavelet shapes, represented by differentiable functions φ and ψ of compact support, are also possible and with the functions satisfying the exact same resolution properties which were first noticed in a very special (nonsmooth) case by Alfred Haar. We now turn to this crucial issue.

The issue of differentiability of wavelets is a rather large subject. We will only be able to touch on it here. Our viewpoint is that when the support size is specified, then we are able to display a corresponding variety of wavelets. The next step then is to identify the most differentiable specimens in the variety. This is in fact an area with current and exciting research, much of it dictated by applications, but to get started we first need easy matrix formulations which facilitate computations. The tools are somewhat technical. Here is a sample of them, identified by their technical names: (i) the vanishing moment method (based on polynomial factorization), (ii) the joint spectral radius method (a clear-cut test, but difficult to apply), (iii) the dominant eigenvalue test (sketched in Figure 5 below), (iv) the spin vector test. This last one amounts to writing the so-called polyphase matrix function $z \mapsto G(z)$ as a product of matrix functions $zp + p^\perp$ where p is a rank-one projection in some $\mathbb{C}^N$; i.e., p is the projection onto some $\mathbf{v} \in \mathbb{C}^N$, $\|\mathbf{v}\| = 1$. By adjusting the configuration of vectors $\mathbf{v}$ contributing to the product factorization for $G(z)$, the more differentiable wavelets can be identified with a search algorithm. The graphics around Figures 5 and 6 may help the reader to visualize method (iv). Figure 6 picks out a particular sample of configurations of two spin vectors. We explain below how variations of a single unit vector $\mathbf{v}$ in $\mathbb{C}^2$ describe a variety of dyadic wavelets supported from 0 to 3 on the x-axis, while two independently moving spin vectors, i.e., unit vectors $\mathbf{v}_1$ and $\mathbf{v}_2$ in $\mathbb{C}^2$, describe the variety of wavelets supported in $[0, 5]$.

Hermitian projections, especially finite-dimensional and one-dimensional ones, along with issues arising from their interactions and compositions, form a chapter of lore in complex geometry and in complex Hilbert space as it is used in quantum theory. This framework describes the wavelet varieties perfectly: First recall that the complex n-dimensional subspaces in $\mathbb{C}^N$ are viewed as, and are by definition, points in the Grassmannian $G(n, N)$. And, starting with Wolfgang Pauli, $n = 1$, $N = 2$, it is popular to identify points in three pairwise isomorphic manifolds, (A)–(C), described as follows (for details see, for example, [BrJo02]): (A) $G(1, 2)$; (B) the two-sphere S^2, which goes under the name "the Bloch sphere" in physics circles (to Pauli, a point in S^2 represents the state of an electron or of some spin-1/2 particle, and the points in the open ball inside S^2 represent mixed states); and, finally, (C) equivalence classes of unit-vectors in $\mathbb{C}^2$, where equivalence of vectors $\mathbf{u}$ and $\mathbf{v}$ is defined by $\mathbf{u} = c\mathbf{v}$ with $c \in \mathbb{C}$, $|c| = 1$. With this viewpoint, a one-dimensional projection p in $\mathbb{C}^N$ is identified with the equivalence class defined from a basis vector, say $\mathbf{u}$, for the one-dimensional subspace $p(\mathbb{C}^N)$ in $\mathbb{C}^N$. A nice feature of the identifications $N = 2$ is that if the unit-vectors $\mathbf{u}$ are restricted to $\mathbb{R}^2$, sitting in $\mathbb{C}^2$ in the usual way, then the corresponding real submanifold in the Bloch sphere S^2 is the great circle: the points $(x, y, z) \in S^2$ given by $y = 0$. To Pauli, S^2, as it sits in $\mathbb{R}^3$, helps clarify the issue of quantum observables and states. Pauli works with three spin-matrices for the three coordinate directions, x, y, and z. They represent observables for a spin-1/2 particle. States are positive functionals on observables, so Pauli gets a point in $\mathbb{R}^3$ as the result of applying a particular state to the three matrices. The pure states give values in S^2. Recall that pure states in quantum theory correspond to rank-one projections or to equivalence classes of unit-vectors. When this viewpoint is applied to the wavelet formulation, we get an economical way of identifying the essential wavelet numbers, i.e., the masking coefficients for the subdivisions of wavelet theory.

Most of the geometry we recall here carries over mutatis mutandis to unit-vectors in $\mathbb{C}^N$. In the wavelet case, the number N represents a fixed scaling. Now

the Grassmannian is $G(1,N)$, $N>2$, but the analogue of the Bloch sphere is a little more complicated. It is worked out in geometry books, such as that of R. O. Wells Jr. [Wel80]. What *is* considerably more complicated mathematics is the parameterization of the variety of states corresponding to several particles. It involves the notion of *entanglement* from quantum theory. For the present purpose, we use a finite set of projections p corresponding to the special $(zp+p^{\perp})$-factors in a factorization of our polyphase matrix $G(z)$, describing a particular wavelet.

The existence of certain differentiable wavelets was discovered in the 1980s; see especially [Dau92]. I. Daubechies's, Y. Meyer's, and A. Cohen's pioneering discoveries opened a floodgate. Since then, new and powerful methods and techniques have emerged that provide constructive algorithms for optimal choices of resolutions and wavelets. These more recent methods, motivated by signal processing, include (i)–(iv) above, and they give existence generally for signals of *compact support*, represented by compactly supported functions in $L^2(\mathbb{R}^d)$. They are also at the core of the many success stories of wavelet algorithms [Coh03], [Mey00] and of harmonic analysis [HeWe96].

When the first wavelet constructions came out in the early 1980s, their significance was in fact not readily accepted or understood, in some cases not believed. Perhaps the first example of J.-O. Strömberg [Str82] was stillborn! What really opened up the subject and enriched both theory and applications was the connection to signal processing. From that came the multiresolutions, the pyramid algorithms, and the applications to data compression, to still image encoding, and more. Connections to signal processing are made in [Dau92] and especially in [Mal99]. Clearly the geometric relations (10), so transparent from Figure 1(a)–(b), invite the following generalization. It takes the form of subdivision operations with masking coefficients, popular in numerical analysis:

$$\varphi(x)=\sqrt{|\det A|}\sum_{k\in\mathbb{Z}^d}a_k\varphi(Ax-k), \tag{13}$$

$$\psi_i(x)=\sqrt{|\det A|}\sum_{k\in\mathbb{Z}^d}b_k^{(i)}\varphi(Ax-k), \tag{14}$$

$$i=1,\dots,|\det A|-1.$$

The numbers (a_k) in (13) are called *masking coefficients* because of the use of (13) in graphics algorithms: there the a-numbers represent the masks in the successive subdivision steps of the algorithm. Here (a_k) and $(b_k^{(i)})$ are scalar sequences indexed by the lattice $\mathbb{Z}^d$, and A is a fixed $d\times d$ matrix over $\mathbb{Z}$. We will assume that the eigenvalues λ of A satisfy $|\lambda|>1$. This generalizes Haar's expansive scaling $x\to 2x$. It is known generally that the wavelets of *compact support* may be described this way using specific systems (a_k) and $(b_k^{(i)})$ of *finite* sequences, i.e., sequences which are identically zero outside a finite subset, Λ say, of $\mathbb{Z}^d$: specifically, $a_k=0$ for all $k\in\mathbb{Z}^d\setminus\Lambda$, and similarly for the sequence $(b_k^{(i)})_{k\in\mathbb{Z}^d}$, $i=1,\dots,|\det A|-1$. Iteration algorithms are used in the solution to the system (13)–(14). When solutions φ and ψ_i to this system can be found in $L^2(\mathbb{R}^d)$, then the starting point of the hierarchical wavelet algorithm is the recursive buildup of the subspaces $\mathcal{V}_n$ and $\mathcal{W}_n$ of (3)–(4) with the use of formulas (19)–(21) below. This can be done with finite matrix algorithms known as subdivision algorithms; see [BrJo02], [Mal99], and [Wic94]. The recursive construction may be visualized in the next example but in a context of fractals.

Example. **Cloud Nine as a Reptile.** (The name *reptile* refers to a tiling property which is self-reproducing in the sense that the picture repeats itself at all scales.) As an example of (13), take $d=2$ and $A=\begin{pmatrix}1&2\\-2&1\end{pmatrix}$. Then $N=\det A=5$, and the five lattice points $D=\left\{\begin{pmatrix}0\\0\end{pmatrix},\begin{pmatrix}\pm3\\0\end{pmatrix},\begin{pmatrix}0\\\pm2\end{pmatrix}\right\}$ represent all the five residue classes for the quotient group $\mathbb{Z}^2/A\mathbb{Z}^2$. The formula $\varphi(x)=\sum_{d\in D}\varphi(Ax-d)$ is then a special case of the scaling equation (13), and it is at the same time a natural extension of Haar's equation (10). It has a solution $\varphi=\chi_{\mathbf{T}}$, and the compact set $\mathbf{T}\subset\mathbb{R}^2$ is the unique solution to the so-called reptile equation $A\mathbf{T}=\bigcup_{d\in D}(\mathbf{T}+d)$; see also Figure 2. It is shown in [BrJo99] that $\mathbf{T}$ tiles $\mathbb{R}^2$ with translations chosen from the lattice $\Lambda=\left\{\begin{pmatrix}l\\2m\end{pmatrix}:l,m\in\mathbb{Z}\right\}$. It follows from this that the measure of $\mathbf{T}$ is 2. Then $\mathbf{T}$ is a reptile or a generalized Haar wavelet. In general, the measure of a reptile is an integer. It is known, however, that in $\mathbb{R}^4$ there are 4-by-4 expansion matrices A over $\mathbb{Z}$ for which generalized Haar wavelets do not exist. In 4-D for special matrices A, it may be that the reptiles generated by this scheme might not tile by a lattice which would turn them into Haar wavelets.

Georg Cantor's Chaos

Note that the generalization from the so-called *refinement equation* in the form (10) of Haar to the general case (13) is not just a jump in dimension, from 1 to d—that is not even the main point. The main issue is identifying the L^2-solutions to (13); then (14) comes along for free. To understand this, consider the seemingly trivial modification of (10) into

$$\varphi(x)=\frac{3}{2}(\varphi(3x)+\varphi(3x-2)). \tag{15}$$

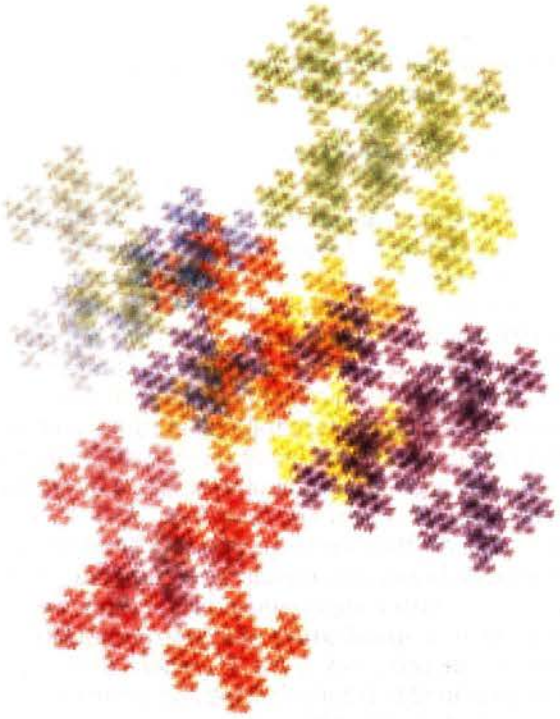


Figure 2. A Rep-Tile: The tile T from the "Cloud Nine" Example.[2] The picture is a result of iterating five linear maps, all having an expansive scaling matrix of determinant 5. The result is an exotic "tiling" of the plane.[3] The boundary of the tile is a fractal, like the self-similar structures that occur in biological systems, in correlations of fluids at critical phase transitions, and in conditions of turbulent flow.

Forgetting *functions* as solutions φ, try *tempered distributions*. Then a Fourier transform of (15) yields

$$\hat{\varphi}(\xi) = e^{-i\xi/2} \prod_{n=1}^{\infty} \cos\left(\frac{\xi}{3^n}\right). \tag{16}$$

It can be checked that, up to normalization, this is the unique solution and that φ is the singular Cantor measure and in particular a tempered distribution corresponding to the middle-third construction. Hence this φ is the unique measure satisfying

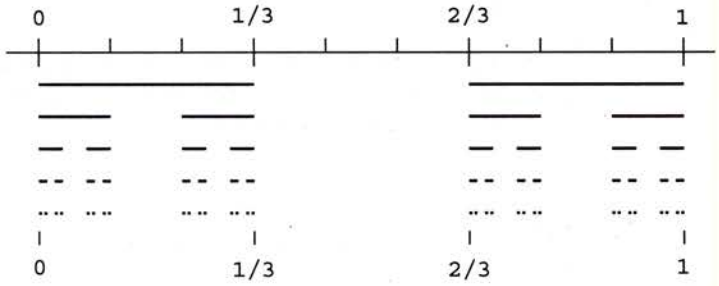


Figure 3. Iteration leading to Cantor-set support of φ in (15).

$$\int_{\mathbb{R}} f(x)\, d\varphi(x) = \frac{1}{2}\left(\int_{\mathbb{R}} f\left(\frac{x}{3}\right) d\varphi(x) + \int_{\mathbb{R}} f\left(\frac{x+2}{3}\right) d\varphi(x)\right) \tag{17}$$

and φ is supported in the set of Figure 3. The use of the Fourier transform in (16) makes perfectly good sense, even if φ is not a locally integrable function on $\mathbb{R}$. It would make sense even if we only knew a priori that φ was a compactly supported distribution: then for each $\xi \in \mathbb{R}$ we would define $\hat{\varphi}(\xi)$ as the distribution φ applied to the C^∞-function $x \mapsto e^{-i\xi x}$. In actual fact, the iteration algorithm based on (17) which is illustrated in Figure 3 shows that φ is the Cantor measure. Hence

$$\hat{\varphi}(\xi) = \int e^{-i\xi x}\, d\varphi(x).$$

For the general theory of affine iteration systems, fractal limits, and their harmonic analysis, the reader is referred to [JoPe98] and [DiFr99].

Groups of Wavelets

The formulas (6) and (9) from Haar carry over to the general case as follows. Consider a $d \times d$ invertible matrix A over $\mathbb{Z}$. With scaling in the form

$$U: f \longmapsto |\det A|^{-1/2} f(A^{-1}x), \qquad x \in \mathbb{R}^d,\ f \in L^2(\mathbb{R}^d), \tag{18}$$

we have

$$UT_yU^{-1} = T_{Ay}, \qquad y \in \mathbb{Z}^d. \tag{19}$$

Note that $Ay \in \mathbb{Z}^d$ for $y \in \mathbb{Z}^d$ if the matrix A is integral. Moreover, generalizing (11)–(12), we get

$$\mathcal{V}_n = \bigvee \varphi(A^n x - k), \tag{20}$$

$$\mathcal{W}_n = \bigvee_{\substack{k \in \mathbb{Z}^d \\ i=1,\dots,|\det A|-1}} \psi_i(A^n x - k), \tag{21}$$

[2] *The name here is from [BrJo99]; the picture represents a dynamical systems orbit of order 9.*

[3] *Take a geometric figure, replicate it five times, in the original location, three units to the right, two units above, two units below, and three units to the left. Then shrink the whole collection to the same size as the original was and rotate it by a "knight's move" angle. Repeat the process any number of times (here seven). If the initial figure is suitably chosen, the figures never overlap, and the collection tiles the plane by the same lattice at each stage of the iteration. Continuously varying colors assigned to the pieces in the order they were created show how the parts interpenetrate at every stage of iteration. See the cover of this issue for another graphical rendition of this fractal tile.*

provided the coefficients in (13)–(14), called masking coefficients, satisfy the following orthogonality relations (where we have set $b_k^{(0)} := a_k$):

$$\sum_{k\in\mathbb{Z}^d} \left|b_k^{(i)}\right|^2 = 1 \tag{22}$$

for all i (normalization), and

$$\sum_{k\in\mathbb{Z}^d} \overline{b_k^{(i)}}\, b_{k-Al}^{(j)} = 0 \tag{23}$$

for all $i \neq j$, and $l \in \mathbb{Z}^d$ (orthogonality).

Introducing the d-torus as $\mathbb{T}^d = \mathbb{R}^d/\mathbb{Z}^d$, it is shown in [BrJo02] that the system (22)–(23) is equivalent to specifying a function from $\mathbb{T}^d$ into the $N \times N$ unitary matrices, where $N = |\det A|$. Since the matrix A is fixed and integral, the matrix multiplication on $\mathbb{R}^d$, $x \to Ax$, passes to the quotient $\mathbb{T}^d = \mathbb{R}^d/\mathbb{Z}^d$, and the induced mapping T_A is N-to-1.

We now describe an isomorphism between the wavelet systems (22)–(23) and the *loop group elements*. (The group $\mathfrak{G}$ of measurable functions from $\mathbb{T}^d$ to the matrix group $\mathrm{U}_N(\mathbb{C})$ is called the *loop group*.) Using a finite Fourier transform, we get a *function-valued inner product*, for functions on $\mathbb{T}^d$:

$$\langle p \mid q\rangle_A(z) = \frac{1}{N} \sum_{\substack{w\in\mathbb{T}^d \\ T_A w = z}} \overline{p(w)}\, q(w), \qquad z \in \mathbb{T}^d, \tag{24}$$

where p and q vary over all scalar-valued functions on $\mathbb{T}^d$. In Haar's case the sum on the right-hand side in (24) is over $\pm\sqrt{z}$. The application is to the case when these functions are

$$m^{(j)}(z) := \sum_{k\in\mathbb{Z}^d} b_k^{(j)} z^k, \qquad j = 1, \ldots, N-1,$$

where $z^k := z_1^{k_1} z_2^{k_2} \cdots z_d^{k_d}$, and $z \in \mathbb{T}^d$. Using the standard inner product on $\mathbb{C}^N$, it is therefore natural to extend (24) to the case of vector-valued functions $p\colon \mathbb{T}^d \to \mathbb{C}^N$, and revise (24) to

$$\langle p \mid q\rangle_A(z) = \frac{1}{N} \sum_{\substack{w\in\mathbb{T}^d \\ T_A w = z}} \langle p(w) \mid q(w)\rangle_{\mathbb{C}^N}\,. \tag{25}$$

The key step in the identification of the solutions to (22)–(23) with the group $\mathfrak{G}$ of matrix functions $G\colon \mathbb{T}^d \to \mathrm{U}_N(\mathbb{C})$ is now the following lemma.

Lemma. *The group $\mathfrak{G}$ of all functions $G\colon \mathbb{T}^d \to \mathrm{U}_N(\mathbb{C})$ from the d-torus into all the $N \times N$ unitary matrices acts transitively on vector functions m on $\mathbb{T}^d$ as follows: $m \mapsto m^G$, where $m^G(z) := G(T_A z)\, m(z)$, and the pointwise product is matrix times column vector.*

Note (recalling that the inner product (25) takes values in functions on $\mathbb{T}^d$) that this is a *unitary* action relative to the functional inner product (25) in the sense that the unitarity identity $\langle m^G \mid p^G\rangle_A = \langle m \mid p\rangle_A$ holds for all $G \in \mathfrak{G}$. The term

$$\|m(z)\|^2 = \langle m(z) \mid m(z)\rangle_{\mathbb{C}^N} = \sum_{k=0}^{N-1} |m_k(z)|^2$$

measures the total contribution to a subband filter system, the N frequency bands being indexed by the cyclic group of order N, and the summation taken over the individual bands. Hence, the lemma states that this total contribution is constant under the specified action of the group $\mathfrak{G}$ of unitary matrix functions, the so-called polyphase matrices. For more details on the terminology of filters and matrix functions, see the list at the end of the paper.

If A is a given scaling matrix, i.e., a $d \times d$ matrix over $\mathbb{Z}$ with eigenvalues $|\lambda| > 1$, and $N := |\det A|$, then the corresponding filters m have N subbands and are considered as functions from $\mathbb{T}^d$ to $\mathbb{C}^N$. With a slight abuse of notation, we say that m is a *quadrature mirror filter* (QMF) if $\langle m_i(z) \mid m_j(z)\rangle_A = \delta_{i,j}$, $z \in \mathbb{T}^d$, where $\langle \cdot \mid \cdot \rangle_A$ is the form in (24). It follows from the lemma and an easy calculation that if m and m' are any two given QMF's corresponding to the same scaling matrix A, then the functions

$$G_{i,j}(z) = \langle m_j(z) \mid m_i'(z)\rangle_A\,, \qquad z \in \mathbb{T}^d,$$

are matrix entries of a polyphase matrix G, i.e., $G \in \mathfrak{G}$, and $m' = m^G$. In other words, G transforms the first QMF m into the second m', and G is determined uniquely from m and m'.

Examples

The significance of the approach via matrix functions is that it offers easy formulas for the numbers which encode our wavelet functions, φ, ψ (if the scale number N is 2), and $\varphi, \psi_1, \ldots, \psi_{N-1}$ in general. Haar's two functions φ and ψ are supported in the unit interval $[0, 1]$, and Daubechies's father function φ and mother function ψ are supported in $[0, 3]$. Then there is a next generation, still for $N = 2$, where φ and ψ are both supported in $[0, 5]$. In terms of the matrix function $G(z)$, the case of $[0, 1]$ is the constant function

$$G(z) = H = \frac{1}{\sqrt{2}} \begin{pmatrix} 1 & 1 \\ 1 & -1 \end{pmatrix},$$

the next one is of the form $G(z) = H(zp + p^\perp)$ where p is a rank-1 projection in $\mathbb{C}^2$ and $p^\perp = I - p$. As p varies, we get the wavelet functions with support in $[0, 3]$. With two rank-1 projections p_1, p_2 in $\mathbb{C}^2$ and $G(z) = H(zp_1 + p_1^\perp)(zp_2 + p_2^\perp)$, we get the wavelet functions supported in $[0, 5]$. The simplest way of reading off the matrix function G which corresponds to a system of masking coefficients

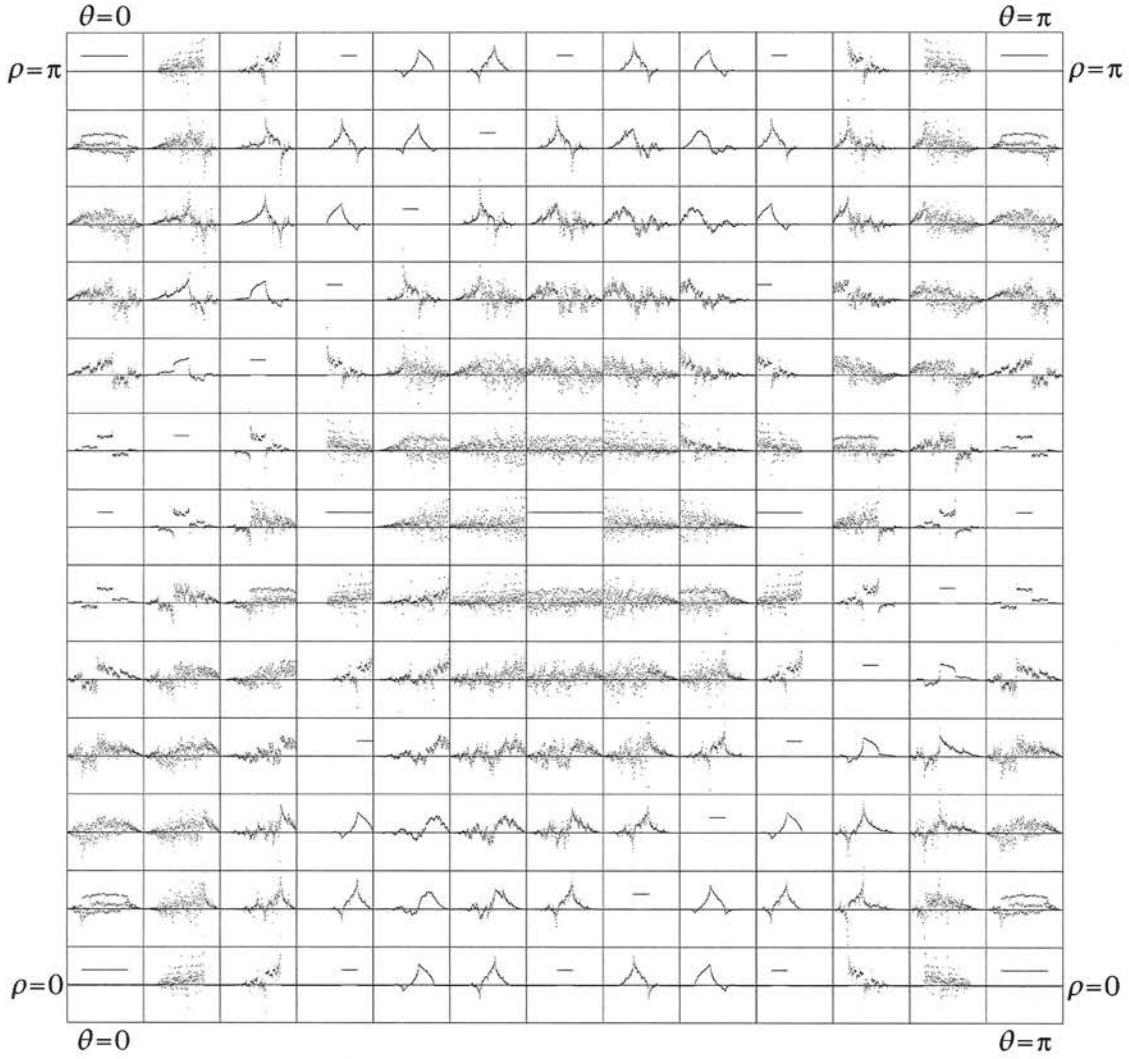


Figure 4. Two-parameter family of wavelet scaling functions.

$\begin{pmatrix} a_0 & a_1 & a_2 & a_3 \\ b_0 & b_1 & b_2 & b_3 \end{pmatrix}$ is to set $A = \begin{pmatrix} a_0 & a_1 \\ b_0 & b_1 \end{pmatrix}$, $B = \begin{pmatrix} a_2 & a_3 \\ b_2 & b_3 \end{pmatrix}$, and $G(z) = A + zB$. The reader will be able to construct the higher-order cases by generalization, or he/she may consult [BrJo02].

The World of the Spectrum

The theme of this section is that central properties of wavelets depend on the spectrum of a certain operator R, named after David Ruelle [Rue69], and also called the wavelet-transfer operator. In the present context, the operator R may be realized on sequences $(x_k)_{k\in\mathbb{Z}^d}$ as follows: $(Rx)_k = \sum_{j\in\mathbb{Z}^d} R_{Ak-j}x_j$ where $R_k = \sum_{j\in\mathbb{Z}^d} \bar{a}_j a_{j+k}$, the numbers $(a_k)_{k\in\mathbb{Z}^d}$ are the masking coefficients in (13), and A is the expansive matrix which defines our subdivision. Let $\epsilon \in \mathbb{R}_+$. On the Hilbert space $\mathcal{H}_\epsilon$ of sequences $(x_k)_{k\in\mathbb{Z}^d}$ such that $\sum_{k\in\mathbb{Z}^d} |x_k|^2 e^{\epsilon|k|} < \infty$, R acts as a trace class operator. Its spectrum is independent of ϵ. See (32) below for details.

Illustration: Spread out over the area of Figure 4 is a family of wavelets, each generating function (scaling function) φ determined by two parameters. Once we have the algorithm for the scaling function, an extra step automatically gets us the wavelet itself. There is a coordinate system of wavelets on the interval [0, 5] with their associated scaling functions; see Figure 4. Since vectors move invariantly under unitary transformations, it is reasonable to expect that varieties of wavelets may be parameterized in a way that is analogous to how we do the classical unitary groups. This will be illustrated in the following graphics experiment.

Wavelets on the Interval [0, 5] and Their Associated Scaling Functions

The scaling functions φ for these wavelets, one for each sample point represented in Figure 4, are pictured in this wall decoration, i.e., in Figure 4. The algorithm used in generating each of the functions

φ in the little rectangles of Figure 4 will be outlined in the discussion below (26). However, Figure 4 is in fact a sampling from a two-parameter variety of orthogonal wavelets. (It is only a variety, because there are isolated points where the strict orthogonality property degenerates!) More precisely, we are looking at a genus-2 surface, but with deletion of these degenerate or singular points: In the overall landscape of Figure 4, these points are visibly represented by little flat scaling functions φ with support of length 3 or 5. (Remember the "honest" Haar wavelets are supported on an interval of unit length!) What is more significant, and also clearly visible in Figure 4, is the fact that "most of" the functions φ in the variety are pretty bad! The nicest that can be said about them is that they are L^2, and that is not all bad. (Remember the Devil's staircase function from Figure 3 with its support on the Cantor set. As a scaling function, this "horrible" φ is not even locally integrable.)

So how *do* we find the nicer wavelets in a variety, those with more derivatives? There are two popular approaches: (i) Following [Dau92], look for vanishing moments. They can be found from factorization of certain polynomials, the Daubechies polynomials. Or: (ii) do factorization of the polyphase matrix! For that, there is a handy operator R; it is a transfer operator (see (32) below). The spectrum of R is pictured in Figure 5; the eigenvalues of R are functions of the two parameters that refer to Figure 4. In the valleys of the mountainous landscape of level-surfaces from Figure 5, i.e., the eigenvalues as they depend on two parameters, is where we pick out the nicest of the functions in the chaos of possibilities from the wavelets in Figure 4. The operator R is nowadays called the wavelet-transfer operator, but it was studied first by David Ruelle in the 1960s in connection with a completely different problem (the phase transition question of quantum statistical mechanics [Rue69]) and later in chaos theory [Rue02].

It is convenient for each $k = 1, 2, \ldots$, to look at the family of all wavelet functions φ and ψ supported in the interval $[0, 2k+1]$ on the x-axis. Within the family of all orthogonal wavelets supported in $[0, 2k+1]$, we look for vanishing moments of order j where $1 \le j \le k$. We know how to find subvarieties $S_j \supset S_{j+1}$, where S_j consists of the functions ψ in the family such that ψ has vanishing moments of order j. As j increases, S_j contains wavelets of higher and higher orders of differentiability. Testing for smoothness in each S_j can be done with the so-called joint spectral radius (JSR) test. It is a JSR computed for two noncommuting square matrices built in a simple way from the system of masking coefficients $a_0, a_1, a_2, \ldots, a_{2k+1}$. But since the square matrices are noncommuting, the JSR is hard to compute. If $k = 2$, there are six masking coefficients, and the two noncommuting square matrices are

$$\frac{1}{\sqrt{2}}\begin{pmatrix} a_0 & 0 & 0 & 0 & 0 \\ a_2 & a_1 & a_0 & 0 & 0 \\ a_4 & a_3 & a_2 & a_1 & a_0 \\ 0 & a_5 & a_4 & a_3 & a_2 \\ 0 & 0 & 0 & a_5 & a_4 \end{pmatrix}$$

and

$$\frac{1}{\sqrt{2}}\begin{pmatrix} a_1 & a_0 & 0 & 0 & 0 \\ a_3 & a_2 & a_1 & a_0 & 0 \\ a_5 & a_4 & a_3 & a_2 & a_1 \\ 0 & 0 & a_5 & a_4 & a_3 \\ 0 & 0 & 0 & 0 & a_5 \end{pmatrix}.$$

An alternative test for smoothness involves the Ruelle operator R. For $k = 2$, the interval is $[0, 5]$, and for real-valued wavelets, the full variety is given by the (θ, ρ) parameters. The eigenvalues of $R_{\theta,\rho}$ may be ordered as follows:

$$1 \ge |\lambda_1(\theta,\rho)| \ge |\lambda_2(\theta,\rho)| \ge \cdots .$$

There is a simple known function s from $\mathbb{R}_+$ to $\mathbb{R}_+$ such that if $|\lambda_1(\theta,\rho)| < c$, then the two functions $\varphi_{\theta,\rho}$ and $\psi_{\theta,\rho}$ are in the Sobolev space $\mathcal{H}^{s(c)}$. Recall that the Sobolev exponent $s(c)$ is a measure of differentiability. But algorithms for calculating the best s are few and not especially efficient. Nonetheless, continuity and differentiability of the wavelet functions are of critical importance in applications: The a priori estimates which give the best wavelet algorithm in JPEG 2000 are done in spaces of functions of bounded variation, and they depend on the smoothness of the wavelets that are used.

In Chapters 1–2 in [BrJo02] and in [Tre01], it is pointed out that families of compactly supported wavelets admit a group-theoretic formulation. When this idea is specialized to the case of multiresolution wavelets which have both the scaling function (father function φ) and the wavelet generator (mother function ψ) itself supported in the fixed interval from 0 to 5, then the full variety of possibilities may be described by two independently varying unit vectors in $\mathbb{C}^2$, in coordinates $\mathbf{v} = (v_1, v_2) \in \mathbb{C}^2$, $\|\mathbf{v}\|^2 = |v_1|^2 + |v_2|^2 = 1$. Unit vectors in $\mathbb{C}^2$ define pure quantum-mechanical states. The latter may be parameterized by points on the (Bloch) sphere S^2, i.e., points $(x, y, z) \in \mathbb{R}^3$, $x^2 + y^2 + z^2 = 1$. If σ_x, σ_y, and σ_z are the Pauli spin matrices $\left(\begin{smallmatrix} 0 & 1 \\ 1 & 0 \end{smallmatrix}\right)$, $\left(\begin{smallmatrix} 0 & -i \\ i & 0 \end{smallmatrix}\right)$, and $\left(\begin{smallmatrix} 1 & 0 \\ 0 & -1 \end{smallmatrix}\right)$ in the three coordinate directions, then $(x, y, z) = (\langle \mathbf{v} \mid \sigma_x \mathbf{v} \rangle, \langle \mathbf{v} \mid \sigma_y \mathbf{v} \rangle, \langle \mathbf{v} \mid \sigma_z \mathbf{v} \rangle)$ is in S^2 if and only if $\|\mathbf{v}\| = 1$. For example, $\mathbf{v} = (\cos\theta, \sin\theta)$ in $\mathbb{C}^2$ corresponds to the point $(\sin 2\theta, 0, \cos 2\theta)$ on S^2. Hence, viewing S^2 as embedded in $\mathbb{R}^3$, the vector moves on a great circle on S^2 in the (x, z)-plane. Thus in the example with two vectors of the form $(\cos\theta, \sin\theta)$, $(\cos\rho, \sin\rho)$ with the parameters θ

and ρ varying independently, displayed in [BrJo02, (1.2.3)–(1.2.4)], the dependence of the masking coefficients $a_k(\theta,\rho)$ on 2θ and 2ρ is as expected: the wavelet parameter is not the vector $\mathbf{v}$ itself, but rather the subspace generated by $\mathbf{v}$, or the projection onto $\mathbf{v}$, so we get the same wavelet masking coefficients for $\mathbf{v}$ and $-\mathbf{v}$. The coefficients a_k are real-valued for a similar reason. The two functions φ and ψ depend on variations in (θ,ρ) periodically, with period π in both parameters, so the whole variety may be represented in a square $[0,\pi)\times[0,\pi)$. This is illustrated graphically in a supplement to [BrJo02], `http://www.math.uiowa.edu/~jorgen/wavelet_motions.pdf`. It may be used as a flip-book of wavelets, displaying a moving picture of their variation along the path shown in the guide diagram in Figure 6. This flip-book is thus a sort of stationary variant of Wim Sweldens's Wavelet Cascade (Java) Applet `http://cm.bell-labs.com/who/wim/cascade/index.html`. With the latter, the viewer may explore changes of scaling and wavelet functions with free movements of the computer mouse, but the variation is limited to the "4-tap" wavelets, i.e., those generated by a single rank-1 projection (spin vector) and supported in the inverval [0,3], while [BrJo02] and its flip-book supplement deal with a bigger "6-tap" family, i.e., with support in [0,5], and generated by two independent spin vectors.

While the functions φ and ψ are square-integrable, they are continuous on $[0,5]$ only for (θ,ρ) in a periodic subset of $\mathbb{R}\times\mathbb{R}$. (This subset is often identified by vanishing moments or by spectral conditions such as the JSR test; see [CGV99].) If we ask whether φ and ψ, as points in a function space, show continuous dependence on (θ,ρ), then that function-space continuity must be measured in mean square, i.e., in the metric defined by the L^2-norm of functions on $[0,5]$. In this metric, continuity follows from [BrJo02, Theorem 2.5.8]; see details below. Actually there are a finite number of exceptions to the L^2-continuous dependence on (θ,ρ). They occur when the wavelet is one of the degenerate Haar cases. These are the Haar wavelets which define not strict orthonormal bases but only tight frames. They have φ of the form $\varphi = c\chi_I$, where I is a subinterval of $[0,5]$ of length 3 or 5, and where $c=\frac{1}{3}$ in the first case, and $c=\frac{1}{5}$ in the second. Find them on Figure 4. If the reader follows the moving wavelet pictures (on a printout, or on the screen), we hope he/she will get some intuitive ideas of fundamental wavelet relationships. The rigorous mathematics relating the various continuity properties to cascade approximation, to moments, and to spectral estimates is covered in much more detail in the references below, especially [BrJo02] and [CGV99].

Once the masking coefficients $a_0, a_1, \dots, a_5$ are specified as functions of the parameters θ and ρ, the computation of cascade approximants of the scaling function φ is done with a series of Mathematica operations. The algorithm is designed to start with a Haar function, and the limit of the iteration will then be a scaling function $\varphi = \varphi^{(\theta,\rho)}$ depending on the two rotation angles θ, ρ, and satisfying

$$\varphi^{(\theta,\rho)}(x) = \sqrt{2}\sum_{k=0}^{5} a_k^{(\theta,\rho)}\varphi^{(\theta,\rho)}(2x-k). \tag{26}$$

The reptile features of the algorithm have the effect of producing fast cascading approximations to the limit function $\varphi^{(\theta,\rho)}$. The algorithm of the solution $\varphi^{(\theta,\rho)}$ to the scaling identity (26) then proceeds as follows (see [Jor01], [Tre01], [BrJo02, §1.2] for details). The relation (26) is interpreted as giving the values of the left-hand $\varphi^{(\theta,\rho)}$ by an operation performed on those of the $\varphi^{(\theta,\rho)}$ on the right. A binary digit inversion transforms this into

$$\mathbf{f}'_{k+1}(x) = \mathbf{A}\mathbf{f}_k(x),$$

where $\mathbf{A}$ is the 2×3 matrix

$$\mathbf{A}_{p,q} = \sqrt{2}a^{(\theta,\rho)}_{5+p-2q} = \sqrt{2}\begin{pmatrix} a_4^{(\theta,\rho)} & a_2^{(\theta,\rho)} & a_0^{(\theta,\rho)} \\ a_5^{(\theta,\rho)} & a_3^{(\theta,\rho)} & a_1^{(\theta,\rho)} \end{pmatrix}$$

constructed from the coefficients in (26), and $\mathbf{f}_j$ and $\mathbf{f}'_j$ are the vector functions

$$\mathbf{f}_j(x) = \begin{pmatrix} \varphi^{(\theta,\rho)}\left(x-\frac{2}{2^J}\right) \\ \varphi^{(\theta,\rho)}\left(x-\frac{1}{2^J}\right) \\ \varphi^{(\theta,\rho)}(x) \end{pmatrix},$$

$$\mathbf{f}'_j(x) = \begin{pmatrix} \varphi^{(\theta,\rho)}(x) \\ \varphi^{(\theta,\rho)}\left(x+\frac{1}{2^J}\right) \end{pmatrix}.$$

Iterations of this operation give values of an approximation to $\varphi^{(\theta,\rho)}$ on successively finer dyadic grids in the x variable.

How To

For an implementation of this computation in Mathematica, we let `loctwont` stand for the transpose of the coefficient matrix $\mathbf{A}$,[4] and normalize the Mathematica variables `a0`, `a1`, etc., to include the factor of $\sqrt{2}$ that appears in the cascade iteration:

```
loctwont[θ_, ρ_] :=
 N[Transpose[{{a4[θ, ρ], a2[θ, ρ], a0[θ, ρ]}, {a5[θ, ρ], a3[θ, ρ], a1[θ, ρ]}}]]

cascadestep[phitable_, θ_, ρ_] :=
 Flatten[Partition[Flatten[{0, 0, phitable, 0, 0}], 3, 1].loctwont[θ, ρ]]

wavelet[phistart_, itercount_, θ_, ρ_] :=
 Transpose[{Table[i (2^(-itercount)), {i, 0, 5 (2^itercount) - 5}],
   Nest[cascadestep[#, θ, ρ] &, phistart, itercount]}]
```

[4] *So named by contraction of "local two-by-n transpose."*

Each cascade step works with the list of values from the previous step (`phitable`), pads it with zeroes on left and right, works it up into a matrix by overlapping divisions (the `Partition` operation), does a matrix multiplication with a matrix of masking coefficients (`loctwont`), and reduces (with `Flatten`) the resulting matrix to a list again. At each stage the implicit grid spacing is halved, and at the specified final iteration the values of these grid points are associated with the elements of the list (using `Table` and `Transpose`), so that a plot of the scaling-function approximant can be made with other Mathematica operations such as `ListPlot`.

A direct implementation in Mathematica of the computation of the wavelet ψ from the scaling function φ by the formula [BrJo02, (2.5.25)] (with the functions and coefficients depending on the rotation angle parameters θ, ρ),

$$\psi^{(\theta,\rho)}(x) = \sqrt{2} \sum_{k=0}^{5} (-1)^k \, a_{5-k}^{(\theta,\rho)} \varphi^{(\theta,\rho)}(2x-k),$$

is (again with $\sqrt{2}$ subsumed in a0, a1, ...)

```
embedwavelet[phistart_, itercount_, θ_, ρ_] :=
 Flatten[{Table[0, {i, -(5 (2^itercount) - 5), -1}], Nest[cascadestep[#, θ, ρ] &
    itercount], Table[0, {i, (5 (2^itercount) - 5) + 1, 2 (5 (2^itercount) - 5)}]}]

avec[θ_, ρ_] := {a0[θ, ρ], a1[θ, ρ], a2[θ, ρ], a3[θ, ρ], a4[θ, ρ], a5[θ, ρ]}

waveletpsi[phistart_, itercount_, θ_, ρ_] :=
 Transpose[{Table[i (2^(-itercount - 1)), {i, 0, 2 (5 (2^itercount) - 5)}],
   Table[Sum[((-1)^(5 - k) avec[θ, ρ][[k + 1]] embedwavelet[phistart, itercount,
       ρ][[j + k (2^itercount - 1)]]), {k, 0, 5}], {j, 1, 2 (5 (2^itercount) - 5)
```

But using the `Table` and `Sum` operations in this way is inefficient for two reasons. First, the sum has, after suitable rearrangement, the form of a sequence correlation that can be implemented with a fast Fourier transform. And second, the way the operations above are interpreted by Mathematica is that the same scaling function (`embedwavelet`) is computed repeatedly for each term of the sum rather than being computed once and saved. Both of these inefficiencies can be remedied by the use of the `ListCorrelate` operation, which Mathematica implements internally by Fourier-transform methods.

```
correlatewavelet[phistart_, itercount_, θ_, ρ_] :=
 Flatten[Transpose[Partition[PadLeft[PadRight[Nest[cascadestep[#, θ, ρ] &, ph:
       itercount], 6 (2^itercount) - 6], 11 (2^itercount) - 11], (2^itercount) -

signavec[θ_, ρ_] := {-a0[θ, ρ], a1[θ, ρ], -a2[θ, ρ], a3[θ, ρ], -a4[θ, ρ], a5[θ, ρ

correlatewaveletpsi[phistart_, itercount_, θ_, ρ_] :=
 Transpose[{Table[i (2^(-itercount - 1)), {i, 0, 11 (2^itercount) - 12}],
   Flatten[Transpose[Partition[ListCorrelate[signavec[θ, ρ],
       correlatewavelet[phistart, itercount, θ, ρ], {1, 1}, 0], 11]]]}]
```

The necessary rearrangement amounts to grouping the list of values into a matrix and transposing the matrix. This is done, at both ends of the computation, with the `Partition` and `Transpose` operations, followed by `Flatten` to return to an ungrouped list. Note also the use of `PadLeft` and `PadRight` to add zeroes to keep the different rows of the matrix from getting mixed in the `ListCorrelate` operation; these could have been used in the direct implementation as well, where zero-padding was needed at the ends of the sum. The Fourier-transform method used in Mathematica's implementation of the `ListCorrelate` operation gives results numerically identical to those obtained by the direct calculation with the `Table` and `Sum` operations, thanks in part to Mathematica's implementation of `ListCorrelate` that uses a real transform method on real data. For the wavelet functions computed for the flip-book, the method using `ListCorrelate` works about 500 times faster than the method using `Table` and `Sum`.

We present a guide diagram in Figure 6 corresponding to the (θ, ρ) plane of Figures 4 and 5, with dots for the point (and its periodic replicas) whose wavelet function and scaling function are displayed on the current page and line. The square outlined in black is the fundamental region $[0, \pi) \times [0, \pi)$, shown with labels in Figure 6. There is a path, part of which represents a vanishing-moment curve where the wavelet function $\psi(x)$ satisfies the moment condition $\int x\, \psi(x)\, dx = 0$, and the masking coefficients $a_0, \ldots, a_5$ satisfy the equivalent divisibility condition $m_0(z) = 2^{-\frac{1}{2}} \sum_{k=0}^{5} a_k z^k = (z+1)^2\, p(z)$ for some polynomial p. The viewer familiar with [Jor01] may find amusement in watching for the appearance in the sequence of the familiar Daubechies wavelets, as well as the single point in the sequence where the additional moment and divisibility conditions $\int x^2\, \psi(x)\, dx = 0$ and $m_0(z) = (z+1)^3\, q(z)$ are met. In Figure 4 you see variations of these wavelets, as the parameters move around and cover a period-square.

The part of the spectrum of the Ruelle operator R in (32) which determines the shape of each wavelet is a finite set of points. As each point in this part of the spectrum is a function of the two parameters, the eigenvalues may be ordered and presented in the sketch as functions of two variables. The graphs represent surfaces starting with a top eigenvalue (a Perron-Frobenius eigenvalue equal to 1 for all values of the parameters). One of the surfaces, two steps down from the top, is pictured in Figure 5. There is a constant eigenvalue $1/2$ that gives the appearance of mountains rising from lakes or Christopher Columbus's hat or a body in bathwater, if you prefer! And then the top eigenvalue equal to 1 is the ceiling. Other eigenvalue surfaces in this series are shown in figures within the book [BrJo02], and one surface with branch cuts, used as a sort of frontispiece, looks like "Half Dome" in Yosemite Valley. This closed-form eigenvalue, when compared

to the eigenvalue surfaces sorted by absolute value, coincides with the second eigenvalue from the top in part of the parameter range and with smaller eigenvalues in other parts of the range. The parameters representing the lower parts of the surfaces are important: for example, they give algorithms that are faster. And wavelets that are more regular tend to be located in the region of the period-square which have a concentration of low-lying spectrum. Hence the flat portions of the "bathwater" surface signify an abundance of "good" wavelets.

Haar Meets Cantor

The scaling identity (13) depends on a choice of masking coefficients $\{a_k\}_{k\in\mathbb{Z}^d}$. This suggests a strategy for finding the scaling function (also called the father function) φ as a solution to an operator identity: the idea is to try to get φ as the limit of an iteration of the following operator:

$$S: f \longmapsto \sqrt{N} \sum_{k\in\mathbb{Z}^d} a_k f(Ax-k); \tag{27}$$

i.e., $\varphi = \lim_{n\to\infty} S^n f$ with a suitable choice of starting point f for the iteration. As suggested by (13), an integration shows that a necessary condition for this to work is that

$$\sum_{k\in\mathbb{Z}^d} a_k = \sqrt{N}. \tag{28}$$

This normalization is indeed satisfied for the two examples (10) and (15). In the first one (10), $d = 1$, $A = N = 2$, and the solution φ is the box-function φ of Haar which is certainly in $L^2(\mathbb{R})$. In the second example (15) of Cantor, $d = 1$, $A = N = 3$, and the solution φ is now the Cantor measure. This measure, while a solution, is a singular measure, and, in fact, it is not even represented locally by an integrable function.

To understand the dichotomy between the case of Haar and that of Cantor, introduce the generating function m_0 for the masking coefficients in (13), i.e., $m_0(z) = \sum_{k\in\mathbb{Z}^d} a_k z^k$. For simplicity, specialize to $d = 1$. It will be convenient for us to consider m_0 as a function on $\mathbb{T}$ by restriction, viewing the torus $\mathbb{T} = \mathbb{R}/\mathbb{Z}$ as a circle in $\mathbb{C}$, i.e., as $\mathbb{T} = \{z \in \mathbb{C} : |z| = 1\}$. Then the normalization condition (28) reads

$$m_0(1) = \sqrt{N}. \tag{29}$$

The other conditions (22)–(23) on the masking coefficients, i.e.,

$$\sum_{k\in\mathbb{Z}} \bar{a}_k a_{k-lN} = \delta_{0,l}, \qquad l \in \mathbb{Z}, \tag{30}$$

then take the functional form

$$\frac{1}{N} \sum_{\substack{w\in\mathbb{T}\\ w^N=z}} |m_0(w)|^2 = 1. \tag{31}$$

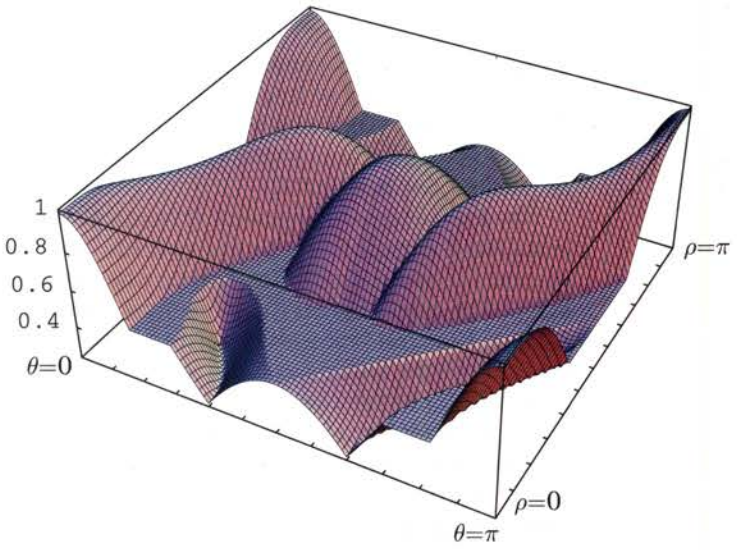


Figure 5. Eigenvalue of two-parameter family of Ruelle operators.

But this is an orthogonality condition, stated in either one of its two equivalent forms, and it is necessary for ensuring orthogonality in the ultimate construction of a wavelet basis for $L^2(\mathbb{R})$. In Haar's example, $N = 2$ and $m_0(z) = \frac{1+z}{\sqrt{2}}$. Setting $z = e^{-i\xi}$, one finds that (31) is equivalent to the familiar trigonometric identity $\cos^2\xi + \sin^2\xi = 1$. But, for Cantor's example, $N = 3$ and $m_0(z) = \frac{\sqrt{3}}{2}(1+z^2)$, and now $\frac{1}{3}\sum_{w^3=z} |m_0(w)|^2 = 3/2$.

Stated differently, if an operator R is defined as acting on functions h on $\mathbb{T}$ by

$$(Rh)(z) = \frac{1}{N} \sum_{\substack{w\in\mathbb{T}\\ w^N=z}} |m_0(w)|^2 h(w), \tag{32}$$

then the formula (31) takes the form $R\mathbf{1} = \mathbf{1}$, where $\mathbf{1}$ denotes the function on $\mathbb{T}$ which is constant and equal to 1. In the analysis of [Dau92] and [BrJo02], the operator R from (32) is called the wavelet transfer operator, or the Ruelle operator, and $\mathbf{1}$ is called the Perron–Frobenius eigenfunction. Hence the significant distinction between the case of Haar and that of Cantor is the numerical size of the Perron–Frobenius eigenvalue: It is 1 in the first case and 3/2 in the second. The operator R in (32) is called the *wavelet transfer operator* because of the analogy to the probabilistic view of the Perron–Frobenius matrix setting and because of the probability content of condition (31): Looking at the right-hand side in (32), for each point $z \in \mathbb{T}$ there are N distinct solutions w to $w^N = z$, and each of the corresponding numbers

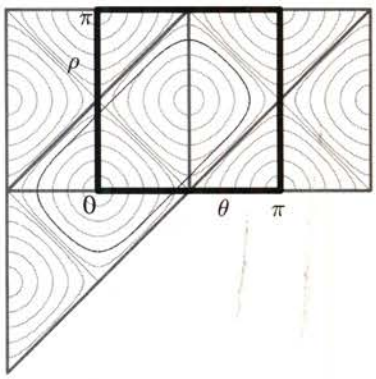


Figure 6. Guide diagram.

$\frac{1}{N}|m_0(w)|^2$ signifies conditional probabilities for transfer from some w to z, where w is one of the N possibilities. This random-walk model helps us understand and compute the spectral theory of R, as pointed out in [BrJo02].

The Ruelle transfer operator R "counts" the accumulated contribution to the cascade approximation, i.e., to the scaling function φ, when the limit exists. But unless the Perron–Frobenius eigenvalue $\lambda_{PF} = 1$, the limit "escapes" out from $L^2(\mathbb{R})$. In the middle-third-Cantor case, $\lambda_{PF} = 3/2$, which accounts for φ in this case being a singular measure, not represented by a locally integrable function on $\mathbb{R}$. The Hausdorff dimension d in Cantor's case can be shown to be $d = \frac{\log 2}{\log 3}$.

Perron-Frobenius and Stability of Wavelets

If the wavelet transfer operator R in (32) is considered in the context of Lipschitz functions on $\mathbb{T}$, $\mathrm{Lip}(\mathbb{T})$, then it has spectral properties which closely mirror those which are familiar classically from Perron and Frobenius for finite positive matrices. Let $R = (r_{i,j})_{i,j=1}^{n}$, $r_{i,j} \geq 0$. A classical theorem [Per07] states that each such matrix R has a positive eigenvalue λ_{PF} which agrees with the spectral radius of R. Specializing to $\lambda_{PF} = 1$, Perron and Frobenius showed that there are positive vectors ν and v, ν a row-vector and v a column-vector, such that $\nu R = \nu$, $R\mathrm{v} = \mathrm{v}$, and $\nu \cdot \mathrm{v} = 1$. The same turns out to hold for R in (32); only now ν is the Dirac measure at $z = 1$, called δ_1, and v is the constant function $\mathbf{1}$ on the torus $\mathbb{T}$. Imitating what is known for finite matrices, we get a reduced form of the Ruelle operator R acting on the subspace $\mathrm{Lip}_{<1} := \{h \in \mathrm{Lip}(\mathbb{T}) : \delta_1(h) = 0\}$. We say that R has *Perron-Frobenius spectrum* if the spectral radius of R, restricted to $\mathrm{Lip}_{<1}$, is strictly less than 1.

Introducing the Lipschitz norm

$$\left\|p\left(e^{i\xi}\right)\right\|_{\mathrm{Lip}(\mathbb{T})} = |p(1)| + \sup_{-\pi<\xi<\eta\leq\pi} \frac{|p(e^{i\xi}) - p(e^{i\eta})|}{|\xi - \eta|},$$

we have:

Theorem. *[BrJo02, Theorem 2.5.8] Let m and m' be in $\mathrm{Lip}(\mathbb{T})$ and suppose they both satisfy (29) and (31). Suppose further that each of the transfer operators R_m and $R_{m'}$ has Perron–Frobenius spectrum. Let $\lambda_{\mathrm{red}}(m)$ (< 1) be the reduced spectral radius of R_m. Then there is a constant C independent of m and m' such that the associated scaling functions (father functions) φ_m and $\varphi_{m'}$ satisfy the following Lipschitz estimate:*

$$\|\varphi_m - \varphi_{m'}\|_{L^2(\mathbb{R})} \leq C \frac{1}{\sqrt{1 - \lambda_{\mathrm{red}}(m)}} \|m - m'\|_{\mathrm{Lip}(\mathbb{T})}.$$

On the other hand, the space Lip is not large enough as repository of the filter functions in the study of limits of wavelets. The wavelet ψ_S on $\mathbb{R}$ with $\hat{\psi}_S = \chi_{(-\pi,-\frac{\pi}{2}]\cup(\frac{\pi}{2},\pi]}$ (i.e., frequency localized), named after Shannon, has the low-pass and high-pass filter functions $\frac{1}{\sqrt{2}} m_0(e^{-i\xi}) = \chi_{[-\frac{\pi}{2},\frac{\pi}{2})}(\xi)$ and $\frac{1}{\sqrt{2}} m_1(e^{-i\xi}) = \chi_{[\frac{\pi}{2},\frac{3\pi}{2})}(\xi)$, and they are clearly not in $\mathrm{Lip}(\mathbb{T})$. Nonetheless, there is a "law of large numbers for wavelets": Let some "nice" (compactly supported) wavelet ψ be given. Two general theorems of Aldroubi et al. establish the following "limit laws":

1. $\underbrace{(\psi * \cdots * \psi)}_{n \text{ times}} \underset{n\to\infty}{\longrightarrow} \psi_S$ in $L^2(\mathbb{R})$ with renormalization, and
2. Let ψ_{D_n} denote the Daubechies wavelets given by the Daubechies polynomials P_n [Dau92]. Then it was shown in [AbAl95] that $\psi_{D_n} \xrightarrow[n\to\infty]{L^2(\mathbb{R})} \psi_S$.

Conclusions

Wavelet analysis and wavelet applications offer a rich variety of interdisciplinary adventures. What is especially striking is the fact that crucial mathematical steps seem to get unexpectedly discovered in diverse communities of engineers, scientists, or mathematicians. If each of the groups of practitioners would make more of an effort to learn about the other, much would be gained. In wavelet theory, it has been exciting to observe the exchanges of ideas in signal-processing engineering. The mathematical developments there might have had a different aim, but nonetheless they have offered key ideas to mathematics, which have given new life to the subject of wavelets and, more generally, to harmonic analysis and approximation theory.

Terminology and Dictionary

- **multiresolution**—*real world:* a set of band-pass-filtered component images, assembled into a mosaic of resolution bands, each resolution tied to a finer one and a coarser one.
  —*mathematics:* used in wavelet analysis and fractal analysis, multiresolutions are systems of closed subspaces in a Hilbert space, such as $L^2(\mathbb{R})$, with the subspaces nested, each subspace representing a resolution, and the relative complement subspaces representing the detail which is added in getting to the next finer resolution subspace.
- **matrix function:** a function from the circle, or the one-torus, taking values in a group of N-by-N complex matrices.
- **subband filter:**—*engineering:* signals are viewed as functions of time and frequency, the frequency function resulting from a transform of

the time function; the frequency variable is broken up into bands, and up-sampling and down-sampling are combined with a filtering of the frequencies in making the connection from one band to the next.

—*wavelets:* scaling is used in passing from one resolution V to the next; if a scale N is used from V to the next finer resolution, then scaling by $\frac{1}{N}$ takes V to a coarser resolution V_1, represented by a subspace of V, but there is a set of functions that serve as multipliers when relating V to V_1, and they are called subband filters.

- **cascades:**—*real world:* a system of successive refinements which pass from a scale to a finer one, and so on; used, for example, in graphics algorithms: starting with control points, a refinement matrix and masking coefficients are used in a cascade algorithm, yielding a cascade of masking points and a cascade approximation to a picture.

  —*wavelets:* in one dimension the scaling is by a number and a fixed simple function, for example, of the form $\sqcap_0^1$, is chosen as the initial step for the cascades. When the masking coefficients are chosen, the cascade approximation leads to a scaling function.
- **scaling function:** a function or a distribution φ, defined on the real line $\mathbb{R}$, which has the property that for some integer $N > 1$, the coarser version $\varphi\left(\frac{x}{N}\right)$ is in the closure (relative to some metric) of the linear span of the set of translated functions $\ldots, \varphi(x+1), \quad \varphi(x), \quad \varphi(x-1), \varphi(x-2), \ldots$.
- **orthogonality in the strict sense:** for $\psi \in L^2(\mathbb{R})$ to be a *dyadic wavelet*, the double-indexed family of functions $\psi_{j,k}(x) := 2^{j/2}\psi(2^j x - k)$, $j, k \in \mathbb{Z}$, must be a basis for $L^2(\mathbb{R})$; i.e., every $f \in L^2(\mathbb{R})$ must admit a unique representation

$$f(x) = \sum_{j,k\in\mathbb{Z}} c_{j,k}\psi_{j,k}(x). \tag{33}$$

If the system $\{\psi_{j,k} : j, k \in \mathbb{Z}\}$ is further assumed *orthonormal*, i.e., if

$$\langle \psi_{j,k} \mid \psi_{j',k'} \rangle = \delta_{j,j'}\delta_{k,k'}, \tag{34}$$

then clearly

$$\|f\|_2^2 = \sum_{j,k\in\mathbb{Z}} |c_{j,k}|^2, \qquad f \in L^2(\mathbb{R}). \tag{35}$$

But (33) and (35) may hold even if the orthonormal property (34) fails. For example, suppose ψ is a multiresolution wavelet in the *strict sense*, with $\{\psi_{j,k}\}$ satisfying (33) and (34); then set $\tilde{\psi}(x) := \frac{1}{3}\psi(x/3)$, and $\tilde{\psi}_{j,k}(x) := 2^{j/2}\tilde{\psi}(2^j x - k)$. We will still have

$$\|f\|_2^2 = \sum_{j,k\in\mathbb{Z}} |\langle \tilde{\psi}_{j,k} \mid f \rangle|^2, \qquad f \in L^2(\mathbb{R}), \tag{36}$$

but now $\{\tilde{\psi}_{j,k}\}$ will *not* satisfy (34), and in fact $\|\tilde{\psi}\|_2 = 1/\sqrt{3}$. A system satisfying condition (36) is called a *tight frame*. Varying the parameters within a family of wavelets of fixed support and each satisfying the orthonormality condition, we find points of degeneracy. They correspond to wavelet bases which are only tight frames in $L^2(\mathbb{R})$, and these special wavelet generators are found precisely at points (in the parameter variety) where the eigenspace of the Perron-Frobenius eigenvalue is of dimension more than one. It is known that the degeneracy can be complicated in general, but within the varieties given by the polyphase matrices, or the spin-vector configurations, the degeneracy is known to happen on subvarieties of lower dimension. The direct correspondence between polyphase matrix and wavelet is further known to break down on the subvariety where the orthonormality degenerates into the tight frame property.

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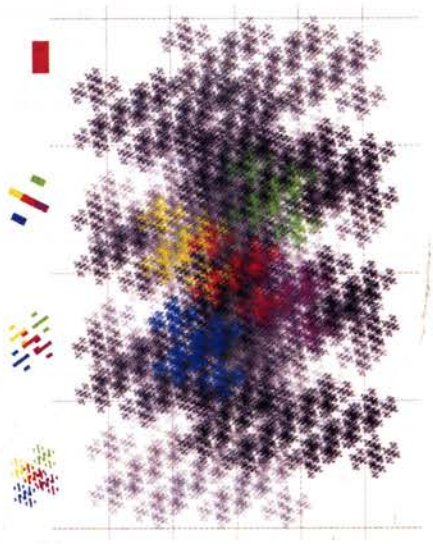
About the Cover

Cloud Nine

This month's cover expands upon the "cloud nine" image in Palle Jorgensen's article. It represents the fractal tile (which Jorgensen calls a 'reptile') constructed by an iteration process, starting with a fundamental domain of the tiling. The central figure shows the results of several iterations applied to a single fundamental domain, together with several neighboring tiles. Along the left side are the results of the first few steps of the iteration, showing successive approximations to the final tile.

Jorgensen writes, "A reptile T arises from a limit construction, a simple algorithm which repeats the same set of affine operations in each step. They are defined from a matrix A, and a finite set of vectors D, i.e., $T = T(A, D)$ where D is a set of representatives of $\mathbb{Z}^2/A\mathbb{Z}^2$. Many interesting questions present themselves. For example, under what circumstances does T tile the plane? And if it does, can it be made to tile with lattice translations? How do you find an admissible lattice L? The simpler planar reptiles T make a tiling by vectors in $\mathbb{Z}^2$, and have area 1. They serve as higher-dimensional versions of the familiar Haar construction from one dimension. The picture on the cover has area 2, and the corresponding lattice L which makes a planar tiling is generated by the vectors $(1, 0)$ and $(0, 2)$."

—Bill Casselman, Covers Editor
(notices-covers@ams.org)



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The Mathematics Doctorate: A Time for Change?

Tony F. Chan

The Carnegie Foundation commissioned a collection of essays as part of the Carnegie Initiative on the Doctorate (CID). Essays and essayists represent six disciplines that are part of the CID: chemistry, education, English, history, mathematics, and neuroscience. Intended to engender conversation about the conceptual foundation of doctoral education, the essays are a starting point and not the last word in disciplinary discussions. Those faculty members, students, and administrators who work in the discipline are the primary among multiple audiences for each of these essays. © 2003 by the Carnegie Foundation for the Advancement of Teaching. Reprinted with permission.

Comments on the essays and on the CID are welcome and may be sent to `cid@carnegiefoundation.org`. Further information may be found at the website `http://www.carnegiefoundation.org/cid` and in the article "The Carnegie Initiative on the Doctorate", by Allyn Jackson, *Notices*, May 2003, pages 566–8.

The other Carnegie essay about mathematics, by Hyman Bass, appeared in the August 2003 issue of the *Notices*, pages 767–76.

—*Allyn Jackson*

One can argue, with ample evidence, that in U.S. universities the system of producing mathematics doctorates is doing very well and needs no major overhaul. It is widely recognized that however poor our K–12 mathematics education—and perhaps also our undergraduate mathematics education—might be, our graduate programs in mathematics are the best and the envy of the world. Top students from around the world are still beating on our doors to get into our doctoral programs. We train them well, and many of these students become international leaders in their research fields. Take, for example, the two 2002 Fields Medalists and the Nevalinna Prize winner. Even though the press (at least the press in Beijing, where I read the news) referred to them as French, Russian, and Indian, two received their doctoral training at U.S. universities. We also seem to be succeeding in getting new support from the federal government for mathematical sciences. The recent increase in funding for the NSF [National Science Foundation] specifically targets the Division of Mathematical Sciences, and doctoral training, in particular for U.S. students, is a core part of this new funding program. Even Hollywood seems to be working in our favor, in view of the generally positive image of mathematics generated by movies such as *A Beautiful Mind*.

However, there are many signs that not all is well with our doctoral programs. Top, talented students, especially those born in the U.S., are choosing fields other than mathematics for graduate study. Many mathematics departments, especially those outside the "top tier", are having trouble filling their graduate programs with reasonably prepared and talented students. As a field of science, mathematics is underfunded compared to other sciences. Most of our doctoral students are supported by teaching assistantships rather than by fellowships or research assistantships. Our doctoral students are taking too long to get their degrees, and they are not sufficiently and broadly trained for career paths outside of academia. Other scientists and academic administrators perceive us as an insular and, worse, irrelevant community.

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None of these symptoms are new. Most are well documented in a series of nationally commissioned reports on the status and health of our community, from the 1984 and 1990 David Reports *Renewing United States Mathematics*, to the 1998 Odom Report *The Senior Assessment Panel of the International Assessment of the U.S. Mathematical Sciences* and the 1999 American Mathematical Society report *Towards Excellence: Leading a Doctoral Mathematics Department in the 21st Century*. Indeed, over the last two decades the mathematics community, perhaps more than that of any other science, has produced many national self-studies that urge fundamental changes to our doctoral programs.

Judging from the persistence and recurrence of some of the same main issues in these reports over a period of twenty years, one can only arrive at the conclusion that very little real change has been made. And recent attempts at change have been met with controversy (e.g., the NSF's Vertical Integration of Research and Education in the Mathematical Sciences, VIGRE program; see recent articles in the November 2002 issue of the *Notices* and the May 24, 2002, issue of *Science*). Viewed against this background, the current Carnegie Initiative on the Doctorate comes at a critical juncture for our community.

Does U.S. doctoral education in mathematics need rethinking at this moment? There is no shortage of ideas about *what* we need to change. We have to decide *whether or not* we want to change.

The Goals of and Context for Doctoral Education in Mathematics

In order to understand the need for change in the mathematics doctorate, we need to consider the goals of and context for doctoral education in the discipline. What are the overarching goals of U.S. doctoral education in mathematics? How does the context of the American university affect these goals? What perspective does each of the key stakeholders bring to doctoral education?

The U.S. doctorate system has its origins in the universities of Europe, especially those of Germany. In this context our system is relatively new, and yet it has acquired certain distinguishing characteristics. One particular characteristic is how we fund our doctoral students. Most are supported by a mix of teaching assistantships (most mathematics departments are responsible for a large amount of service teaching on university campuses), federal research support (through grants to advisors and departments), and fellowships (through the federal government, private foundations, and universities). Thus, in addition to the faculty and the doctoral students, the federal government and the universities play important roles in shaping doctoral programs, because each party brings particular goals and needs to the system.

Within the profession of mathematics, among the faculty the goal and purpose of doctoral education in the field is quite clear. To borrow from the principles of the current Carnegie Initiative on the Doctorate, the goal is "generation, conservation, and transformation" of the knowledge of the discipline. To quote Lee S. Shulman, president of the Carnegie Foundation for the Advancement of Teaching, "The Ph.D. recipient is expected to serve as a steward of her discipline or profession: dedicated to the integrity of its work in the generation, critique, transformation, transmission and use of its knowledge." I very much agree with this statement. Certainly the future health of the discipline cannot be guaranteed if we cannot generate its human resources and train its next generation of leaders.

Yet we have to keep in mind that the federal government, the universities, and the doctoral students have different perspectives on the goals of doctoral education in mathematics. From the perspective of the federal government, funding for doctoral students is justified primarily by societal needs: at one time, national defense during the cold war, and now, a scientifically well-trained work force for supporting industry and the government in order to ensure a robust economy and international leadership in science and technology. The federal government is interested in the work force issue, not the specific research output generated by doctoral students.

For their part, universities support mathematics primarily for its role in providing service teaching to a large number of students from other disciplines. They pay for teaching assistantships and want qualified students—with content knowledge and communication and teaching skills—to staff them.

For the doctoral students, the purpose of the doctorate is usually more than the stewardship of an academic discipline. They care about their future careers and hence the job prospects of the discipline. Those who enter our doctoral programs expect career preparation as well as the skills and content knowledge of the discipline necessary to become a scholar and researcher.

These goals and perspectives, although quite different, need not be conflicting. And to be realistic, U.S. doctoral programs must take all of them into account.

Ensuring Our Source of Quality Doctoral Students

A key issue in any discussion on the doctorate in mathematics is our "pipeline". How do we increase the number of students in the field, and how do we ensure that we attract the best-qualified students to join the field?

Much of the problem is our own fault. Traditionally, we have expected that undergraduate students choose to enter a doctoral program in mathematics

purely out of intellectual interest in the subject. Perhaps the student has been "good in math" from elementary school into college classes. Perhaps she was inspired by a teacher in an upper-division class. Our basic assumption has been if you are good at it, then surely you will want to do it. However, if the data in the many national reports are correct, that U.S. students have a declining interest in entering doctoral programs in mathematics, then our assumptions are not well founded.

Perhaps this decline is not felt as much in the handful of top mathematics departments in the country, as they continue to attract the "cream" on the top of the student pool, even as the size of the pool shrinks. But many departments, including my own (which by all measures is among the top research departments: eleventh in the 1995 NRC ranking and tenth in the most recent *U.S. News and World Report* survey), acutely feel the decline. And some suggest that we might briefly see a silver lining over the dark clouds of the recent dot-com collapse, which has led to increased applications to and enrollments in doctoral programs in all of the physical sciences. The good news notwithstanding, what this says to me is that clearly the talent pool is there, but career choice is a critical factor for potential students.

Entering a doctoral program in mathematics is usually one of many choices for a talented undergraduate student. The virtue we often preach about, the versatility of an undergraduate degree in mathematics, is true: students qualified to enter mathematics doctoral programs have many choices: mathematics, other scientific disciplines, and industries that require a good mathematics background. Some of these choices are as intellectually interesting or financially rewarding (or both) as mathematics, and many students choose other fields for a postbaccalaureate degree. Are we missing an opportunity?

One opportunity occurs as undergraduates choose majors. We should try to increase those numbers. Mathematics would seem to have an advantage over other fields, as most undergraduates are required to take at least one course in mathematics and many take more. But many freshmen and sophomores have told me something like this: "I was really interested in math in high school, but after the calculus sequence I lost my interest and chose another major." I have told students that mathematics is not just calculus and that there is a whole new world waiting for them to explore. Nonetheless, we lose many potential majors and potential doctoral students. I have often wondered if mathematics departments could offer an undergraduate "Math 101" course to give students a panoramic view of the field. Perhaps this course could be offered at the sophomore level in order to present the scope and the excitement of the field to potential majors. (I proposed such a course when I was department chair but was advised by the faculty that it would never work because it would not be a required course for any other majors.)

As I mentioned above, besides pure intellectual reasons, career prospects are a critical factor in a student's decision. In my opinion, mathematics faculty members could do a much better job of presenting employment prospects for those with undergraduate and graduate degrees. For example, the career paths most obvious to undergraduate math majors are high school teacher and perhaps actuary, respectable professions certainly but not commonly viewed as the center of excitement in either science or the business world. Similarly, students often assume that with a doctorate in mathematics their career choices will be limited. The career path most obvious to them is becoming a professor, preferably one in a department that values and allows time for research. However, in reality only a small percentage will become faculty members in a research-oriented department; simple arithmetic will confirm this, given the small number of research universities in relation to teaching-focused colleges and universities and the mode of nonexpansion in most universities. The number of new Ph.D.'s produced each year far exceeds the number of current research faculty who retire. Available data (see the article "2001 Annual Survey of the Mathematical Sciences (Second Report)" in the August 2002 issue of the *Notices*) show that only about 25 percent of mathematics Ph.D.'s are finding jobs in doctoral-granting academic departments; most others who find jobs in academia are at colleges with heavy teaching duties. The doctoral degree often takes six to seven years, and the opportunity cost, as well as lost potential earnings, constitutes a high barrier for entry. Moreover, the *apparent* noncentral role of mathematics in the frontiers of science and technology and the necessary specialization inherent in a doctoral program would seem to limit employment options outside of academia. Against this background and considering the other career choices which do profitably leverage good mathematics undergraduate training, it is not surprising to find that only a small percentage of our math majors choose to pursue a doctorate in mathematics.

The above is the case with U.S. students. Many of our doctoral programs have a high percentage of foreign students who are often the most talented students in their countries of origin. When these students enter our doctoral programs, they are focused on mathematics as a career. However, as time passes they begin to appreciate the array of career choices available to them. Some choose to switch to other fields with better prospects, such as computer science and finance. This can be quite

frustrating for the mathematics departments that gave them the initial financial support.

My point is that to ensure a good source of quality students for our doctoral programs, we have to consider the potential candidates' perspective and address their concerns. We have to make the doctorate itself as attractive as, or more attractive than, other fields. The doctorate must take less time to complete than it takes currently. We must recognize the fact that most of our "products" will not become professors in research universities, and so we must train them in a way that better prepares them for a broad range of career options.

To ensure a steady talent pool for the doctorate, mathematics departments should start by improving the undergraduate math major, making it more attractive and providing research opportunities to students well before they graduate. Departments should also get more involved with K–12 mathematics curricula and teacher training programs. The whole "pipeline" need not feed into the doctorate; in fact, it is beneficial to have students branching off to other math-related careers. But if we do not pay attention to increasing the source of good students, then we risk turning our doctorate into a kind of esoteric priesthood for the few.

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Ensuring That Mathematics Is Part of Science

Another critical issue is the role of mathematics in the overall science enterprise. Despite good formal relationships with other science communities, often for political expedience in arguing for increased funding for science in general, mathematics generally has not been seen by other scientists to be at the frontiers of science. This may come as a surprise to some in our community: historically, mathematics has always been at the core of science as both its language and its method of analysis. Giants of the past such as Newton, Gauss, and Poincaré are all great mathematicians with enormous impact on other sciences. But how often do we see articles on mathematics in *Science* or *Nature* these days? And even in the few articles that do appear, the mathematics is usually not immediately relevant to the other sciences. Many scientists I have talked to view mathematicians as bright people who "prove theorems" but who are not relevant to the frontiers of their particular field of science. The notable exception is perhaps theoretical physics: historically, its interaction with mathematics has been extremely beneficial for both. But even the most heralded of the recent interactions (such as string theory) have quite a few skeptics in physics. In any case, the influence of deep mathematics is felt at only a portion of the frontier of modern physics.

Why should mathematics concern itself with being at the frontiers of science? One can argue that mathematics can do quite well on its own. History has shown that many purely internally driven developments in mathematics have ultimately proven to be essential for science. However, I see at least two reasons for getting our community more directly involved in science and working at its frontiers. One is lost opportunities; the other is our doctorate.

Let us consider the first: lost opportunities. Many problems at the frontiers of science are fundamentally mathematical in nature. By being inward-looking and not getting involved, mathematicians are missing out on the chance to make a real impact on science. Take two recent examples I have come across. The 2002 Nobel Prize in Chemistry was given for work that involved a mathematical framework for determining the 3D geometry of large biomolecules by using NMR [nuclear magnetic resonance] techniques. Similarly, a recent issue of *Science* (January 24, 2003) included an article on a breakthrough by two chemists: a fast mathematical algorithm for doing NMR analysis that is based on Fourier analysis. These contributions are mathematical and are of immediate relevance to science, yet our community has not been involved.

Science is not only fertile ground for the application of mathematics, it can also give inspiration for mathematics itself in the form of new problems and new ideas. The opportunities for interaction with science are plentiful and well documented. See, for example, the 1999 NSF report *Mathematics and Science* by Wright and Chorin, and the 2000 NSF report *Opportunities for the Mathematical Sciences.* Others in our community have also called for a

closer integration of mathematics within science (see the article "Mathematics and sciences" by Weinan E in the *Beijing Intelligencer*, August 2002).

Working to place mathematics at the frontiers of science can also be beneficial to our doctoral programs. If we make mathematics more explicitly central to the science enterprise, our doctorate will be more attractive to students who are intellectually interested in the interaction between math and other sciences. It will also provide a means to broaden the perspective of our doctoral students. If backed up by appropriate changes in doctoral training, our students will be more versatile and more attractive in the job market.

I would even go as far as advocating that we require some formal interaction with at least one other science during doctoral training. This is probably common practice for "applied" mathematics students, but it should not be limited to them. This interaction could take several forms: a course or a seminar series in another department, a joint research project with someone from another discipline, in-depth reading on the scientific background of a mathematical problem.

Our doctoral students should be encouraged to explore all areas of science, especially the current frontiers. They should not limit themselves only to the "classical" areas, such as classical theoretical physics. New opportunities for mathematicians are present in many exciting new frontiers in nanoscience, biomedical research, the Internet, and computational science, to name just a few examples.

Ensuring Societal Support for Mathematics Doctoral Education

Finally, mathematics must consider the issue of support for doctoral-level education in the discipline. Few would argue that the health of mathematics doctoral programs, at least in their current forms, depends critically on governmental support. Unlike the other sciences, we can, in theory, carry on most research and train graduate students without federal support. But this would make mathematics much less attractive to potential students than other fields. To ensure continued governmental support, we need to convince society at large that mathematics is worth supporting. We must ensure that outsiders, from other scientists to the public at large, understand the purpose of our field without needing a detailed understanding of its inner workings. It is certainly not intrinsically obvious to the public that research in mathematics at the doctoral level is worth supporting any more than the humanities or the arts. Society expects a return on its investment. Government support for academic research has always been tied to short-term national needs and benefits to society. My experience from serving on NSF advisory committees suggests that societal support for science is based on three kinds of expected returns: (1) long-term investment (fundamental research and human knowledge), (2) impact on the economy and furthering national goals (e.g., national defense), (3) education and development of human resources. The history of U.S. governmental support for science bears this out. Vannevar Bush proposed our current system of national support for academic scientific research after the Second World War to prepare the nation for national defense. Sputnik led to further strengthening of support for science as a response to the Soviet challenge. Will September 11, 2001, be the new Sputnik? The current rationale for structuring support at the NSF is "Ideas, People and Tools": the "people" are as important as the "ideas".

What does this mean for the mathematics doctorate? The first two returns described above call for a balance between fundamental (including curiosity-driven) and targeted research, even though some of us would prefer more of the former. The third return emphasizes the importance of ensuring a stable pipeline of talented students, trained in a broad way to meet a variety of societal needs. Most of our recent success in garnering more funding from Congress for the mathematical sciences is, in fact, based on our discipline's promise to deliver a combination of all three returns. It is certainly not an act of benevolence from Congress to correct past "injustice" in funding levels. Our promise requires the mathematics community to pay more than lip service to the important role of mathematics in society, the economy, and the private sector, and to the impact of mathematics on other disciplines. Our promise should be reflected in how we train our students, including our graduate students. After all, if our products do not satisfy societal needs, then society will stop supporting us and will hire students from other disciplines.

Ensuring That Mathematics Doctoral Education Meets Its Goals

After laying out the different perspectives and goals of the stakeholders in mathematics doctoral education, pointing out the obvious importance of ensuring a stable and talented pipeline of doctoral students by making our doctorate more attractive and more relevant to a variety of career choices, and arguing for a stronger integration of mathematics in science in our doctoral programs, I hope I have provided a context to begin a discussion on concrete steps that we can take to improve on our doctorate.

Actually, if we can agree on the context and the goals, then the steps are quite natural. In fact, the plethora of reports published by national organizations (a useful and comprehensive list is provided in Appendix C of *Strengthening the Linkages between the Sciences and the Mathematical Sciences*, published by the National Academy of Sciences in 2000, based on the work of a committee chaired by

Thomas Budinger) contains a wealth of specific ideas and suggestions.

I cannot add many new ideas to the many that have been suggested, but I can offer four practical steps in light of the goals and perspectives of the stakeholders in mathematics doctoral education and the critical issues of the discipline. I hope these steps and accompanying examples will prompt discussions within individual departments so that they arrive at their own plans, based on local strengths and constraints, for improving their doctoral programs:

1. We should make doctoral education in mathematics more attractive to students and competitive with other fields.

• Expose students to the full range of mathematics. We should emphasize the intellectual challenges as well as usefulness and applications of mathematics.

• Shorten the time to degree. For example, departments could streamline qualifying examinations without lowering academic standards. We could offer summer courses to better prepare the students for their examinations. We could also bring students into research groups as early as possible rather than after several years spent preparing for these examinations.

• Ensure ample research support for doctoral students. At present, many doctoral students are supported by nonresearch-related jobs, such as TAs and tutoring, which take time away from their research and increase time to degree. Faculty should explore all sources of funding and consider various strategies for supporting students. It might be better, for example, to have a smaller doctoral program and provide better funding for the students.

2. We should prepare our doctoral students for a broad range of future careers.

• Expand students' awareness of rewarding career possibilities in mathematics. We could take a big step in this direction by changing departmental culture so that nonacademic careers are as respectable as academic careers. One step in this direction would be to invite a wide variety of outside speakers to talk with the students: a department could invite, for example, former graduates who have successful careers both inside and outside academia, leaders from the mathematics community who can provide a national perspective and a broad science perspective, and potential employers.

• Make teaching an integral part of doctoral training. Many of the graduates who do go into academic settings will have jobs with heavy emphasis on teaching. We could, for example, offer formal TA training courses, assign senior TAs to mentor junior ones (with faculty supervision), select a few TAs to be in charge of a small number of classes, and offer teaching awards to recognize the best TAs and motivate the others.

• Broaden the training of doctoral students. Students should learn about different subfields within mathematics and interact with disciplines outside mathematics. Students should be encouraged to keep abreast of the latest developments, not just in their own research area, but also in mathematics as a whole and in science in general. We should require this broad understanding of the field—and of science—of all students, not just those in applied mathematics.

• Develop professional skills. We must make sure our students leave our programs with essential professional skills. For example, we could provide training in mathematical writing and presentations, proposal writing, and mentoring of junior graduate students and undergraduates.

3. We should improve mentoring during the doctoral training.

• Mentor for the student's career. Early in the mentoring relationship, doctoral mentors must have their students' careers in mind. We should recognize that we train both the researcher and the scholar.

• Help students develop independent research approaches. We should encourage our students to learn the history and the broader literature of a research problem. We can encourage students to formulate their own problems rather than to solve the next problem in the mentor's research program. We can assign broadly defined research areas that have a potential for postdoctoral investigations rather than niche areas that are potential dead ends.

• Help students find the right mentor. Departments should have a formal mechanism for exposing the full portfolio of faculty research programs to doctoral students early on. For example, faculty could give lectures on their research programs; these lectures would be intended for doctoral students looking for thesis advisors. Faculty could offer research area seminars and encourage new students to join. We should encourage our students to attend department colloquia; we should invite good expository speakers and ask them to use part of their lectures to reach out to graduate students.

• Encourage students to mentor each other. We should encourage graduate students to form their own organizations and have senior students mentor junior ones. The senior students can also be involved in organizing the faculty research lectures.

• Improve career counseling. We could formalize career counseling and introduce it early in a doctoral student's career. We should encourage students to attend national and regional conferences and workshops (and, to the extent possible, provide funding for them to attend).

4. We should adopt some effective practices from other sciences.

• Work in groups. Working in groups is a prevalent feature of almost all areas of science and engineering research. The benefits are peer support and a gentler introduction to a research area.

• Include beginning students in research groups. This should be done before they advance to candidacy to reinforce the idea that the main emphasis of a doctoral education is the research experience, not courses and examinations.

• Drop the barriers between "pure" and "applied". Most sciences are not organized according to a "pure" versus "applied" dichotomy. Each sub-discipline within a department usually has faculty with interests ranging from foundational to applied. For example, chemistry departments are not organized into "pure chemistry" and "applied chemistry" units. In physical chemistry, one of the common subfields, one often finds theoreticians who solve Schrödinger's equations, experimentalists who look for new molecules and their properties, computational chemists who do numerical simulations, and material chemists who design new materials. Doctoral students in chemistry are thus in a better position than are their mathematics counterparts to be aware of the whole range of problems in their subfield beyond their own research problems. Is there something worth emulating here?

Conclusion

In the final analysis, perhaps the most critical questions facing doctoral education in mathematics are not those about how to improve it. The critical questions are these: Do we have the will to make serious improvement, and is now the time to do so? Specific ideas such as those I offer above have been pointed out for more than two decades, yet until very recently very few of them have been widely adopted. What is different now? What suggests that change is possible now?

For one, money speaks. And it is speaking now. The NSF has been quite proactive recently in using its funding programs to effect changes in the mathematical sciences doctoral programs. The most notable is the VIGRE program, which specifically calls for an overhauling of doctoral programs. The funding varies from several hundred thousand dollars to close to a million dollars for each department, a sum most departments would consider substantial. The NSF's rationale for VIGRE is that not only is it good for the discipline, it also appeals to Congress: it is the mechanism that allowed the NSF to obtain funding for mathematical sciences from Congress. The NSF made a successful case, arguing for the importance of maintaining a pool of well-trained U.S. doctoral students in the mathematical sciences, and thus obtained extra funding for implementing the program.

As the VIGRE program currently goes through its first review after an initial three years, it has generated its share of controversy (see "VIGRE turns three" by Rick Durrett in the November 2002 issue of the *Notices*, and his "Opinion" piece in the same issue; see also "NSF moves with VIGRE to force changes in academia" in the May 24, 2002, issue of *Science*). Some leading departments, including some that have not been funded by VIGRE or recently lost the funding, are complaining that the NSF is attempting a form of social engineering of the doctorate and is thus interfering with the long traditions in many top departments. The restriction of VIGRE to U.S. students has also created problems at some departments. Of course, the matter worsened after September 11, 2001, with tightened issuance of visas to students from "sensitive" countries. Despite the controversies, however, it is generally agreed that VIGRE has had a healthy influence on the mathematics doctorate, but its full long-term effects still remain to be assessed.

But there is another reason that this might be the moment for important change in the mathematics doctorate: the explosion of exciting new opportunities in, and competition from, other areas of science and technology in which mathematics has the potential to play a big role. Many have pointed out that, several decades ago, the mathematics community relinquished the enormous opportunity offered by the advent of computer science (see Susan Landau's editorial in the March 2000 issue of the *Notices*). Are we going to repeat the blunder by letting the current revolutions in nano- and biomedical sciences pass us by?

The question of whether or not we make the improvements we need remains fundamentally a cultural issue. Our action cannot be dictated from any one source of authority. Change must be instigated by faculty. Yet faculty are often the most resistant to change: it is human nature to base decisions on one's own experience, and when some of us were graduate students, things were quite different. Real change, however, requires real leadership from individuals and institutions. The NSF, at least, is trying to effect change. But real change in mathematics doctoral education must be initiated from within our own community.

Do we have the will to make significant changes to our doctoral programs now? Do we want real changes, or do we simply want the national reports to say the right things only for the expedience of the political process of bringing in more resources to the community? I suggest we look forward and that we do so for the long-term interest of our discipline and for the next generation of doctoral students.

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Book Review

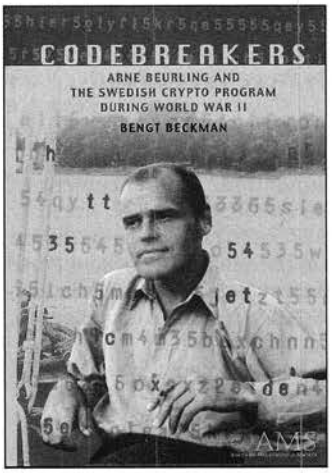
Codebreakers: Arne Beurling and the Swedish Crypto Program During World War II

Reviewed by F. L. Bauer

Codebreakers: Arne Beurling and the Swedish Crypto Program During World War II
Bengt Beckman
Translated from the Swedish by Kjell-Ove Widman
AMS, 2002, ISBN 0-8218-2889-4

The author of this book, Bengt Beckman, started in 1946 to work as a conscript for the *Försvarsväsendets radioanstalt* (abbreviated FRA), which is the cipher bureau of the Swedish *Försvarsstaben* (Defense Staff Headquarters). By that time the war was already history, but the young Beckman was told stories by some who took part in and carried out very important and impressive cryptanalytic feats. Now, more than fifty years later, this information is no longer classified. In fact, the story of the breaking of the German *Geheimschreiber* by Arne Beurling can be told—at least to the extent that Beurling disclosed it.

For many years Bengt Beckman, who retired in 1991, was head of the cryptanalysis section of the FRA. Thus he is equipped with comprehensive knowledge about many aspects and details of cryptology. While such a person usually remains behind a screen of inaccessibility, in 1993 Beckman was allowed to appear in a Swedish television documentary about cryptology. He was also permitted



to publish in 1996 a revealing and generally intelligible book, *Svenska kryptobedrifter* (*Swedish Codebreaker*). Credit is due to the American Mathematical Society that now an English translation, carried out with great competence by Kjell-Ove Widman, has appeared. The translation allows a wide general public with no knowledge of the Swedish language to compare the Swedish successes with the Polish and British cryptanalytic achievements against the communication lines of the German *Wehrmacht*.

The book provides evidence that the Swedish achievements are remarkable. Just as Poland had Marian Rejewski and Great Britain had Alan Turing, Sweden had a hero: Arne Beurling, whose name appears in the subtitle of the book. Like Turing, Beurling (1905–1986) was a mathematical genius whose posthumous fame in mathematics has long been well established—after all, after the war he became a permanent member of the famous Institute for Advanced Study (IAS) in Princeton. Thus the AMS had good reasons to support the translation into English. The preface by Peter W. Jones, whose own

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This is a new version of Bauer's review of Codebreakers *that originally appeared in German in Mitteilungen der Deutschen Mathematiker Vereinigung, 2-2003.*

work is quite distant from cryptology, provides with judicious conciseness an impressive picture of the mathematical work of Arne Beurling.

Beckman's book naturally concentrates on the cryptanalyst Beurling. In this field, among a number of Beurling's astounding successes requiring great analytic aptitude and an almost prophetic gift, one result stands out because of its eminent importance for Swedish security in World War II: The cracking of enciphered communications traffic on the *Wehrmacht* line between Berlin and occupied Oslo. This line ran for some distance on a cable lying in Swedish territory.

In mid-1940, without having more than a slight inkling of the nature of the encryption used on the line, without ever having seen and investigated the machine (a Siemens *Chiffrierfernschreiber* T 52a), Beurling discovered the principles of the encryption after just two weeks of work. While the British codebreakers at Bletchley Park were familiar with the relevant patents—the German one by Jipp and Rossberg (1930) and the American one by Jipp, Rossberg, and Hettler (1933)—the FRA apparently was not aware of the importance this information would have for Beurling.

Beurling entered Uppsala University in 1924 and was a young mathematics postgraduate student when in 1931 he was conscripted and sent to a course in general cryptology and cryptanalysis conducted by Captain Erik Anderberg. One day Anderberg showed Beurling a new crypto device the military had bought and encouraged him to take the machine home over the weekend. After finding a weakness, Beurling asked Anderberg to give him a ciphertext containing a not-too-short "probable word". Anderberg enciphered a message starting with the word *överbefälhavaren* (supreme commander). Beurling came back and showed the full deciphered text to the surprised Anderberg, who could barely believe what he saw. (The device was the Swedish B21, the first machine constructed by the Swedish inventor Boris Hagelin.)

One can guess that this event made Anderberg remember Beurling. Beurling started a mathematical career after completing in 1933 his doctoral thesis, which became immediately famous and earned him a docentship (a kind of time-limited assistant professorship) at Uppsala University. In 1937 he was appointed to a chair for mathematics. On the first day of World War II, Beurling was drafted into the Defense Staff Headquarters under the assumption that for the Russian and German section a certain amount of mathematical cryptanalysis would be needed. Beurling first struggled successfully with the traffic of the Russian navy, in particular that of the Baltic navy, which used a five-digit code book, encrypted again by a polyalphabetic letter substitution, with a periodic key of length 300. While he was trying to use his results with the Red Army and the Arctic navy traffic, Beurling was called to help with a completely new and strange cipher: It had a 32-character alphabet, the 26 letters of the Latin alphabet having been supplemented by the numerals 1 to 6. Other signs that this cipher was unusual piqued Beurling's curiosity, and only then was he told the great secret, that Sweden had leased telex lines to the Germans and that naturally these lines were being tapped. In fact, this had started a few days after the German assault on Denmark and Norway on April 9, 1940, and by April 20 the eavesdroppers had established that standard teletype transmission of messages was involved. Frequently, the traffic consisted of the trivial chattering of idle operators, but increasingly, incomprehensible text was interspersed. It always started and ended with the sequence UMUM, and one could guess that this meant *umschalten* (switchover), i.e., that a transition involving an encryption machine was taking place.

By mid-May 1940 the necessary recording devices were set up, and Beurling started work. With the signals of May 25 and May 27, he was lucky. A German operator repeatedly committed a "sin": he retransmitted a message using the same initial setting. This would have been harmless had the transmissions been letter-for-letter absolutely identical. But because of the comfort the teletype machines offered, carelessness was frequent, and Beurling, who was waiting for such an occasion, spotted it. Some stupid regulations the German operators had been taught also helped Beurling, e.g., that for technical reasons a space symbol, 5, should always be followed by a letter shift symbol, 3, and that frequently internationally standardized technical terms were used, like QEV ("Did you understand?"). These small slip-ups, caused by the negligent habits of the German operators and by the ignorance of their supervisors, were later exploited on a daily basis by the Swedish codebreakers and by the Polish and British ones as well. Still, to the layman and even the hobby-cryptologist, this looks like a miracle. Beurling did not correct this impression; he never revealed exactly how he found the initial break and used to say, "A magician does not reveal his tricks." But, according to Jones, Beurling at least gave the enigmatic hint that "threes and fives were important."

Beurling finally was able to reconstruct completely the Siemens machine and had a great number of replicas built. He also organized the reconstruction of the keys that were changed from day to day. The information the Swedish government thus gained was vital for the survival of Sweden.

Beckman's book has completed the picture of the great cryptanalyst Arne Beurling given in the 1967 book by David Kahn and the 1993 *Mathematical Intelligencer* article by Bo Kjellberg. But for years

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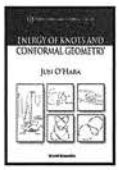

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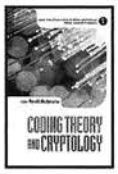

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Beckman also knew Beurling the man, and he hints that his colleague had some remarkable facets, similar to those of Alan Turing. Both of them were eccentric. Young Beurling hunted alligators in Panama with his father, Ahlfors reported. Beurling loved hunting in the mountains of Lapland and sailing Sweden's archipelago. And with affectionate clarity Beckman reports that Beurling was a "lady-killer", attracted by intellectual women; in this regard his orientation differed from that of Turing. Kjellberg wrote that Beurling was one of the most charming persons one could meet and was helpful to his friends, but at the same time he scared some less gifted people. He was not averse to alcohol—understandable in the cold Swedish winter—and suffered from time to time from persecution mania.

Although Beurling was appointed a professor at the IAS in 1954, he never felt fully at home in the United States and did not become an American citizen. It was difficult for him to find the right social environment: He could hurt people without really meaning to, and, being suspicious, he could unexpectedly react in a hurt way himself. He mellowed as time went by, but for most of his life mathematics meant more to him than anything else. He was a perfectionist and loved to surprise people with a deus ex machina. He considered his mathematical results almost like private property. And he had no sense for public relations. As a result, despite the charisma he emitted he did not find in his lifetime the full recognition his genius deserved.

Bengt Beckman has produced a well-written, fascinating book showing the mathematician Arne Beurling in the Scandinavian world of Lars Ahlfors, Harald Bohr, Bo Kjellberg, Rolf Nevanlinna, and Lennart Carleson, as well as the part-time cryptologist Beurling in the depressing atmosphere in Sweden during the Second World War. This is an unforgettable book, even for those not addicted to cryptology.

The Millennium Problems: The Seven Greatest Unsolved Mathematical Puzzles of Our Time

Reviewed by Brian E. Blank

The Millennium Problems: The Seven Greatest Unsolved Mathematical Puzzles of Our Time
Keith J. Devlin
Basic Books, 2002
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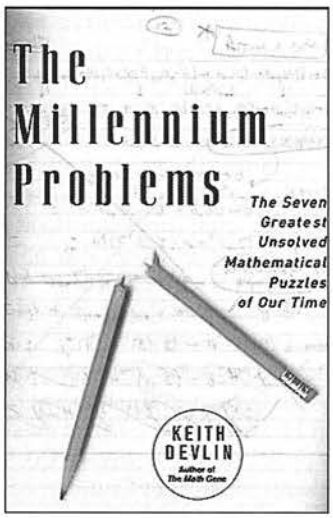
On May 24, 2000, the Clay Mathematics Institute (CMI), inspired by the centenary of the Hilbert Challenge and seeking to put its own stamp on the new century and perhaps beyond, announced awards of one million dollars each for solutions to seven "Millennium Prize Problems" [6]. The problems selected by the CMI were neither new nor concerned with pressing practical matters. Ordinarily the popular press would not have found them newsworthy. But, as the CMI correctly reckoned, seven million dollars concentrates the mind wonderfully. Journalists worldwide reported the story, stirring up so great an interest that the CMI website was quickly overwhelmed. It is reasonable to suppose that most of the fuss was concerned not with the zeros of the Riemann zeta function but with the zeros of the prize fund.

The custom of prize problems in mathematics is an old one. The funds have variously come from governments, societies, interested amateurs, and mathematicians themselves. Among the latter, Paul Erdős is no doubt most associated with the practice of placing bounties on obstinate problems. It



is reported that $10,000 was his greatest offer, $1,000 the greatest claim on his funds. Several other mathematicians have announced prizes of a comparable size. The £1,500 offered by Thwaites for the solution of the $3x+1$ problem is possibly the best known of these. In 1997 Andrew Beal, a Dallas banker with an interest in number theory, upped the stakes considerably by announcing the Beal Conjecture and Prize, worth $100,000 at the time of this writing. During a relatively brief publicity stunt, the Goldbach Conjecture carried a one million dollar price tag. There have been even more lucrative prize funds. At the time of its endowment, the purchasing power of the most famous of all mathematical prizes, the Wolfskehl Prize for the solution of Fermat's Last Theorem, came to about 1.7 million dollars (as measured in 1997 currency) [1]. These sums for abstract problems stack up very well against the £20,000 reward (worth more than three million dollars in today's currency) that the Parliament of England established in 1714 for the invention of the marine chronometer, an instrument

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of incalculable commercial and lifesaving importance.

Using the Wolfskehl Prize as an example, Barner has convincingly argued that a conspicuous prize can play an important role in registering mathematics on the public's radar screen [1]. The question is, now that the initial buzz has died down, will the Millennium Prize Problems retain an interest outside the professional community? With his new book, *The Millennium Problems: The Seven Greatest Unsolved Mathematical Puzzles of our Time*, Keith Devlin joins a group of authors who are betting that the answer is "yes". Indeed, there does appear to be a ready market for books of this sort. The enduring popularity of elementary (albeit arduous) classics such as Dörrie [3], Khinchin [7], and Klein [8] compellingly illustrates the lure of the difficult problem. Recently there have appeared popular accounts of the Kepler Conjecture and the Four-Color Problem, three books on the Riemann Hypothesis (of which I have read only [9]), and two books on the entire set of Hilbert problems [5], [11].

Several of the cited authors liken unsolved mathematical problems to challenging mountain peaks. The analogy is a useful one, because it highlights differences as well as similarities. You might be surprised to know that climbers make the same comparison. In his account of the recent expedition that found George Mallory's body on Mount Everest, Doug Bell wrote, "Climbing a truly high mountain is not unlike the academic quest for truth. Both require rigid discipline and yet a flexibility of approach—and to reach either goal a person needs both the ability to slog along hour after hour and the finesse to find a way past tricky narrows." To Devlin "the seven Millennium Problems are the current Mount Everests of mathematics." They are, in the order of appearance in his book: the Riemann Hypothesis, Yang-Mills existence and the mass gap, the *P* versus *NP* problem, the Navier-Stokes existence and smoothness problem, the Poincaré Conjecture, the Birch and Swinnerton-Dyer Conjecture, and the Hodge Conjecture. The number of pages devoted to each ranges downward from 44 to 16 in what would have been a monotone decreasing sequence but for the graphics in the Poincaré Conjecture chapter. Addressing a reader who is assumed to have no more than a good high-school knowledge of mathematics, Devlin sets himself four tasks: "to provide the background to each problem, to describe how it arose, explain what makes it particularly difficult, and give you some sense of why mathematicians regard it as important."

Now if Devlin's audience consisted of well-prepared second-year graduate students with eclectic tastes, then his agenda would seem ambitious but worthwhile. Devlin, however, is serious about reaching a much less sophisticated audience. When his readers encounter "10!" he feels obliged to tell them, "You don't read this aloud as 'ten' in an excited or startled voice." Surely it is pointless trying to convey to such readers just how difficult the millennium problems are. Experience is required for such a judgment. Those of us who have never climbed even a moderately difficult mountain cannot appreciate how hard it is to summit Eiger via its north face. But Reinhold Messner tells us that it is a scary ascent, and we are prepared to take his word for it. That is pretty much how Devlin achieves his goal of explaining the particular difficulties of the millennium problems. He shows us no failed routes to the top, no lines of attack that might get us there if only we could see them through.

Establishing the importance of the millennium problems is another task that is not easily accomplished. Devlin is correct to assume that for his audience "We must know! We shall know!" will not suffice. I suspect that of the seven millennium problems, only *P versus NP* has the type of significance that will resonate with the majority of Devlin's readers. He explains it to them well. Not so with the other problems. To affirm the importance of the Mass Gap Hypothesis, Devlin quotes Witten, who tells us that "the proof would shed light on a fundamental aspect of nature." That is as deep and convincing as it gets. The reader is told that "A proof of the Hodge Conjecture would establish a fundamental link among the three disciplines of algebraic geometry, analysis, and topology," "A solution to [the Birch and Swinnerton-Dyer Conjecture] will add to our overall understanding of the prime numbers," "A solution of the Navier-Stokes equations would almost certainly lead to advances in nautical and aeronautical engineering." A proof of the Riemann Hypothesis, Devlin writes, "might well lead to a major breakthrough in factoring techniques...with Internet security...hanging in the balance." I suppose it is a sign of the times that internet commerce is being used to validate interest in the Riemann Hypothesis.

The last two of Devlin's goals, explaining the genesis of each problem and developing its background, can be grouped together. These tasks are the heart of the book, and Devlin scores some successes amid the expected failures. The Hodge Conjecture, for example, completely defies elementary discussion. Devlin does not impart a good sense of this problem, and he admits it. But it is the concept of the book that is at fault, not the effort. The Birch and Swinnerton-Dyer Conjecture might also seem to be out of the reach of a popular book, but in this case I think that Devlin's discussion is surprisingly effective. The chapter on Yang-Mills Theory and the Mass Gap Hypothesis is essentially devoid of mathematics, but it is fun, interesting, and a painless summary of a good deal of physics. An introduction to topology makes up most of the chapter

that is devoted to the Poincaré Conjecture. Half the chapter on the Navier-Stokes equation is given over to a crash course on calculus and partial derivatives. Maybe it is the case of a glass-half-full author meeting a glass-half-empty reviewer, but I am not convinced that it was wise to target this book at an audience with such minimal background.

I come now to the two problems that I think are best suited for Devlin's concept. The well-known *P versus NP* problem was actually a prize problem long before the CMI put up its one million dollars. In January 1974 Donald Knuth offered one live turkey to the first person who proves that $P = NP$. This problem is quite different from the others. Few undergraduate texts in mathematics focus on the other six millennium problems, but *P* versus *NP* has become a mainstay of the computer science literature. Most books about algorithms, complexity theory, or theoretical computer science introduce the classes *P*, *NP*, and *NP*-complete (as well as others such as *co-NP*). The Traveling Salesman Problem (TSP) is almost always chosen as an example. By now most computer scientists anticipate that many of their readers will already be familiar with TSP. As a rule they supplement it with a few less hackneyed examples. Shasha and Lazere [10] find another way to avoid the commonplace by interviewing Leonid Levin, overlooked by Devlin, and Stephen Cook. (As an aside, let me note that when scientists write in a popular vein, they often consult colleagues about facts, but they rarely *interview* fellow scientists. The books of Yandell [11] and Sabbagh [9], like that of Shasha and Lazere, demonstrate how effective the technique can be.)

Devlin's treatment of *P versus NP* is mundane but effective. He refers briefly to another *NP* problem but otherwise sticks closely to TSP. Generally speaking, his discussion is a scaled-down version of the treatment that he gave in *The New Golden Age* [2]. The *Time-complexity* table that appears in both books is but one illustration of how closely Devlin sometimes follows his earlier writings. A jaded reviewer who is apt to regard the new discussion as merely a superfluous rehashing must concede that many of Devlin's readers will be learning these ideas for the first time. Those readers will understand the discussion in Devlin's book and come away with a good idea of what this millennium problem is about. It is therefore a successful chapter.

We reach the Riemann Hypothesis (RH) at last. Because it is a great problem that can be accessible when approached in a thoughtful way, it should be ideal for Devlin's type of book. Like Fermat's Last Theorem, RH originates with a fascinating story that encourages speculation. Many interesting, easily stated facts about the ζ function are known. Several curious, seemingly unrelated conjectures are equivalent to RH. Many of the greatest mathematical characters of the twentieth century were drawn to it. There are anecdotes, false proofs by famous mathematicians, mammoth computer calculations, unimaginably large counterexamples to related conjectures—in short, a treasure trove from which any expositor can profitably plunder if he is so inclined. On the evidence, Devlin was only lukewarm to the idea.

As mentioned earlier, the chapter on RH, Devlin's longest, comes to 44 pages. That includes a lot of standard padding such as Euclid's proof of the infinitude of primes. Devlin makes the connection between the zeta function and the sequence of primes via the Euler Product Formula, but after that everything becomes needlessly imprecise. The Prime Number Theorem is discussed, there is a lot of *vague* talk about its relationship to the equation $\zeta(s) = 0$, but neither the fact that $\zeta(1 + it) \neq 0$ nor its import is mentioned. Even the *critical strip* does not appear. A plot of $z = \sin(xy)$ finds its way into the chapter, but $z = |\zeta(\sigma + it)|$ is not graphed. Although it will not bother the typical reader, Devlin's speculation about Riemann's insight (pp. 50–51) is at odds with Edwards's exposition of the Riemann-Siegel Formula [4, pp. 136–170]. In the final analysis, much better treatments of RH abound. Indeed, Devlin wrote one of them [2, pp. 193–221].

To Devlin "the seven Millennium Problems are the current Mount Everests of mathematics."

The job of the popularizer is admittedly difficult. These authors are constantly faced with optimization problems that are not present in more advanced monographs. I confess that I am often baffled by the solutions that they find. For example, Devlin records the symmetric form of the analytic continuation formula for $\zeta(s)$ using an unspecified expression, $\gamma(s)$, for $\Gamma(s/2)$ or $\Pi(s/2 - 1)$. So far as I can see, little is gained by using nonstandard notation—the symmetry is a bit more transparent—but there is a real loss: the reader who knows the gamma function but who is learning the zeta function from Devlin will be deprived of a beautiful formula. Twice Devlin tells us that RH is the most important unsolved problem in mathematics. There is something to be gained by replacing tangled, indecisive discourse with simple, clear-cut assertions. The loss is that such pronouncements invite questions that are not answered. Why should a topologist consider RH more important than the Poincaré Conjecture? The $3x + 1$

problem, to cite but one example, does not *appear* to have the *gravitas* of RH, but until we get to the bottom of it and any number of other unsolved problems, is it not premature to bestow highest honors?

Like journalists, mathematical popularizers are well served by the precept "the truth, nothing but the truth, but never the whole truth." Devlin lives by the third part of that saying but often runs afoul of the second. When an author does not bother to check his facts, no matter how unimportant, he puts his credibility at risk. It is not true that the Riemann Hypothesis "is the only problem that remains unsolved from Hilbert's list" (p. 4). Not all the seventy-two savants memorialized on friezes of the Eiffel Tower are "nineteenth-century French scientists" (p. 131). Devlin writes that "the term 'imaginary' for the square root of a negative quantity seems to have been first used by Euler" (p. 37). He is confusing the term "imaginary" with the notation i. Descartes, Wallis, and Leibniz all used "imaginary" prior to Euler. A footnote on page 54 refers to "... the (false) assumption that there is no largest prime." Finally, it is foolish and inappropriate to suggest that mathematicians are "the seekers of the only 100% certain, eternal truth there is." Surely there will be curious scientists from other fields who will pick up this book. Do we need to pick fights with them?

What I find most lacking is a real sense of what these problems are all about. What drives our passion for these and similar problems?

Devlin is a professional author, and anything he writes will reflect that. However, there is no way to disguise a suspect idea. Several editors, he tells us, approached him with the concept of this book. It shows. Writing that does not burst forth from an author is bound to be halfhearted. What I find most lacking is a real sense of what these problems are all about. What drives our passion for these and similar problems? At the press conference that accompanied the prize announcements, Landon Clay, founder of the CMI, explained that "It is the desire for truth and the response to the beauty and elegance of mathematics that drives mathematicians." Put aside the incongruity of such thoughts being expressed by a man who has just put up seven million dollars of incentives. More to the point, his list of driving forces is seriously incomplete. To get the tacky subject of financial gain out of the way, tangible benefits *are* expected to ensue, one way or another, from the cracking of a tough nut. I am reminded that many years ago when Quillen solved Serre's Problem, the assistant professor who taught my algebra class did not speak of truth, beauty, or elegance; he lamented that a perfectly good problem had been squandered needlessly on a mathematician who already had tenure.

There are other powerful driving forces that Clay and Devlin are too discreet to mention. As an undergraduate I attended a lecture that touched upon the solution of a famous problem that dominated its field for half a century. A twenty-year-old can be startled to learn that ten years of a mathematician's life might be expended on the solution of one problem. How can anyone persevere so long without admitting defeat? When a fellow student phrased that thought as a question, my professor, himself a leader in the field, laughed and said "You have to know Professor ___ . He thinks he can solve anything." It was a funny answer that only momentarily concealed his sincere admiration for the confidence that can be so essential for success. Ego, competition, one-upmanship—not noble forces, perhaps, but mathematics is the richer for them. In a recent book devoted entirely to RH, Karl Sabbagh elicits unusually candid remarks from many of the top mathematicians in the chase [9]. Several mathematicians confront the controversial practice of hoarding partial results. One admits, "I'm afraid I see all of mathematics as a competition. If someone has a theorem, I always want to prove a better one." Another expresses relief that a highly publicized proof of RH fell apart, sending the unfortunate aspirant back "to oblivion where he came from."

All of this leads one to conclude that Devlin is being a tad genteel when he gives high-minded reasons or even practical reasons that attempt to explain why mathematicians are drawn to unsolved problems. In the preliminary chapter, appropriately titled "The Gauntlet Is Thrown", he comes closer to the truth when he writes "Ultimately, mathematicians pursue these problems for the same reason the famous British mountaineer George Mallory gave in answer to the newspaper reporter's question, 'Why do you want to climb Mount Everest?': 'Because it is there'." Although the words ascribed to Mallory may have been composed by an unnamed *New York Times* reporter as a response to a putative query, alpinist Robert

Jasper *was* asked why he pioneered a new route up the Matterhorn. He cited "the challenge of the line, which I've always regarded as an end in itself." Indeed! As soon as climbers have conquered a peak they strive to find new, more taxing routes to the top. And when those routes have been traversed, they relax the hypotheses and try to be the first to summit in winter. And so on. It sounds just like mathematics. To paraphrase a credit card commercial: CMI Prize Problems—$1,000,000; succeeding where everybody else has failed—priceless.

As I write this review, purported proofs of both the Riemann Hypothesis and the Poincaré Conjecture are circulating. However those claims turn out, we are sure to reap a fine harvest of books and papers inspired by the Millennium Prize Problems. We may all look forward to the day when a fellow mathematician brings news from the summit and echoes the first words of Edmund Hillary on his descent: "We've knocked the bastard off!"

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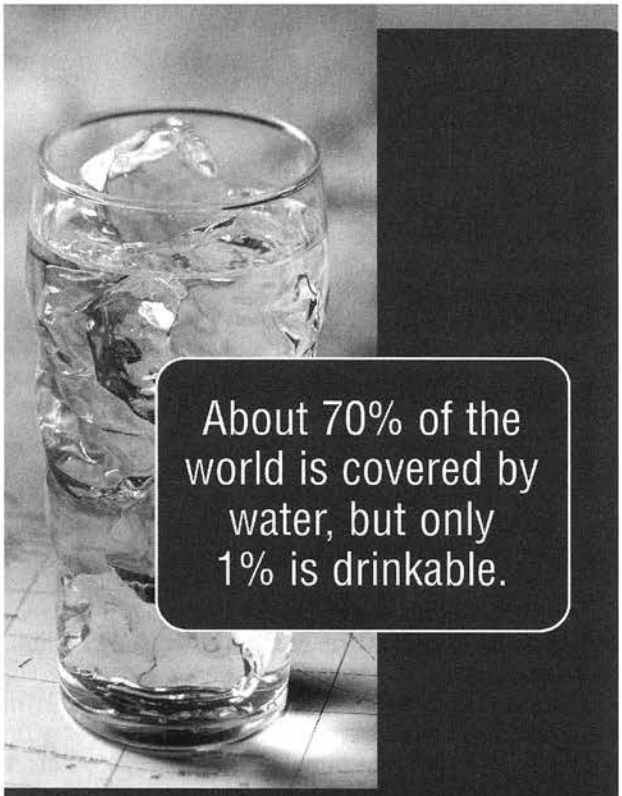

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The On-Line Encyclopedia of Integer Sequences

N. J. A. Sloane

This article gives a brief introduction to the On-Line Encyclopedia of Integer Sequences (or OEIS). The OEIS is a database of nearly 90,000 sequences of integers, arranged lexicographically. The entry for a sequence lists the initial terms (50 to 100, if available), a description, formulae, programs to generate the sequence, references, links to relevant web pages, and other information.

To Consult the Database

Since 1996 an electronic version [20] has been accessible via the Internet at the URL `http://www.research.att.com/~njas/sequences/`. If a list of numbers is entered there, the reply will display the entries for all matching sequences.

For example, suppose you were trying to count the ways to insert parentheses into a string of n letters so that the parentheses are balanced and there are at least two letters inside each pair of parentheses. The outer pair of parentheses is to be ignored. For $n = 3$ and 4 there are respectively 3 and 11 possibilities:

$n = 3$: $abc, (ab)c, a(bc)$;
$n = 4$: $abcd, (ab)cd, a(bc)d, ab(cd), (ab)(cd), (abc)d, a(bcd), ((ab)c)d, (a(bc))d, a((bc)d), a(b(cd))$.

Further work shows that for $n = 1, \ldots, 5$ the numbers are 1, 1, 3, 11, 45. Entering these into the web page produces nine matching sequences, but they are sorted, with the most probable match appearing first. Indeed, this entry tells you that these are the numbers (sequence `A1003`) arising from "Schröder's second problem" and are also known as "super-Catalan numbers".

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The reply (an abridged version is shown in Figure 1) gives 21 references, ranging from Schröder (1870) [17] to articles published electronically in the last few years. There is an explicit formula:

$$a(n) = \frac{1}{n}\sum_{k=0}^{n-2}\binom{2n-k-2}{n-1}\binom{n-2}{k}, \quad n > 1;$$

a recurrence:

$$(n+1)a(n+1) = 3(2n-1)a(n) - (n-2)a(n-1)$$
$$\text{when } n > 1, \text{ and } a(1) = a(2) = 1;$$

programs to produce the sequence in Maple and Mathematica; and much more.

There is no other reference work that will carry out this kind of search.

The Encyclopedia can also be consulted via email. There are two addresses. Sending email to `sequences@research.att.com` with a line in the body of the message saying

lookup 1 1 3 11 45

will trigger the same search that the web page performs, only now the results are sent, almost immediately, via email. Superseeker (`superseeker@research.att.com`) carries out a more sophisticated analysis and tries hard to find an explanation for the sequence, even if it is not in the database. If the simple lookup fails, Superseeker carries out many other tests, including:

- applying over 130 transformations to the sequence, including the binomial, Euler, Möbius, etc., transforms [1], and checking to see if the result is in the database;
- applying Padé approximation methods to try, for example, to express the n^{th} term as a rational function of n (using the "gfun" package of Salvy and Zimmermann [16], the "guesss" program of

Derksen [6], and the "RATE" program of Kratenthaler [8]);

- checking to see if changing one or two characters produces a sequence in the database.

Since Superseeker carries out a nontrivial amount of calculation, users are asked to submit only one sequence per hour.

The electronic version of the Encyclopedia had its origins in the books [18] (1973) and [21] (1995). Disk space is cheap, and the present incarnation (excluding illustrations) contains about 72 times as much data as the 1995 book. The history of the Encyclopedia is described in more detail in [19].

Applications

Most people use the Encyclopedia to identify a sequence, as illustrated above. It has been around long enough that there is a good chance that your sequence will be there. If not, you will see a message encouraging you to submit it.

Most of these applications are unspectacular, akin to looking up a word in a dictionary (cf. [2]). One encounters a sequence in the middle of a calculation, perhaps

1 2 4 6 10 12 16 18 22 28 30 ... ,

and one wants to know quickly what it is—preferably a formula for the n-th term (in this case it is probably prime(n) − 1, A6093) or a recurrence. Successful applications of this type usually go unremarked. Some are more dramatic: there is a web page[1] that lists several hundred articles that acknowledge help from the OEIS. One quotation will serve to illustrate this. Emeric Deutsch of Polytechnic University, Brooklyn, said in a recent email message: "... your database is invaluable. For example, for a certain sequence a_n, using Maple I found the first 100 or so indices i for which a_i is odd. Only the OEIS could tell me that the sequence of these i's is a known sequence related to the Thue-Morse sequence. Of course, this had to be followed by further reading and proof."

The other main application is to find out the current status of work on a problem, for example, the search for Mersenne primes (see A43), the enumeration of Hadamard matrices (A7299), Latin squares (A315), or meanders (A5316), the latest information about the decimal expansion of π (A796) or, better, its continued fraction expansion (A1203).

Of course people trying to solve puzzles or intelligence tests find the database useful. A5228 is a classic:

1 3 7 12 18 26 35 45 56 69 83 ... .

There are also some less obvious applications. One is in simplifying complicated integer-valued

[1] http://www.research.att.com/~njas/sequences/cite.html.

AT&T Integer Sequences RESEARCH

Greetings from the On-Line Encyclopedia of Integer Sequences!

Matches (up to a limit of 30) found for 1 1 3 11 45 :

ID Number: A001003
Sequence: 1,1,3,11,45,197,903,4279,20793,103049,518859,2646723,
13648869,71039373,372693519,1968801519,10463578353,
55909013009,300159426963,1618362158587,8759309660445,
47574827600981,259215937709463,1416461675464871
Name: Schroeder's second problem (generalized parentheses); also called super-Catalan numbers or little Schroeder numbers.
Comments: a(n) = number of ways to insert parentheses in a string of n symbols. The parentheses must be balanced but there is no restriction on the number of pairs of parentheses. The number of letters inside a pair of parentheses must be at least 2. Parentheses enclosing the whole string are ignored.
Stanley gives several other interpretations for these numbers.
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I. M. H. Etherington, Some problems of non-associative combinations, Edinburgh Math. Notes, 32 (1940), 1-6.
T. S. Motzkin, Relations between hypersurface cross ratios, and a combinatorial formula for par titions of a polygon, for permanent preponderance, and for non-associative products, Bull. Amer. Math. Soc., 54 (1948), 352-360.
E. Schroeder, Vier combinatorische Probleme, Zeit. f. Math. Phys., 15 (1870), 361-376.
R. P. Stanley, Enumerative Combinatorics, Cambridge, Vol. 2, 1999; see page 178.
.....
Links: H. Bottomley, Illustration of initial terms
E. Pergola and R. A. Sulanke, Schroeder Triangles, Paths, and Parallelogram Polyominoes, J. Integer Sequences, 1 (1998), #98.1.7.
Formula: Recurrence: a(1) = a(2) = 1; for n > 1, (n+1)a(n+1) = 3(2n-1)a(n)-(n-2)a(n-1). G.f.: (1/4)*(1+x-sqrt(1-6*x+x^2)).
For n > 1, a(n) = (1/n) * sum_{k = 0 .. n-2} binomial(2*n-k-2,n-1)*binomial(n-2,k).
Example: a(3) = 3: abc, a(bc), (ab)c; a(4) = 11: abcd, (ab)cd, a(bc)d, ab(cd), (ab)(cd), a(bcd), a(b(cd)), a((bc)d), (abc)d, (a(bc))d, ((ab)c)d.
Maple: t1:=(1/4)*(1+x-sqrt(1-6*x+x^2)); series(t1,x,40);
Math'ca: Sch[1]=Sch[2]=1;Sch[n_Integer]:=Sch[n]=(3(2n-3)Sch[n-1]-(n-3)Sch[n-2])/n; Array[Sch[#]&, 20]
See also: See A000108, A001190, A001699, A000081 for other ways to count parentheses. Cf. A000311, A010683, A065096.
Keywords: nonn,easy,nice

Figure 1. Part of the reply when the sequence 1, 1, 3, 11, 45 is submitted to the On-Line Encyclopedia. Many references, links, and comments have been omitted to save space.

expressions. You might, for example, have encountered the sum

$$\sum_{k=0}^{n} \binom{4n+1}{2n-2k}\binom{n+k}{k}.$$

There are powerful methods for evaluating such sums [12], [13], but it doesn't take long to work out the first few terms: 1, 12, 240, 5376, and to look them up in the database. In this case you would have been lucky. The reply suggests that this is sequence A6588, $4^n\binom{3n}{n}$, and supplies, with references, the binomial coefficient identity you were hoping for.

Another application is in proving inequalities. You might suspect that $\sigma(n) < n\sqrt{n}$ for $n > 2$, where σ is the sum-of-divisors function (A203). If the initial terms of $[n\sqrt{n}] - \sigma(n)$ (where [ ] denotes the "floor" function) are submitted to the database, the reply suggests that this is A55682 and points you to a reference that gives a proof of your inequality.

I cannot resist mentioning sequence A57641, which gives the values of

$$[H_n + \exp(H_n)\log(H_n)] - \sigma(n)$$

for $n \geq 1$, where H_n is the harmonic number $\sum_{i=1}^{n} 1/i$. Lagarias [9], extending earlier work of Robin [15], has shown that this sequence is nonnegative if and only if the Riemann hypothesis holds!

Although the database contains a number of sequences of both of the above types, I have not made a systematic search through reference works such as [7], [11], and it would be nice to get many more examples.

The database can also be used to save space when referring to particular sequences. When introducing the Motzkin numbers, for example, instead of giving the definition, references, and the first few terms, it is simpler just to say "... the Motzkin numbers M_n (sequence A1006 of [20])."

One can also search the database for sequences that mention a particular name (Riemann, say), and there is a separate alphabetical index, useful for keeping track of all sequences on a certain topic—e.g., the entry for *groups* lists abelian (A688), primitive permutation (A19), transitive permutation (A2106), simple (A5180), total number (A1), and others.

In the past year the main look-up page has been translated into twenty-eight languages, with the goal of making it easier to use throughout the world. The entries from the database still appear in English, but the headings in the replies and the error messages have also been translated.

The Database

To be included in the database a sequence should be integer valued, well defined, and interesting.

The main sources are combinatorics, number theory, and recreational mathematics, but most branches of mathematics are represented (e.g., A27623, the number of rings with n elements), and there are hundreds of entries from chemistry and physics (e.g., A8253, the coordination sequence for diamond: the number of carbon atoms that are n bonds away from a particular carbon atom).

Sequences of rational numbers are entered as a linked pair giving numerators and denominators separately. The Bernoulli numbers B_n form the pair A27641/A27642.

Triangular arrays of numbers are read row-by-row, so that Pascal's triangle gives A7318:

1, 1,1, 1,2,1, 1,3,3,1, 1,4,6,4,1, ...

Square arrays are read by antidiagonals, so that the Nim-addition table

0	1	2	3	4	5	...
1	0	3	2	5	4	...
2	3	0	1	6	7	...
3	2	1	0	7	6	...
...		...		...		...

produces A3987:

0, 1,1, 2,0,2, 3,3,3,3, 4,2,0,2,4, ...

Most well-defined submissions get accepted, since an open-door policy seems the best. The amazing coincidences of the Monstrous Moonshine investigations [4], for example, make it difficult to say that a particular sequence, no matter how obscure, will never be of interest.

Sequences that are discouraged are those that depend on an arbitrary and large parameter: primes of the form $x^2 + y^2 + 2003$, say, whereas primes of the form $x^2 + y^2 + 1$ form a perfectly acceptable sequence (A79545).

The Encyclopedia currently receives between 10,000 and 12,000 downloads per day. The rate of arrival of *new* sequences has remained constant at about 10,000 per year for the past seven years, with roughly the same number of comments and updates. To keep this flood of information from getting out of control, people are asked to use a web form[2] when submitting new sequences or comments.

For most of its life the Encyclopedia has been maintained by the author, but in the past year a board of associate editors has been formed to help with the work. There is also a group of regular users who constantly send corrections and extensions and help maintain the accuracy of the entries.

Even so, much remains to be done. There are more journals and e-print servers now than ever, and the trained eye sees integer sequences everywhere. I still discover articles in the library or on the Web where authors have published sequences without sending them to the Encyclopedia. If you come across an integer sequence in your own work or elsewhere, please submit it to the Encyclopedia!

Of course, accuracy is a major concern in maintaining the database. The entries in [18] and [21] were checked very thoroughly, and almost all the errors that have been discovered in those books were already present in the sources from which the sequences were taken. As the number of sequences has increased in recent years, it has become more difficult to check them all. However, the number of users has also increased, and a large number of the entries carry a comment that the sequence has been extended (or sometimes corrected and extended) by someone. Contributors see a reminder that the standards are those of a

[2] http://www.research.att.com/~njas/sequences/Submit.html.

mathematics reference work, and all submissions should be carefully checked. So, on the whole, users can be confident that the sequences are correct. The keywords "uned" and "obsc" indicate sequences that have not yet been edited or for which the definition is unclear. These serve both to warn users and to indicate places where volunteers can help.

One of the pleasures of maintaining the database is seeing the endless flow of new sequences. I will end by mentioning a few recent examples:

Home primes (A37274), [5]: $a(n)$ is the prime reached when you start with n, concatenate its prime factors, and repeat until a prime is reached. ($a(n)$ is defined to be -1 if no prime is ever reached, although it is conjectured that this never happens). E.g., $8 = 2 \times 2 \times 2 \to 222 = 2 \times 3 \times 37 \to 2337 = 3 \times 19 \times 41 \to 31941 \to \cdots \to$ (after 13 steps) 3331113965338635107, a prime, so $a(8) = 3331113965338635107$:

1 2 3 211 5 23 7 3331113965338635107
311 773 11 223 13 ....

The EKG sequence (A64413), [10]: $a(1) = 1$, $a(2) = 2$, and, for $n \geq 3$, $a(n)$ is the smallest natural number not in $\{a(k) : 1 \leq k \leq n-1\}$ with the property that $\gcd\{a(n-1), a(n)\} \geq 2$:

1 2 4 6 3 9 12 8 10 5 15 18 14 7 21 24 16 20 22 11....

Lacing a shoe (A78601), [14]: Number of ways to lace a shoe that has n pairs of eyelets. The lace must follow a Hamiltonian path through the $2n$ eyelets, and at least one of the neighbors of every eyelet must be on the other side of the shoe.

1 3 42 1080 51840 3758400
382838400 52733721600 ....

A "bootstrap" sequence (A79000), [3]: $a(n)$ is taken to be the smallest positive integer greater than $a(n-1)$ which is consistent with the assertion "n is a member of the sequence if and only if $a(n)$ is odd."

1 4 6 7 8 9 11 13 15 16 17 18 19 20 21 23 25 27 29 31 ....

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Progress and Opportunities in Mathematical Sciences Funding

William Rundell

By the time you read this, the federal fiscal year (FY) 2004 budget may be completed and much of the conjectural aspects of this article part of the past. However, it is written in a spirit of long-term optimism that the budget momentum gathered over the last few years can be maintained.

By the end of the 1990s two issues dominated much of the mathematical science policy discussions: the unmistakable sense of research vitality in the discipline, and work force support.

The reason for the first is not hard to see. Many disciplines, in particular the life sciences, were taking on a more quantified perspective: the needs for advanced computation and information technology expansion were opening up new avenues for mathematical and statistical tools, and in the core of mathematics itself several long-standing conjectures were resolved and major advances were taking place in all of the subareas. One of the advantages of being at the National Science Foundation (NSF) is the bird's-eye view one obtains, and it is quite clear that the evolution of ideas is proceeding at a staggering rate. From this perspective the last decade was a wonderful time to be in mathematics.

From another perspective the discipline was facing difficult issues concerning the recruitment of students, the extremely small amount of research funding for their training, and the ultimate placement of graduates into the broad work force. This was not a new phenomenon, for there had been a series of reports dating from the mid-1980s that highlighted the problems very well, and many other science and technology disciplines suffered from some of the same issues.

A graph of the Division of Mathematical Sciences (DMS) budget adjusted for the inflation rate over the two decades before 1999 shows a barely perceptible positive slope line. Despite obvious research growth, increasing utility for other disciplines, and the need to invest in bringing new people into the mathematical sciences, the ability to translate needs into budgets seemed elusive. But then the situation changed dramatically, as the DMS budget approximately doubled in the next five years.

Making the case for a budget is more than just sending the right message. It must also reach the right people at the right time. It is clear that the budget shift was a confluence of a number of things. One could argue it was largely zeitgeist, but this would unfairly ignore the effects of individuals and miss certain essential points. It also underestimates the importance of the message's resonance. My two predecessors, Philippe Tondeur and Don Lewis, made key moves with the initiation of bold programs, and Rita Colwell, the current NSF director, has been enormously supportive and understanding of the importance of the mathematical sciences.

The first of these changes was VIGRE,[1] which addressed the work force issue by providing considerable resources to departments willing to evaluate and, if need be, change their training methods. The second was the initiation of the Mathematical Sciences Priority Area at NSF. This not only recognizes the importance of core mathematics and facilitates interdisciplinary research involving the mathematical sciences but also provides a platform for doing so.

I certainly do not believe that the current situation represents the end of a cycle. Significant progress in key directions has been achieved, along with a much better and balanced funding base from which to operate, but there is a great deal left to accomplish. To paraphrase Churchill, it is not the end, it is not even the beginning of the end, but it is the end of the beginning.

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[1] *Grants for Vertical Integration of Research and Education in the Mathematical Sciences.*

Ensuring an adequate supply of first-class talent for the discipline remains a high priority. The concept of a pipeline modelling the flow of talent from high school through final research career is a useful analogy. In mathematics it is relatively rare that the pipe has any feeders after the mid-level undergraduate period, but there are many important exit paths from the main stream. NSF can provide assistance here by making sure that support opportunities along various parts of the pipe are in balance: from recruitment into university until research careers are established.

While it is still too early for an adequate assessment of the impact of VIGRE, several trends and outcomes are clear. Perhaps the most telling measure of success is the fact that it has caught the attention of policymakers, and the model is being emulated by other disciplines. In more practical terms, in virtually every VIGRE program the numbers of undergraduates, domestic graduate students, and postdocs have increased, often significantly. It has also highlighted needs, especially that a substantial increase in the number of undergraduates who go on for graduate training is required. We should set a target: double the number of mathematics majors progressing to graduate programs in the *sciences* within three to five years. This is ambitious but within our capabilities. For many departments this will require a broadening and an increase in depth of their undergraduate training. The newly expanded "pipeline" solicitation EMSW21[2] is designed to meet goals such as these and to provide greater flexibility. It should also be a very clear signal to the mathematics community and beyond that DMS is serious about long-term commitments to the work force. While solicitation details may change over time, the need for first-class training programs is always pressing.

A second priority is addressing the shortage of researchers in emerging and exciting areas. Assuming the request level for FY2004 is met ($201 million compared to $178.5 million in FY2003), there will be an increase in the Priority Area funding. This will allow an expansion of core activities as well as enable further collaborative efforts with other disciplines. In early fall 2003 there will be a solicitation that consolidates the various elements of the Mathematical Sciences Priority Area and emphasizes the importance of mathematics as collaborators to virtually every corner of the foundation. Considerable funds are available, making it imperative that the mathematical sciences community respond with strong proposals. Part of the solicitation will simply point at existing activities—such as the joint collaborations with the Geosciences Directorate, with the National Institute of General Medical Sciences of the National Insitutes of Health, and with the NSF Biological Sciences Directorate—while others will be new activities aimed at expanding interactions on a broad scale. It would be useful for investigators and departments to keep a close watch on the DMS website.

There have been other accomplishments from previous budget increases. By the end of FY2003 individual DMS program budgets will have increased by almost 40 percent since 1999. This has allowed us to meet the National Science Board directive to increase median award sizes. These have not increased uniformly, but the very best proposals have been funded at the request level when this is commensurate with the project, and more five-year grants are being awarded. In a typical program, one-quarter to one-third of the awards are supported at the lowest step with essentially the same amount, while the top awards receive about four times this level. We have a funding rate of 38 percent, which exceeds the foundation average of 30 percent. However, in every program there remains a substantial number of very strong proposals that remain unsupported due to lack of funds, and a priority for future yearly increments must be to increase the number of investigators supported.

An obvious question concerns an adequate size for the DMS budget and what should be proposed in future requests. If one assumes that the NSF will continue to play the same dominant role in federal support for mathematical sciences research (and I should emphasize that such a funding structure is not an optimal situation), then the computation becomes a little simpler. I have constructed various funding models based on reasonable requirements and approaching the final figure from different directions; these figures are all extremely close. Here is an exceedingly simple version. The NSF publication *Science and Engineering Indicators* shows that the proportion of research-active mathematicians with federal support is approximately one-half of the other sciences. Despite a more than doubling of graduate student support since 1998, the discipline is also still only at one-half the level of other sciences and engineering. Thus to meet even *current* parity, one would have to double the *present* budget to around $400 million. If the Presidential Authorization Bill for a doubling of the NSF budget over the next five years becomes a fiscal reality and if DMS just maintains the foundation average, then this target can be met. However, parity arguments by themselves are weak; the rationale for increased budgets must be made primarily on the contributions the mathematical sciences are able to make for the total scientific enterprise. Vast new opportunities in mathematical research lie ahead, and this is where we should set our, and our students', targets.

[2]*Enhancing the Mathematical Science Workforce in the 21st Century. For more information about this new program, see "Mathematics Opportunities" in this issue.*

The Digital Mathematics Library

Not long ago, Keith Dennis, a mathematician at Cornell University, walked into the departmental photocopying room and saw a bunch of old journals with articles tabbed for photocopying. He told the secretary assigned to make the copies that the journals are available electronically through the JSTOR journal storage website. She was delighted not to have to spend time standing in front of the copy machine. For his part, Dennis was puzzled that one of his colleagues evidently did not realize how easily one can get the material on the Web. "You would hope mathematicians would have some idea of where their literature is," he said. "But that's simply not true."

Dennis told this anecdote at a meeting of the Digital Mathematics Library (DML) Planning Group that took place in May this year in Göttingen, Germany. Despite the committee's work, which was supported by a one-year grant from the National Science Foundation (NSF), and despite progress in getting older paper literature online, the mathematical community remains largely unaware of what is available through the Web. Back issues of such major journals as *Inventiones Mathematicae*, *Mathematische Annalen*, and *Publications Mathématiques de l'IHÉS* were recently made available for free online, and there is more to come. This work is mostly being carried out by a few disparate projects that operate independently. The challenge now facing the world mathematical community is not only to secure funding for such projects but also to come up with ways to coordinate them to prevent duplication of effort, encourage adherence to standards, and ensure that the material is widely accessible.

Pursuing a Dream

The grand vision of the DML is to have all of the mathematical literature online and available through a central source to anyone who has a computer and an Internet connection. Much of the current literature is "born-digital", that is, created electronically and available online from the time of publication. Although high subscription fees can hinder access, that material at least exists in electronic form. But the vast majority of mathematics books and journals are still available only on paper. "Retrodigitization" is the name for the process of creating electronic copies of paper-only works. The initial goal of the DML is the retrodigitization of all of the past mathematics literature.

This goal was strongly pushed by Philippe Tondeur, now retired from the University of Illinois at Urbana-Champaign, who served as director of the NSF's Division of Mathematical Sciences from 1999 until 2002. He used the bully pulpit of his NSF position to proselytize widely for the DML. After discussing the idea with science funding officials in several countries, including officials at the European Commission, Tondeur felt that there was sufficient worldwide support to undertake a program of retrodigitizing all of mathematics. The NSF then provided a one-year grant to Cornell University Library to support meetings of what came to be called the DML Planning Group (the co-principal investigators on the grant were Keith Dennis and Jean Poland, Cornell's associate university librarian for engineering, mathematics, and physical sciences). The group included a steering committee as well as six working groups

and two liaisons to the International Mathematical Union (IMU) (see sidebar). Three meetings were held, the most recent on May 21–22, 2003, at the Niedersächsische Staats- und Universitätsbibliothek in Göttingen.

To explore the potential and challenges of the DML vision, Tondeur asked AMS executive director John H. Ewing to write a "concept paper", and this paper came to be widely circulated ("Twenty centuries of mathematics: Digitizing and disseminating the past mathematical literature", *Notices*, August 2002, pages 771–7). Among the hurdles identified in the paper were negotiating permissions for copyrighted works, making editorial decisions about which books and papers should be included, choosing storage formats, and archiving over the long term. Ewing argued that, despite those difficulties, the grand vision of the DML is feasible: with today's technology, it is actually a tractable task to put all 50 million pages of the past mathematical literature online.

One reason the DML idea has gained momentum is that, as Ewing's paper points out, mathematics is an ideal discipline for massive retrodigitization. In a sense, mathematics is indistinguishable from its literature. Unlike researchers in many other disciplines, especially in the sciences and engineering, mathematicians rely heavily on past literature while working at the frontiers of research. Having that literature available electronically would have a large impact on current research in mathematics.

On the other hand, compared to other disciplines, mathematics presents special challenges for retrodigitization. For one thing, the mathematics literature is extremely diffuse. Dennis, who served as executive editor for *Mathematical Reviews* (MR) from 1995 until 1998, recalled an early conversation with the developers of JSTOR, which has retrodigitized journals in mathematics and other areas. They asked Dennis how many mathematics journals they should put online. Jaws dropped when he replied, "Let's start with five hundred." He was not joking: About six hundred mathematics journals are treated cover-to-cover by MR, and mathematical items are chosen for review from hundreds of other journals not exclusively devoted to mathematics. In some other disciplines, by contrast, it would suffice to retrodigitize as few as a dozen of the most important journals. What is more, mathematics journals are published by commercial publishers, university presses, professional societies, mathematics departments, even ad hoc groups of mathematicians. It would be an enormous legal task to negotiate copyright agreements with such a diverse and geographically dispersed group.

Digital Mathematical Library Planning Group

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Economic Model
Jonathan Borwein
Simon Fraser University
James Crowley
Society for Industrial and Applied Mathematics
John Ewing
American Mathematical Society
Arnoud de Kemp
Springer-Verlag
David Tranah
Cambridge University Press

Retrodigitized Mathematics Journals

Below is a listing of retrodigitized mathematics journals available on the Web. Not included here are websites providing "born digital" material.

Biblioteka Wirtualna Matematyki
http://matwbn.icm.edu.pl/
Fundamenta Mathematicae (1920–1993)
Studia Mathematica (1929–1964)
Prace matematyczno-fizyczne (1888–1952)

Departamento de Ingeniería Matemática
Universidad de Chile
http://www.dim.uchile.cl/revmat.html
Revista de Matemáticas Aplicadas (1994-2002)
(complete retrodigitization under way)

DIEPER
DIgitised European PERiodicals
http://dieper.aib.uni-linz.ac.at
Monatshefte für Mathematik und Physik (1890–1918)

EMIS
European Mathematical Information Service
http://www.emis.de/
Jahrbuch über die Fortschritte der Mathematik (1868–1931)

Gallica
Bibliothéque nationale de France
http://gallica.bnf.fr
Journal de Mathématiques Pures et Appliquées (1836-1880)
(access available through http://www-mathdoc.ujf-grenoble.fr/jmpa)
Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences (1835-1930)

JSTOR
Journal STORage
http://www.jstor.org
(paid subscription required)
American Journal of Mathematics (1878–1995)
American Mathematical Monthly (1894–1997)
Annals of Applied Probability (1991–1997)
Annals of Mathematical Statistics (1930–1972)
Annals of Mathematics (1884–1997)
Annals of Probability (1973–1997)
Annals of Statistics (1973–1997)
Applied Statistics (1952–1998)
Biometrika (1901–1997)
Bulletin of Symbolic Logic (1995–2002)
College Mathematics Journal (1984–1997)
Econometrica (1933–1998)
Journal of the American Statistical Association (1922–1997)
Journal of the AMS (1988–1997)
Journal of the Royal Statistical Society. Series A (Statistics in Society) (1988–1998)
Journal of the Royal Statistical Society. Series B (Statistical Methodology) (1998)
Journal of Symbolic Logic (1936–1998)
Mathematics Magazine (1947–1997)
Mathematics of Computation (1960–1997)
Philosophical Transactions: Mathematical, Physical and Engineering Sciences (1665–1997)
Proceedings: Mathematical, Physical, and Engineering Sciences (1800–1997)
Proceedings of the AMS (1950–1997)
SIAM Journal on Applied Mathematics (1966–1997)
SIAM Journal on Numerical Analysis (1966–1997)
SIAM Review (1959–1997)
Statistical Science (1986–1997)
The Statistician (1962–1998)
Transactions of the AMS (1900–1997)

NUMDAM
NUMérisation de Documents Anciens Mathematiques
http://www.numdam.org
Annales de l'Institut Fourier (1949–1997)
Annales Scientifiques de l'École Normale Supérieure (1864–1997)
(to be added fall 2003)
Bulletin de la Société Mathématique de France (1872–1992)
Journées Équations aux dérivées partielles (1974–2000)
Mémoires de la Société Mathématique de France (1964–1992)
Publications Mathématiques de l'IHÉS (1959–1997)

Project Euclid
http://ProjectEuclid.org/mmj
Michigan Mathematical Journal (1952–present)

SciELO
Scientific Electronic Library Online
http://www.scielo.cl/scielo.php
Proyecciones—Revista de Mathemática (2000–2002)

WDML-Göttingen
Göttinger Digitalisierungszentrum
http://www.sub.uni-goettingen.de/gdz
Abhandlungen der Gesellschaft der Wissenschaften in Göttingen, Mathematisch-Physikalische Klasse (1900–1939)
Abhandlungen der Königlichen Gesellschaft der Wissenschaften in Göttingen (1843–1892)
Acta Facultatis Rerum Naturalium Universitatis Comenianae (1956–1975)
Acta mathematica Universitatis Comenianae (1980–1980)
Aequationes mathematicae (1968–1997)
Archivum mathematicum (1965–1991)
Beiträge zur Algebra und Geometrie (1971–1992)
Casopis pro pestování matematiky (1951–1990)
Casopis pro pestování matematiky a fysiky (1872–1950)
Commentarii mathematici Helvetici (1929–1937/38)
Commentationes mathematicae Universitatis Carolinae (1960–1990)
Geometric and functional analysis (1991–1996)
Inventiones mathematicae (1966–1996)
Matematicki vesnik (1964–1995)
Mathematica Bohemica (1991–1994)
Mathematica Scandinavica (1953–1957)
Mathematische Annalen (1869–1996)
Mathematische Zeitschrift (1918–1996)
Mémoires de l'Académie Royale des Sciences, des Lettres et des Beaux-Arts de Belgique (1777–1788; 1847–1897)
Metrika (1958–1971)
Nachrichten von der Gesellschaft der Wissenschaften zu Göttingen, Mathematisch-Physikalische Klasse (1895–1933)
Nachrichten von der Königl. Gesellschaft der Wissenschaften und der Georg-Augusts-Universität zu Göttingen (1865–1893)
Nouveaux mémoires de l'Académie Royale des Sciences et Belles-Lettres de Bruxelles (1820–1845)
Numerische Mathematik (1959–1982)
Revista colombiana de matematicas (1967–1993)
Seminaire de Théorie des Nombres de Bordeaux (1971–1988)
Vesnik Društva Matematicara i Fizicara Narodne Republike Srbije (1949–1963)
Zentralblatt für Mathematik und ihre Grenzgebiete (1931–1978)

Examples of Retrodigitization Projects

Much of the process of turning paper into electronic files can be automated. Generally, the material is not retyped. Rather, each page is scanned to create an electronic "picture" of the page. Often optical character recognition software is used to produce a text file from the scanned image so that the actual text of the material is searchable electronically. Sometimes the search feature highlights the sought-after word rather than just displaying the page on which the word appears. Users typically retrieve the material in the form of PDF files; other formats such as PostScript or DjVu[1] are sometimes available. Usually the bibliographic data must be typed to ensure standardization and accuracy.

So far retrodigitization projects in mathematics have tended to be fairly small and regionally based. Three examples are JSTOR in the U.S., NUMDAM in France, and WDML-Göttingen (World Digital Mathematical Library) in Germany. JSTOR, which began in 1997, currently offers seventeen journals in the mathematical sciences, most of them based in the U.S., including the *Annals of Mathematics*, *Journal of the AMS*, *Transactions of the AMS*, and the *American Mathematical Monthly*; there are also thirteen journals in statistics and probability. The text of the articles is fully searchable, and one can download them in TIFF, PDF, and PostScript formats. Like most retrodigitization projects, JSTOR operates with a "moving wall": Only material that has been out more than a certain number of years can appear on JSTOR. The number of years varies from journal to journal but is generally three to five years. Publishers have demanded such policies in order to protect journal subscription revenues.

NUMDAM (NUMérisation de Documents Anciens Mathématiques), based at the Université Joseph Fourier in Grenoble and supported by the Centre National de la Recherche Scientifique (CNRS), came online in December 2002. It offers back issues of five French journals, and there are plans to add more. One can find on NUMDAM, for example, the complete text of the landmark work *Éléments de Géometrie Algébrique*, by Alexandre Grothendieck and Jean Dieudonné, which appeared in *Publications Mathématiques de l'IHÉ S* in the 1960s. Articles are available in PDF and DjVu formats, and the text is fully searchable. NUMDAM has a feature similar to the "author identification" feature of MathSciNet: there is a complete alphabetical listing of all authors, organized to account for variations in the spelling and presentation of the authors' names. To the extent possible, NUMDAM has added links from articles to reviews in MathSciNet (the online version of MR) and to reviews in Zentralblatt MATH (the online version of *Zentralblatt für Mathematik und ihre Grenzgebiete*). NUMDAM also provides links from references within articles to reviews in MR and *Zentralblatt*.

The other European example, WDML-Göttingen, is part of a retrodigitization center based at the Niedersächsische Staats-und Universitätsbibliothek in Göttingen. This center, the Göttinger Digitalisierungszentrum (GDZ), currently offers access to 4,100 volumes and 1.5 million pages (900,000 of them mathematics), including such culturally significant works as the Gutenberg Bible. The capabilities of WDML-Göttingen are more limited than those of JSTOR and NUMDAM: for one thing, optical character recognition has not been performed on the files, so the actual text of the articles is not searchable (though one can search bibliographic and structural metadata, and there are special tools to navigate within documents). Nevertheless, WDML-Göttingen has brought a large amount of significant material to the Web. It offers twenty-eight journals, including complete pre-1996 runs of such Springer-Verlag journals as *Inventiones Mathematicae*, *Mathematische Annalen*, and *Mathematische Zeitschrift*. In addition, there are almost four hundred monographs and about twenty multivolume works, including the collected works of Carl Friedrich Gauss, Felix Klein, and David Hilbert, and both the 1898 and the 1939 editions of the *Encyklopädie der Mathematischen Wissenschaften mit Einschluss ihrer Anwendungen*. At the meeting of the DML Planning Group, hopes were high that *Crelle's Journal* (*Journal für die Reine und Angewandte Mathematik*) would soon be added.

The appearance of the Springer journals on WDML-Göttingen is the result of a project called EMANI (Electronic Mathematical Archiving Network Initiative), which aims to make retrodigitized and born-digital materials available on the Web. Bernd Wegner of the Technische Universität in Berlin, who is editor of *Zentralblatt*, is a main mover behind EMANI. He helped to negotiate the terms with Springer, a commercial publisher in Germany. Similarly, French mathematicians associated with NUMDAM were successful in persuading some French publishers to allow retrodigitization of their journals. Local knowledge was essential in the success of these negotiations. Other commercial publishers, such as Elsevier, have begun their own in-house retrodigitization programs, access to which is not free of charge.

NUMDAM and WDML-Göttingen have received support from the science funding agencies of the French and German governments—the CNRS in France, and the Deutscheforschungsgemeinschaft in Germany. In the U.S., despite the NSF's support

[1] *The DjVu format, though less well known than PostScript and PDF, is in some ways superior. More information about it may be found at* http://www.djvuzone.org. *The site includes convenient tools for converting from other formats to DjVu.*

Retrodigitized Mathematics Books

The Cellule MathDoc at the Université Joseph Fourier in Grenoble provides a centralized catalogue for digitized books in four locations: the Digital Math Books of the Cornell University Library, the mathematics books in the Gallica Collection of the Bibliothèque Nationale de France, the WDML-Göttingen project at the Göttinger Digitalisierungszentrum, and the University of Michigan Historical Mathematics Collection. See `http://math-doc.ujf-grenoble.fr/LiNuM/`.

Some monographs by Polish mathematicians are available on the Biblioteka Wirtualna Matematyki, `http://matwbn.icm.edu.pl/`.

for the DML Planning Group, there is essentially no federal funding for such projects. JSTOR got its start with funding through a private foundation, the Andrew W. Mellon Foundation, and, unlike NUMDAM and WDML-Göttingen, charges access fees. These fees run into the thousands of dollars, making JSTOR difficult for many institutions to afford. Nevertheless, JSTOR provides a successful model of a self-supporting, nonprofit organization that raises enough money through access fees to support ongoing maintanance and continued expansion of its database.

The economics of retrodigitzation are somewhat surprising. Scanning in printed material is actually quite cheap. Many retrodigitization projects send material to low-wage countries to be scanned. But even the GDZ, which is located in the exceptionally high-wage country of Germany, can hire local workers for a reasonable cost to scan material on a per-page basis. In fact, the lion's share of the cost of retrodigization is outside of the scanning step; without further processing, the actual content of the scanned works is largely inaccessible. As Ewing put it during the Göttingen meeting, "If you just have a bunch of images, you can't do anything."

During the meeting, representatives from the GDZ outlined the entire process whereby they convert paper materials into accessible electronic archives. Even without performing optical character recognition on the materials they scan, there is a substantial amount of work to be done in performing quality control and in collecting, organizing, and managing bibliographic data and information about the structure of the documents. Creating and maintaining long-term archives is another costly task. Because the GDZ is embedded in a large library, it is difficult to obtain precise estimates of per-page costs of the documents they retrodigitize. But when the figure of $2 per page was mentioned during the Göttingen meeting, one of the GDZ team members said that figure was in line with some early estimates they had done. The scanning might comprise just 10 percent of that amount.

Uniting the Literature

As helpful as resources like JSTOR, NUMDAM, and WDML-Göttingen are, mathematicians do not want to have to stop and remember whether a particular journal is on this or that server. What is needed is some kind of centralized access. One natural idea, which was discussed at the Göttingen meeting, is to add the necessary links to the two main bibliographic databases, MathSciNet and Zentralblatt MATH. In fact, this has already begun to happen. For example, for any paper that has been reviewed in MR and is available on JSTOR, MR has added links so that one can click directly from the review on MathSciNet to the paper on JSTOR (assuming one is at an institution subscribing to JSTOR). Many of the papers on JSTOR appeared before MR began in 1940, so those papers have no bibliographic records in MathSciNet. MR has begun the process of adding these records to MathSciNet, together with links to the papers in JSTOR. This process has been completed for all pre-1940 papers in *Transactions of the AMS* and is under way for *Annals of Mathematics* and for the *American Journal of Mathematics*. Similarly, links have been added from Zentralblatt MATH and from the *Jahrbuch* reviewing journal (which has been retrodigitized and is available online) to the materials available on WDML-Göttingen. At the Göttingen meeting, there was an enthusiastic consensus that such linking should be expanded as much as possible. During the meeting a small group of representatives from MR, *Zentralblatt*, and some retrodigitization projects agreed to confer on developing technical standards to facilitate this linking.

As the DML is now taking form, it consists of a collection of disparate projects working independently. Would it perhaps make sense to create a central body that would coordinate the entire DML retrodigitization program? Such an approach was described in Ewing's paper and discussed within the DML Planning Group, but it did not take root. Those running existing retrodigitization projects want to continue their work as they see fit rather than follow rules set by a larger authority. Similarly, the idea of raising money for the DML in a centralized way, by asking publishers to contribute 1 or 2 percent of their journal revenues, was discussed by the planning group and abandoned. It was assumed that publishers would simply raise subscription prices to cover the contribution. That the group would propose a plan that could lead to increased journal prices was anathema to the group members.

Nevertheless, the DML Planning Group, through its meetings, has already stimulated better coordination among the various retrodigitization projects. It has also produced a report containing contributions by each working group, thereby bringing together the thoughts and ideas of some of the members of the international mathematical community who are the most knowledgeable about retrodigitization. The report, submitted to the NSF in June, will likely prove useful in helping new projects get off the ground and in providing a starting point for standards. Although the planning group disbanded at the end of the Göttingen meeting, there was a clear consensus that a new body was needed to continue the discussion and coordination the group had begun. This task will now be taken up by the IMU Committee on Electronic Information and Communication (CEIC). The CEIC is considering organizing a meeting about the DML sometime within the next year.

Another coordinating body may emerge from a new retrodigitization program proposed in Europe. In April 2003 a group of European mathematicians submitted a proposal to the European Commission for funding for a DML in Europe, to be called DML-EU. Rolf Jeltsch of the Eidgenössische Technische Hochschule Zürich, who was an IMU liaison for the DML Planning Group, is the principal investigator on the proposal. The five-year project would involve more than forty groups in about two dozen nations across Europe. The idea is to stimulate in the individual countries new retrodigitization projects, so that each country takes responsibility for converting journals based in that country. The grant would fund only research and start-up efforts; the actual retrodigitizing would be financed by the individual countries. The proposal requests 7.9 million euros (about US$9.2 million) from the European Commission; another 2.4 million euros is expected to be contributed by the individual countries. A preliminary meeting for the DML-EU was held May 22–23, 2003, immediately following the meeting of the DML Planning Group; in fact, many members of the group stayed for the DML-EU meeting.

The DML-EU proposal describes the formation of an entity provisionally called the "World Mathematical Library Club." The word "club" is intended to suggest, as the proposal puts it, that the entity "does not itself control the digitization projects nor [sic] the contents." Rather, the club would encourage worldwide coordination of retrodigitization projects, including those under the DML-EU. The club would have representatives from various groups having a stake in retrodigitization efforts: publishers, mathematical societies, libraries, retrodigitization projects, and so forth. In addition to providing a forum for communication among these groups, the club would, according to the proposal, "function as the body to approve guidelines for the digitization, codes of conduct and so on." The government of Finland has indicated willingness to host the club, provide it with legal status, and support a small office. Membership fees may be collected to provide financial support for the club.

Momentum Is Building

During the Göttingen meeting, IMU president John Ball of Oxford University said that the IMU views the DML as a "vital effort for the mathematical community." He also noted that a good deal of momentum has now built up for the DML, "for mathematicians and for funding agencies," and he urged that this momentum not be lost. Indeed, this is a critical moment in the development of the DML. The next steps taken by the international mathematical community may determine the future of this emerging resource, which could have a profound impact on mathematics research.

—Allyn Jackson

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Online ISSN: 1029-032X

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2002 Annual Survey of the Mathematical Sciences

(Third Report)

Faculty Profile
Enrollment and Undergraduate Degrees/Majors Profile
Graduate Student Profile

Ellen E. Kirkman, James W. Maxwell, and Kinda Remick Priestley

This Third Report of the 2002 Annual Survey gives information about faculty size, departmental enrollments, majors, and graduate students for departments of mathematical sciences in four-year colleges and universities in the United States. Prior to 2000, these data were included as part of the Second Report.

The 2002 Annual Survey represents the forty-sixth in an annual series begun in 1957 by the American Mathematical Society. The 2002 Survey is under the direction of the Data Committee, a joint committee of the American Mathematical Society, the American Statistical Association, the Institute of Mathematical Statistics, and the Mathematical Association of America. The current members of this committee are Amy Cohen-Corwin, Donald M. Davis, Lorraine Denby, Alexander J. Hahn, Naresh Jain, G. Samuel Jordan, Stephen F. Kennedy, Ellen E. Kirkman (chair), David J. Lutzer, and James W. Maxwell (ex officio). The committee is assisted by AMS survey analyst Kinda Remick Priestley and survey coordinator Colleen Rose. Comments or suggestions regarding this Survey Report may be directed to the committee.

Introduction

The Annual Survey of the Mathematical Sciences collects information each year about departments, faculties, and students in the mathematical sciences at four-year colleges and universities in the United States. Definitions of the various groups surveyed in the Annual Survey can be found in the box on page 935 of this report. Departments in the former Group Vb are no longer surveyed. We present information about the faculties and instructional programs at the undergraduate and graduate levels in these departments for the 2002–2003 academic year. For 1999–2000 and earlier years, these data were presented as part of the Second Report.

Information about departments was gathered on a questionnaire called the Departmental Profile. This questionnaire was mailed to all departments in Groups I, II, III, IV, and Va and to stratified random samples from Groups M and B. The percentage of the departments responding in each of the doctoral groups was greater than 94 percent. Prior to 2001, if doctoral departments did not respond, simple projections were made to the whole population using the data from those departments who did respond. Beginning last year, if a department did not return the Departmental Profile questionnaire but had returned one within the last three years, the data from the most recent questionnaire was used. This change in procedure will produce even more accurate results than those in past reports for these doctoral departments.

The Departmental Profile questionnaire is mailed to a stratified random sample of departments drawn from each of Groups M and B, and standard statistical projections are made using the data from the respondents. The stratification for Groups M and B is based on the enrollment of the school and whether it is a public or a private school. For the second year, standard errors are reported for several of the more important projections made in Groups M and B. The box on page 926 discusses these standard errors in more detail.

The careful reader will note that a row or column total may differ slightly from the sum of the individual entries. All the table entries are the rounded

Ellen E. Kirkman is professor of mathematics, Wake Forest University. James W. Maxwell is AMS associate executive director for Membership and Programs. Kinda Remick Priestley is AMS survey analyst.

Highlights

- The estimated total number of full-time doctoral positions under recruitment in Groups I, II, III, Va, M, and B combined is down to 1,867 from 2,314 last year (a drop of 19%). Of these 1,867 full-time positions, 1,320 were tenured/tenure-track, down from 1,618 last year (a drop of 18%). Of the 1,320 full-time tenured/tenure-track doctoral positions, 1,124 were open to new doctorates, down from 1,459 last year (a drop of 23%).
- The estimated total number of full-time doctoral positions filled with a doctoral hire in Groups I, II, III, Va, M, and B combined is down to 1,319 from 1,621 last year (a drop of 19%). Groups I, II, III, and Va combined filled 593 doctoral positions, of which 254 (43%) were tenured/tenure-track positions. Groups M and B combined filled 725 doctoral positions, of which 528 (73%) were tenured/tenure-track. Last year Groups I, II, III, and Va combined filled 666 doctoral positions, of which 281 (42%) were tenured/tenure-track positions, and Groups M and B combined filled an estimated 955 doctoral positions, of which 681 (71%) were tenured/tenure-track.
- The estimated number of new doctoral hires into tenured/tenure-track positions was up in Groups I, II, III, and Va combined (79 from 59 last year), and about the same in Groups M and B combined (258 from 259 last year). But the estimated number of not new doctoral hires into tenured/tenure-track positions was down in both Groups I, II, III, and Va combined (175 from 222 last year) and in Groups M and B combined (270 from 422 last year, a 36% drop over last year).
- The total number of full-time faculty in Groups I, II, III, Va, M, and B combined is estimated at 20,007, with a standard error of 269; this total is up 295 from last year. The number of full-time faculty having doctorates in this total is estimated at 16,430, up from 16,374 last year. The number of full-time doctoral non-tenure-track faculty in this total is estimated at 2,057, up from 1,920 last year. The size of the standard error makes it possible that the changes observed are due to sampling error.
- The number of female full-time faculty in Groups I, II, III, Va, M, and B combined is estimated at 5,019, up from 4,795 last year. The number of nondoctoral full-time faculty is estimated at 3,577, up from 3,338 last year. The estimated number of part-time doctoral faculty in this total is 7,771, down from 8,057 last year. Detailed information is given in this report about these groups.
- The number of junior/senior mathematics majors in Groups I, II, III, Va, M, and B is estimated at 64,800 in 2002 (the highest since 1995), up 5,900 over the estimated 58,900 in 2001.
- The estimated number of full-time graduate students in Groups I, II, III, Va, and M combined increased to 12,647 from 12,127 last year. The estimated numbers of graduate students in Groups I, II, III, and Va combined who are first year, who are female, who are male, who are U.S. citizens, and who are non-U.S. citizens all were up over last year. The estimated number of first-year graduate students in Group M dropped from 1,236 to 1,012; however, the standard errors for the Group M estimates are large, making estimates vary simply due to the sampling variability rather than any real change.

Remarks on Statistical Procedures

This report is based on information gathered from departments of mathematical sciences in the U.S., separated into groups by highest degree granted as defined on page 935. Groups for doctoral-granting departments are I (Public), I (Private), II, III, IV, and Va. Groups M and B consist of those departments offering master's and bachelor's degrees respectively.

While the questionnaire on which this report is based is sent to every doctoral department, it is sent to a stratified random sample in Group M and B departments.

The response rate is typically between 90 and 100 percent for the doctoral groups. Prior to last year, simple projections were made using the questionnaires that were returned to get estimated totals for the entire population. After a couple of years of experimentation, a new procedure was begun for the 2001 survey. If a doctoral department did not return its questionnaire this year but had returned one within the past three years, those numbers were used as its response for the current year. This procedure will give us even more accurate estimates than we have gotten in the past.

The stratified random sampling procedures used for Groups M and B were put in place four years ago. Beginning last year, standard errors were calculated for some of the key estimates. Standard errors are calculated using the variability in the data and can be used to crudely measure how closely our estimate is to the true value for the population. As an example, the number of full-time faculty in Group M is estimated at 4,342, with a standard error of 121. This means the actual number of full-time faculty in Group M is most likely between 4,342 plus or minus two standard errors, or between 4,100 and 4,584. This is much more informative than simply giving the estimate of 4,342.

Estimates are also given for parameters that are totals from all groups, such as the total number of full-time faculty. The values given for the doctoral groups are assumed to be the true parameters for these groups, because they are not sampled and hence are not subject to sampling variability. The only variability in a total of several groups comes from the sampling for Groups M and B. Using the standard errors for M and B, it is possible to calculate a standard error for the total. For example, an estimate of the total number of full-time faculty in all groups but group IV is 20,007, with a standard error of 269.

Standard errors, when calculated for an estimate, appear in the tables in parentheses underneath the estimate.

Table 1: Faculty Attrition,[1] Fall 2002

	GROUP									
	I Public	I Private	II	III	Va	I, II, III, & Va	M	B	I, II, III, Va, M, & B	IV
Full-time faculty who retired or died										
Total number	34	9	69	42	7	**162**	135	310	**607**	39
(Standard error)							*(16)*	*(90)*	*(92)*	
Percentage	1.9	1.0	2.9	2.0	2.3	**2.2**	3.1	3.8	**3.0**	2.8

[1] Number and percentage of full-time faculty who were in the department in fall 2001 but were reported to have retired or died by fall 2002.

values of the individual projections associated with each entry, and the differences are the result of this rounding (as the sum of rounded numbers is not always the same as the rounded sum).

Faculty Profile

The Departmental Profile, sent in fall 2002 to mathematical sciences departments at four-year colleges and universities as part of the Annual Survey, gathered information about faculties at these schools, which is reported in this section. The 2002 First Report presented data collected earlier about faculty salaries (pages 238–53 of the February 2003 issue of the *Notices of the AMS*.)

Faculty Attrition

Table 1 displays losses of full-time mathematical sciences faculty due to retirements and deaths. The fall 2002 mathematics faculty attrition rate for Groups I, II, III, Va, M, and B combined was 3.0%. Figure 1 shows the trend in the attrition rate for these departments during the years 1987 to 2002.

Figure 1: Percent of Full-Time Doctoral Faculty Who Retired or Died in Groups I, II, III, Va, M, & B, Fall 1987 to Fall 2002

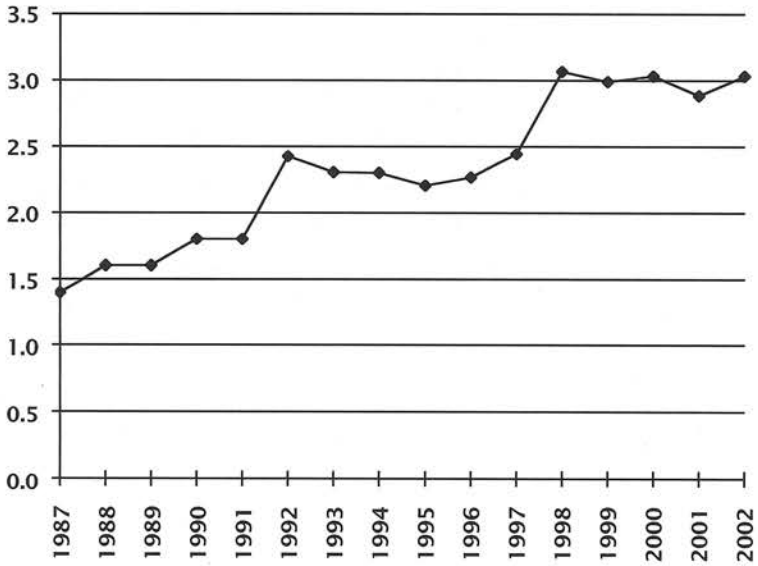


Table 2A: Recruitment of Doctoral Faculty, Fall 2002

	GROUP									
	I Public	I Private	II	III	Va	I, II, III, & Va	M	B	I, II, III, Va, M, & B	IV
Posted Doctoral Positions										
Total number[1]	**200**	**117**	**188**	**189**	**31**	**726**	**349**	**793**	**1867**	**169**
(Standard error)							*(42)*	*(60)*	*(73)*	
Tenured/tenure-track	77	33	112	145	18	**386**	313	621	**1320**	141
Open to new doctoral recipients	146	87	156	174	25	**587**	311	771	**1670**	121
Tenured/tenure-track	33	10	86	129	15	**272**	278	573	**1124**	108
Open at assoc/full level	39	25	40	48	7	**159**	60	97	**317**	59
Reported Hires for Above										
Total number	**174**	**101**	**161**	**151**	**23**	**611**	**290**	**598**	**1499**	**110**
Male doctoral hires	143	78	114	112	16	**464**	170	349	**983**	65
Tenured/tenure-track	42	18	60	73	7	**201**	151	217	**569**	53
Female doctoral hires	30	22	43	30	4	**129**	73	133	**335**	45
Tenured/tenure-track	7	1	22	22	1	**53**	65	95	**213**	34
Male temporary hires	0	1	3	5	3	**13**	16	81	**110**	0
Female temporary hires	0	0	1	4	0	**5**	30	34	**70**	0
Total new doctoral hires	103	64	71	59	12	**309**	102	212	**624**	58
Male new doctoral hires	83	47	56	45	10	**241**	79	136	**455**	29
Tenured/tenure-track	1	2	21	34	4	**63**	76	96	**235**	25
Female new doctoral hires	21	17	15	14	2	**69**	24	76	**168**	29
Tenured/tenure-track	0	0	7	8	0	**16**	22	64	**101**	23
Unfilled positions	**26**	**16**	**27**	**38**	**7**	**115**	**58**	**195**	**368**	**59**

[1] Number of full-time doctoral positions under recruitment in 2001–2002 to be filled for 2002–2003.

After a significant increase from 1997 to 1998, the overall rate has remained relatively stable over the last five years. However, the rates vary quite a bit from group to group and from year to year within each of the groups. For fall 2002, Group I Private had the lowest attrition rate at 1.0%, while Group B the highest at 3.8%.

Faculty Recruitment

Table 2A contains detailed information on the number of full-time doctoral faculty positions in mathematical sciences departments under recruitment in 2001–2002 for employment beginning in the academic year 2002–2003. Among mathematics departments (Groups I, II, III, Va, M, and B), 1,867 positions were under recruitment in 2001–2002 for employment beginning in the academic year 2002–2003, down 19% compared to last year. Of those 1,867 positions, 1,670 (89%) were available to new doctoral recipients, and of those 1,670 positions, 1,124 (67%) were tenured/tenure-track positions. The 1,124 tenured/tenure-track positions open to new doctoral recipients was down 23% from the 1,459 such positions under recruitment in 2000–2001; the biggest drop was in Groups M and B, where the total number of tenured/tenure-track positions open to new doctoral recipients dropped from 1,192 last year to 851 this year (a 29% drop). The total number of tenured/tenure-track full-time doctoral positions under recruitment in Groups I, II, III, Va, M, and B combined is 1,320, down from last year's 1,618 (a drop of 18%). In Groups I, II, III, and Va combined, the total number of posted doctoral positions open at the associate/full level rose from 138 last year to 159 this year.

Table 2B condenses the information in Table 2A. It also reorganizes the doctoral hires into one section for new doctoral hires and another for other doctoral hires (so excludes posted doctoral positions that were temporarily filled with a person without a doctorate). Table 2C is derived from Table 2B with the percentage of the filled positions that were tenured/tenure-track included in the table.

From Table 2B we find that the total number of full-time doctoral positions filled in Groups I, II, III, Va, M, and B combined is down to 1,319 from 1,621 last year (a drop of 19%). Groups I, II, III, and Va combined filled 593 doctoral positions, of which 254 (43%) were tenured/tenure-track positions. Groups M and B combined filled 725 doctoral positions, of which 528 (73%) were tenured/tenure-track. Last year Groups I, II, III, and Va combined filled 666 doctoral positions, of which 281 (42%) were tenured/tenure-track positions, and Groups M and B combined filled 955 doctoral positions, of which 681 (71%) were tenured/tenure-track.

The number of tenured/tenure-track new doctoral hires was up in Groups I, II, III, and Va combined (79 from 59 last year), and about the same in Groups M and B combined (258 from 259 last year). But the number of tenured/tenure-track not new doctoral hires was down in both Groups I, II, III, and Va combined (175 from 222 last year) and in Groups M and B combined (270 from 422 last year, a 36% drop over last year).

From Tables 2B and 2C we can compare the hiring patterns of Groups I, II, III, and Va with that of Groups M and B. In Groups I, II, III, and Va 52% of the positions hired went to new doctoral recipients (last year 47%), while in Groups M and B 43% of the positions hired went to new doctoral recipients (last year 40%). In Groups I, II, III, and Va only 26% of the hires of new doctoral recipients were in tenured/tenure-track positions (last year it was 19%), while in Groups M and B 82% of the hires were in tenured/tenure-track positions (last year it was 69%).

Table 2B: A Summary of Recruitment of Doctoral Faculty, Fall 2002

	GROUP		
	I, II, III, & Va	M & B	IV
Posted Doctoral Positions			
Total number	**726**	**1142**	**169**
Tenured/tenure-track	386	934	141
Open to new doctoral recipients	587	1082	121
Tenured/tenure-track	272	851	108
Reported Hires for Above			
Total new doctoral hires	**309**	**314**	**58**
Tenured/tenure-track	79	258	48
Male	241	215	29
Tenured/tenure-track	63	172	25
Female	69	100	29
Tenured/tenure-track	16	86	23
Total not new doctoral hires	**284**	**411**	**52**
Tenured/tenure-track	175	270	39
Male	223	304	36
Tenured/tenure-track	138	196	28
Female	60	106	16
Tenured/tenure-track	37	74	11

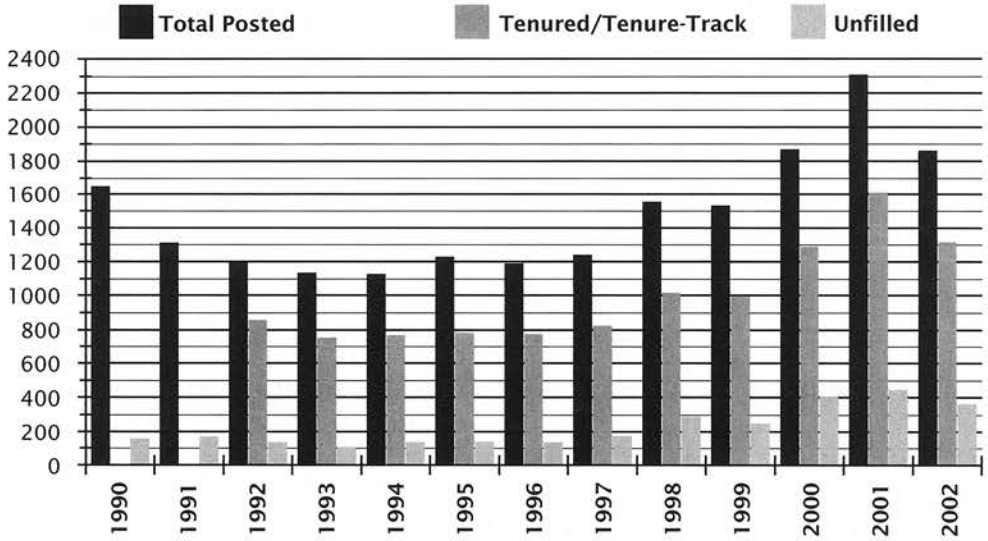
Table 2C: Percentage Tenured/Tenure-Track for Positions Posted and Filled, Fall 2002

	GROUP		
	I, II, III, & Va	M & B	IV
New Doctoral Positions			
Positions posted	587	1082	121
% tenured/tenure-track	46	79	89
Positions filled	309	314	58
% tenured/tenure-track	25	82	83
Not New Doctoral Positions			
Positions posted [1]	-	-	-
% tenured/tenure-track	-	-	-
Positions filled	284	411	52
% tenured/tenure-track	62	66	75

[1] The current survey requests the number of positions posted and the number open to new doctoral recipients. As some positions are open to both new and not new doctoral recipients, there is no way to use the data collected to identify positions open to not new doctoral recipients only.

From Table 2B we find that of the new doctoral recipients hired in Groups I, II, III, and Va combined, 26% of the males and 23% of the females took tenured/tenure-track positions. For new doctoral recipients hired in Groups M and B combined, 80% of the males and 86% of the females took tenured/tenure-track positions. Even though 46% of the positions available in doctoral departments (Groups I, II, III, and Va) for new doctoral recipients were tenure-track positions, only 26% of the new doctoral recipients hired were given tenured/tenure-track positions. At the same time, 284 of those hired were not new doctoral recipients and 62% had tenured/tenure-track positions.

Figure 2: Number of Full-Time Doctoral Positions under Recruitment: Total, Tenured/Tenure-Track, and Unfilled in Groups I, II, III, Va, M, & B Combined, Fall 1990 to Fall 2002



Note: The tenured/tenure-track status of positions under recruitment was not surveyed until 1992.

Table 3A: Total Faculty Size, Fall 2002

	GROUP									
	I Public	I Private	II	III	Va	I, II, III, & Va	M	B	I, II, III, Va, M, & B	IV
Total full-time faculty *(Standard error)*	**1752**	**949**	**2422**	**2068**	**320**	**7511**	**4342** *(121)*	**8154** *(240)*	**20007** *(269)*	**1397**
Doctoral full-time faculty	1693	945	2179	1764	309	**6890**	3464	6076	**16430**	1355
Tenured	1163	536	1567	1292	182	**4740**	2361	3858	**10959**	812
Untenured, tenure-track	162	97	269	314	34	**876**	827	1711	**3414**	308
Non-tenure-track *(Standard error)*	368	312	343	158	93	**1274**	276 *(62)*	507 *(71)*	**2057** *(94)*	235
Nondoctoral full-time faculty	59	4	243	304	11	**621**	878	2078	**3577**	42
Total part-time faculty *(Standard error)*	**222**	**57**	**443**	**747**	**35**	**1504**	**2150** *(175)*	**4117** *(254)*	**7771** *(309)*	**172**

Table 3B: Female Faculty Size, Fall 2002

	GROUP									
	I Public	I Private	II	III	Va	I, II, III, & Va	M	B	I, II, III, Va, M, & B	IV
Female full-time faculty *(Standard error)*	**219**	**100**	**422**	**451**	**46**	**1238**	**1277** *(62)*	**2504** *(115)*	**5019** *(131)*	**354**
Doctoral full-time faculty	181	99	279	274	39	**872**	811	1473	**3156**	332
Tenured	87	26	114	147	18	**392**	452	791	**1635**	125
Untenured, tenure-track	27	12	57	86	4	**186**	252	500	**938**	110
Non-tenure-track	67	61	108	41	17	**294**	107	182	**583**	97
Nondoctoral full-time faculty	38	1	143	177	6	**365**	467	1031	**1863**	23
Female part-time faculty	**85**	**11**	**175**	**251**	**8**	**530**	**810**	**1855**	**3195**	**63**

Table 3C: Number and Percentage of Full-Time Faculty, Fall 2002

	GROUP								
	I Public	I Private	II	III	Va	M	B	IV	TOTAL
Full-Time Faculty									
Number	1752	949	2422	2068	320	4342	8154	1397	**21403**
Percentage of total full-time faculty	8	4	11	10	1	20	38	7	**100**
Female Full-Time Faculty									
Number	219	100	422	451	46	1277	2504	354	**5373**
Percentage of female full-time faculty	4	2	8	8	1	24	47	7	**100**
Female Full-Time Faculty									
Percentage female full-time faculty by group	13	11	17	22	14	29	31	25	**25**

Table 3D: Number, and Percentage of Those Female, of Non-tenure-track Doctoral Full-Time Faculty and Part-Time Faculty by Group, Fall 1996 to Fall 2002

	1996	1997	1998	1999	2000	2001	2002
Groups I, II, III, & Va							
Non-tenure-track doctoral full-time faculty	672	708	904	1014	993	1233	1274
Percentage female	25	22	21	22	20.6	21	23
Part-time faculty	1093	954	1141	1217	1399	1467	1504
Percentage female	37	37	38	38	37	38	35
Group M							
Non-tenure-track doctoral full-time faculty	138	216	140	146	262	183	276
Percentage female	24	30	27	56	29	24	39
Part-time faculty	1879	1612	1768	1906	2323	2393	2150
Percentage female	41	46	43	35	36	37	38
Group B							
Non-tenure-track doctoral full-time faculty	419	385	427	514	407	504	507
Percentage female	23	26	31	24	30	29	36
Part-time faculty	3055	3107	3585	3298	3580	4197	4117
Percentage female	44	46	42	41	40	43	45

Figure 2 shows the number of full-time doctoral positions available in all groups except Group IV, as well as the number of those that were tenured/tenure-track and the number unfilled for the years 1990 to 2002. There was a sharp decrease in available positions in the first few years of the 1990s, but the number of positions and the number of tenured/tenure-track positions had been increasing steadily until this year.

Faculty Size

Table 3A gives the number of faculty for different categories of faculty broken down by group. Table 3B gives the same information for females only. The estimated total number of full-time faculty in Groups I, II, III, Va, M, and B combined is 20,007, up 295 from last year, with a standard error of 269. We can be quite confident that the actual total number of faculty in these groups is in the interval 20,007 +/- 538. The doctoral departments I, II, III, and Va were up 79 full-time faculty members, Group M was up 6 faculty members, and Group B was up 210. Since the standard errors for the total number of full-time faculty in Groups M and B are 121 and 240 respectively, there may not be an actual change, as these increases are well within the variability we expect with standard errors of 121 and 240.

Table 3C gives some percentages based on the information in Tables 3A and 3B.

The number of non-tenure-track doctoral full-time faculty and the number of part-time faculty have been increasing in recent years, though this year the estimated number of part-time faculty is down to 7,771 from 8,057 last year. Table 3D gives a seven-year history of these two types of faculty for Groups I, II, III, and Va combined; for Group M; and for Group B. Also shown for each number in this table is the percentage of females. Table 3D shows that over the last seven years, the percentage in non-tenure-track doctoral full-time faculty has increased by 90% in Groups I, II, III, and Va; 100% in Group M; and 21% in Group B, and the percentage of part-time faculty has increased in these groups 38%, 14%, and 35%, respectively. This increase in non-tenure-track full-time doctoral positions continues a disturbing trend highlighted in "Staffing shifts in mathematical sciences

departments, 1990–2000" (David J. Lutzer and James W. Maxwell, *Notices of the AMS*, June/July 2003, pages 683–6).

Table 3E gives a summary of the various types of faculty found in departments of mathematical sciences by sex and group.

Tables 3F and 3G give more information about two types of faculty: full-time faculty without a doctorate and part-time faculty. The top half of Table 3F is a somewhat condensed version of the doctoral full-time faculty in Table 3A broken down by sex. The bottom half of Table 3F shows this same information for the 3,576 full-time faculty who do not have doctoral degrees. The majority of these faculty, 2,956 (83%), are found in Group M and B departments. Table 3G shows the part-time faculty broken down by sex and whether they have a doctoral degree.

Table 3E: Summary of Full-Time and Part-Time Faculty by Sex, Fall 2002

	GROUP					
	I, II, III, & Va		M & B		IV	
	Male	Female	Male	Female	Male	Female
Full-time faculty	**6273**	**1238**	**8714**	**3781**	**1043**	**354**
Percentage	84	16	70	30	75	25
Doctoral full-time faculty	6018	872	7256	2284	1023	332
Percentage	87	13	76	24	76	24
Tenured	4348	392	4977	1243	687	125
Percentage	92	8	80	20	85	15
Untenured, tenure-track	690	186	1786	752	199	110
Percentage	79	21	70	30	64	36
Non-tenure-track	980	294	493	289	137	97
Percentage	77	23	63	37	59	41
Nondoctoral full-time faculty	255	365	1459	1497	19	23
Percentage	41	59	49	51	46	54
Part-time faculty	**973**	**530**	**3602**	**2665**	**109**	**63**
Percentage	65	35	57	43	63	37

Table 3F: Doctoral and Nondoctoral Full-Time Faculty Size, Fall 2002

	GROUP					
	I, II, III, & Va		M & B		TOTAL	
	Male	Female	Male	Female	Male	Female
Doctoral full-time faculty	**6018**	**872**	**7256**	**2284**	**13274**	**3156**
Tenured	4348	392	4977	1243	9325	1635
Untenured, tenure-track	690	186	1786	752	2476	938
Non-tenure-track	980	294	493	289	1473	583
Nondoctoral full-time faculty	**255**	**365**	**1459**	**1497**	**1714**	**1862**
Tenured	19	10	483	337	502	347
Untenured, tenure-track	5	2	172	244	177	246
Non-tenure-track	231	353	803	916	1034	1269

Faculty Profile for Females

Table 3B gives a complete breakdown of all categories of female faculty by group and shows increasing estimated numbers of female faculty in most categories. The estimated total number of full-time faculty in all groups for 2002–2003 is 21,403, of which 5,373 (25%) are females, up from 5,135 (24%) last year. In the B group doctoral female faculty dropped to 1,473 from 1,527 last year, tenured female faculty dropped from 870 last year to 791 this year, and non-tenure-track doctoral female faculty rose from 147 last year to 182 this year. In the M group non-tenure-track female doctoral faculty rose from 43 last year to 107 this year.

Table 3C shows the number and percentage of all full-time and female full-time faculty that fall in each group for 2002–2003. The number of faculty in each group and the percentage who are female are given in the bottom section of Table 3C. The number of females as a percentage of full-time faculty varies considerably among the groups, from 11% for Group I Private to 31% for Group B. This is the same pattern as reported last year. Note: In Table 3C the percentages for each group in rows 2 and 4 are of the row totals. The percentages in row 6 are column percentages using the numbers in rows 1 and 3.

Table 3D contains information about non-tenure-track doctoral full-time faculty and part-time faculty for the years 1997 to 2002 for Groups I, II, III, and Va combined, M, and B. This table includes the total number for each category as well as the percentage female for each number.

Table 3E gives the male/female breakdown by count and percentage for Groups I, II, III, and Va combined for various categories of faculty in columns 2 and 3. The same breakdowns are given for Groups M and B combined in columns 4 and 5 and for Group IV in columns 6 and 7.

Table 3G: Part-Time Faculty Size, Fall 2002

	GROUP				
	I, II, III, & Va		M & B		
	Male	Female	Male	Female	TOTAL
Doctoral part-time faculty	400	130	834	331	**1695**
Nondoctoral part-time faculty	573	400	2768	2334	**6075**
TOTAL	**973**	**530**	**3602**	**2665**	**7771**

Table 4A: Undergraduate and Graduate Enrollments (thousands), Fall 2002

	GROUP									
	I Public	I Private	II	III	Va	I, II, III, & Va	M	B	IV	TOTAL
Undergraduate Course Enrollments Total number (thousands) *(Standard error)*	187	41	275	250	16	**768**	507 *(16)*	774 *(22)*	76	**2125** *(27)*
Graduate Course Enrollments Total number (thousands)	10	4	11	10	3	**38**	12	-	29	**79**

Table 4B: Total Undergraduate Enrollments (thousands), Fall 1997 to Fall 2002

	GROUP								
	I Public	I Private	II	III	Va	M	B	IV	TOTAL
1997	173	42	247	220	24[1]	561	701	69	**2037**
1998	182	43	258	214	20[1]	585	741	78	**2121**
1999	182	45	271	251	13	568	810	92	**2232**
2000	175	47	279	241	13	526	729	77	**2087**
2001	176	42	279	246	12	513	743	81	**2092**
2002	187	41	275	250	16	507	774	76	**2125**

[1] Prior to 1999, Group Va was combined with Group Vb, which is no longer surveyed. Separate Group Va figures for these years are not available.

Table 3F shows that of the 3,576 nondoctoral full-time faculty in Groups I, II, III, Va, M, and B, 1,862 (52%) are females. In Table 3G we see that in these same groups there are 7,771 part-time faculty, of which 3,195 (41%) are females.

Enrollment Profile and Undergraduate Degrees/Majors Profile

Enrollment

The Departmental Profile Survey obtained information about enrollments and distribution of instructional effort among various course categories in mathematical sciences departments. Table 4A gives the total undergraduate and total graduate enrollments in mathematics courses for each group that is part of the Annual Survey. Each enrollment in this and other tables in this section is projected from schools responding to the survey, as discussed on page 926. In fall 2002, for the fourth year the projections for Groups M and B were made from those schools responding in the stratified random sample for each of these groups. This makes it possible to calculate standard errors for the estimated enrollments for these groups and for the estimated total enrollment for all groups. These standard errors, available for the second year, are also found in Table 4A. The estimated total enrollment for all groups is 2,125,000, with a standard error of 27,000, indicating

Table 4C: Undergraduate and Graduate Enrollments per Full-Time Faculty Member, Fall 2002

	GROUP							
	I Public	I Private	II	III	Va	M	B	IV
Undergraduate Course Enrollments Number per full-time faculty member	107	43	114	121	50	117	95	55
Graduate Course Enrollments Number per full-time faculty member	6	5	4	5	9	3	-	20

Table 4D: Undergraduate Enrollments per Full-Time Faculty Member, Fall 1997 to Fall 2002

	GROUP							
	I Public	I Private	II	III	Va	M	B	IV
1997	110	52	115	113	-[1]	106	96	57
1998	109	52	114	108	-[1]	117	94	60
1999	115	54	111	122	43	127	114	68
2000	107	52	117	119	39	110	95	56
2001	101	47	114	120	41	118	94	57
2002	107	43	114	121	50	117	95	55

[1] Prior to 1999, Group Va was combined with Group Vb, which is no longer surveyed. Separate Group Va figures for these years are not available.

Table 5A: Undergraduate Degrees Awarded and Junior/Senior Majors (hundreds), Fall 2002

	GROUP								
	I Public	I Private	II	III	Va	M	B	I, II, III, Va, M, & B	IV
Total Undergraduate									
Degrees awarded (hundreds)	18	8	18	15	2	45	109	217	3
(Standard error)						*(6)*	*(7)*	*(9)*	
Computer science only	1	0	0	2	0	13	31	48	0
Junior/senior majors (hundreds)	57	19	51	52	6	162	302	648	10
(Standard error)						*(14)*	*(17)*	*(22)*	
Computer science only	5	1	1	8	0	38	95	148	0
Female Undergraduate									
Degrees awarded (hundreds)	7	2	8	7	1	20	46	91	1
Computer science only	0	0	0	0	0	4	9	14	0
Junior/senior majors (hundreds)	20	5	21	22	2	70	129	270	4
Computer science only	1	0	0	1	0	10	28	41	0

Table 5B: Undergraduate Degrees Awarded and Junior/Senior Majors (hundreds) in Groups I, II, III, Va, M & B Combined, Fall 1993 to Fall 2002

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Total Undergraduate										
Degrees awarded (hundreds)	–	–	–	–	–	–	–	–	–	217
Junior/senior majors (hundreds)	696	669	678	631	596	590	568	599	589	648
Female Undergraduate										
Degrees awarded (hundreds)	–	–	–	–	–	–	–	–	–	91
Percentage female	–	–	–	–	–	–	–	–	–	42
Junior/senior majors (hundreds)	301	287	286	273	257	255	248	244	242	270
Percentage female	43	43	42	43	43	43	44	41	41	42

that the actual total enrollment is likely within 2,125,000 +/- 54,000. Table 4B gives these totals for fall 1997 to fall 2002.

Beginning with this 2002 survey, the Departmental Profile form no longer requests a breakdown of the total undergraduate enrollments into eight subcategories of courses. For a comprehensive survey of specific undergraduate courses, please refer to the report of the 2000 CBMS survey, *Statistical Abstract of Undergraduate Programs in the Mathematical Sciences in the U.S.: Fall 2000 CBMS Survey* (American Mathematical Society, Providence, RI, 2002). This publication is available on the AMS website at `www.ams.org/cbms/`.

Table 4C gives the undergraduate enrollments per faculty member and the graduate enrollments per faculty member for each group. Table 4D gives the undergraduate enrollments per faculty member in each group for fall 1997 to fall 2002.

Looking at the historical data among the enrollment tables just presented for fall 1997 to fall 2002, one sees no major trends. This has been a relatively stable period for enrollments.

Undergraduate Degrees and Majors

Table 5A gives the number of undergraduate degrees awarded and the number of junior/senior majors, and the number of each that are female and that are in computer science for each group. Table 5B presents the trends in these data for fall 1993 to fall 2002. This year for the first time our table includes "undergraduate degrees awarded", as this statistic may be more accurate than "junior/senior majors"; future comparisons will be to undergraduate degrees awarded. The number of junior/senior mathematics majors in Groups I, II, III, Va, M, and B dropped from 69,600 in 1993 to 56,800 in 1999 but has been higher in the past three years; it is estimated at 64,800 in 2002 (the highest since 1995), up 5,900 over the estimated 58,900 in 2001. The percentage of the junior/senior majors who are females remained relatively stable for the years 1993 to 2002, from a low of 41% to a high of 44%.

The reader should be aware that at least 50 of the 192 departments in the 2002 Group M population and at least 270 of the 1,029 departments in the 2002 Group B population also offer a computer science program in addition to their offerings in mathematics. In some instances, these computer programs account for a major fraction of the department's undergraduate degrees and majors. This year's estimated 64,800 majors includes an estimated 14,800 majors in computer science programs that are located in mathematics departments,

and this year's estimated 21,700 undergraduate degrees awarded includes 4,800 in computer science.

The report of the 2000 CBMS survey provides a more comprehensive study of departmental bachelor's degrees.

Graduate Student Profile

Table 6A summarizes information gathered about graduate students by the 2002 Departmental Profile survey. This table gives the number of full-time, full-time first year, and part-time graduate students for each type of graduate department. These same numbers are also given for female graduate students and for U.S. citizen graduate students.

The total number of full-time graduate students in Groups I, II, III, Va, and M combined increased from 2001 to 2002, with 12,127 and 12,647 respectively. In general, in Table 6A there were gains in every group except Groups I Private and M. First-year full-time graduate students in Groups I, II, III, Va, and M combined decreased by 103 to 4,008, a decrease of 3%; this decrease occurred entirely in Groups Va and M. Female full-time graduate students in Groups I, II, III, Va, and M combined increased from 4,088 to 4,328, a 6% increase. U.S. citizen full-time graduate students in these same groups increased by 10% to 6,724. There is a great deal of variability in the number of full-time graduate students in Group M, even in universities that are roughly the same size. Evidence of this is the standard error of 336. We can also expect substantial variation in the total number of all full-time graduate students from year to year due to the large variation in Group M.

Part-time graduate students in Groups I, II, III, and Va held steady at 1,490 this year. The figure for last year, 1,475, had been a considerable drop from the 1,600 reported in 2000. Group III has 779 (52%) of the part-time graduate students in these groups. In these doctoral groups, 37% of the part-time graduate students are females and 75% are U.S. citizens. Group M part-time graduate students decreased from 3,682 to 3,064, down 17%. Last year's

Table 6A: Graduate Students, Fall 2002

	GROUP								
	I Public	I Private	II	III	Va	I, II, III, & Va	M	I, II, III, Va, & M	IV
Total Graduate Students									
Number who are full-time	**2627**	**1471**	**2777**	**2251**	**846**	**9972**	**2675**	**12647**	**3996**
(Standard error)							*(336)*	*(336)*	
Number who are first-year	723	414	888	772	199	**2996**	1012	**4008**	1402
Number who are part-time	**164**	**185**	**299**	**779**	**63**	**1490**	**3064**	**4554**	**916**
(Standard error)							*(806)*	*(806)*	
Female Graduate Students									
Number who are full-time	**673**	**326**	**991**	**860**	**286**	**3136**	**1192**	**4328**	**2151**
Number who are first-year	199	118	338	312	71	**1038**	416	**1454**	782
Number who are part-time	**74**	**40**	**121**	**302**	**15**	**552**	**1349**	**1901**	**522**
U.S. Citizen Graduate Students									
Number who are full-time	**1391**	**617**	**1516**	**1079**	**452**	**5055**	**1669**	**6724**	**1707**
(Standard error)							*(193)*	*(193)*	
Number who are first-year	433	165	531	384	117	**1630**	642	**2272**	624
Number who are part-time	**115**	**119**	**243**	**598**	**49**	**1124**	**2515**	**3639**	**721**
(Standard error)							*(723)*	*(723)*	

Table 6B: Full-Time Graduate Students in Groups I, II, III, & Va by Sex and Citizenship, Fall 1993 to Fall 2002

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Total full-time graduate students	**10525**	**10185**	**9761**	**9476**	**9003**	**8791**	**8838**	**9637**	**9361**	**9972**
First-year full-time	2762	2668	2601	2443	2386	2458	2664	2839	2875	2996
First-year full-time U.S. citizen	1700	1664	1551	1465	1316	1349	1401	1527	1517	1630
Female full-time graduate students	2990	2927	2877	2760	2691	2770	2766	3016	2899	3136
Male full-time graduate students	7535	7258	6884	6716	6312	6021	6072	6621	6462	6836
U.S. citizen full-time graduate students	5865	5945	5623	5445	4947	4831	4668	5085	4631	5055
Non-U.S. citizen full-time graduate students	4660	4240	4138	4031	4056	3960	4170	4552	4730	4917

figure of 3,682 had been an increase of 76% from the 2000 figure of 2,091 part-time graduate students in Group M. The standard error for part-time graduate students in Group M departments is 806, indicating huge differences in the number of part-time graduate students from department to department. This also means we can expect to see large differences from year to year in the total number of part-time graduate students in all groups. For Group M, 44% of the part-time graduate students are females, and 82% are U.S. citizens.

Table 6B gives the total number of full-time, of full-time first-year, of full-time female, of full-time male, of full-time U.S. citizen, and of full-time non-U.S. citizen graduate students in Groups I, II, III, and Va combined for fall 1993 through 2002. All of these had increases this year compared to 2001. All of these had substantial increases from 1999 to 2000, with a leveling off from 2000 to 2001. This year showed increases again in every category.

Previous Annual Survey Reports

The 2002 Annual Survey First and Second Reports were published in the *Notices of the AMS* in the February and August 2003 issues respectively. For the last version of this report, the 2001 Annual Survey Third Report was published in the *Notices of the AMS* in the September 2002 issue. These reports and earlier reports, as well as a wealth of other information from these surveys, are available on the AMS website at `www.ams.org/employment/surveyreports.html`.

Acknowledgments

The Annual Survey attempts to provide an accurate appraisal and analysis of various aspects of the academic mathematical sciences scene for the use and benefit of the community and for filling the information needs of the professional organizations. Every year, college and university departments in the United States are invited to respond. The Annual Survey relies heavily on the conscientious efforts of the dedicated staff members of these departments for the quality of its information. On behalf of the Annual Survey Data Committee and the Staff, we thank the many secretarial and administrative staff members in the mathematical sciences departments for their cooperation and assistance in responding to the survey questionnaires.

Definitions of the Groups

As has been the case for a number of years, much of the data in these reports is presented for departments divided into groups according to several characteristics, the principal one being the highest degree offered in the mathematical sciences. Doctoral-granting departments of mathematics are further subdivided according to their ranking of "scholarly quality of program faculty" as reported in the 1995 publication *Research-Doctorate Programs in the United States: Continuity and Change.*[1] These rankings update those reported in a previous study published in 1982.[2] Consequently, the departments which now comprise Groups I, II, and III differ significantly from those used prior to the 1996 survey.

The subdivision of the Group I institutions into Group I Public and Group I Private was new for the 1996 survey. With the increase in number of the Group I departments from 39 to 48, the Data Committee judged that a further subdivision of public and private would provide more meaningful reporting of the data for these departments.

Brief descriptions of the groupings are as follows:

Group I is composed of 48 departments with scores in the 3.00–5.00 range. Group I Public and Group I Private are Group I departments at public institutions and private institutions respectively.

Group II is composed of 56 departments with scores in the 2.00–2.99 range.

Group III contains the remaining U.S. departments reporting a doctoral program, including a number of departments not included in the 1995 ranking of program faculty.

Group IV contains U.S. departments (or programs) of statistics, biostatistics, and biometrics reporting a doctoral program.

Group V contains U.S. departments (or programs) in applied mathematics/applied science, operations research, and management science which report a doctoral program.

Group Va is applied mathematics/applied science; Group Vb, which is no longer surveyed as of 1998–99, was operations research and management science.

Group M contains U.S. departments granting a master's degree as the highest graduate degree.

Group B contains U.S. departments granting a baccalaureate degree only.

Listings of the actual departments which comprise these groups are available on the AMS website at `www.ams.org/employment/surveyreports.html`.

[1]Research-Doctorate Programs in the United States: Continuity and Change, *edited by Marvin L. Goldberger, Brendan A. Maher, and Pamela Ebert Flattau, National Academy Press, Washington, DC, 1995.*

[2]*These findings were published in* An Assessment of Research-Doctorate Programs in the United States: Mathematical and Physical Sciences, *edited by Lyle V. Jones, Gardner Lindzey, and Porter E. Coggeshall, National Academy Press, Washington, DC, 1982. The information on mathematics, statistics, and computer science was presented in digest form in the April 1983 issue of the* Notices, *pages 257–67, and an analysis of the classifications was given in the June 1983* Notices, *pages 392–3.*

Mathematics People

Packard Fellowships Awarded

The David and Lucile Packard Foundation has awarded twenty Fellowships for Science and Engineering for the year 2002. Among the new fellows are two with links to the mathematical sciences. RONALD P. FEDKIW of Stanford University and RAJESH P. RAO of the University of Washington, both of whom work in computer science, will each receive a fellowship of $625,000 over five years.

The fellowships are awarded to researchers in mathematics, natural sciences, computer science, and engineering who are in the first three years of a faculty appointment.

—From a Packard Foundation announcement

Werschulz Receives Prize for Achievement in Information-Based Complexity

ARTHUR G. WERSCHULZ of Fordham University is the fifth winner of the Prize for Information-Based Complexity.

The prize committee consisted of Stefan Heinrich, University of Kaiserslautern; Sergei Pereverzev, Ukrainian Academy of Science; Joseph F. Traub, Columbia University; G. W. Wasilkowski, University of Kentucky; and Henryk Wozniakowski, Columbia University and University of Warsaw.

The Prize for Achievement in Information-Based Complexity consists of $3,000 and a plaque. The award will be presented at the Conference on Modern Computational Methods in Applied Mathematics in Bedlewo, Poland, in June 2004.

—Joseph F. Traub, Columbia University

Royal Society of London Elections

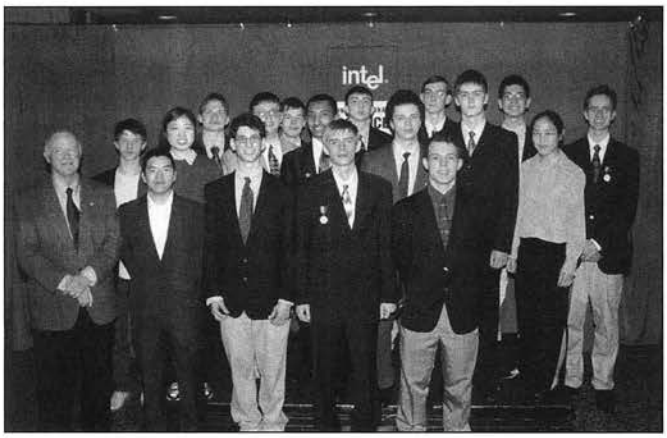
Six mathematical scientists are among those elected as new fellows of the Royal Society of London for 2003. They are ELEANOR DODSON, University of York; ROGER FLETCHER, University of Dundee; PETER GREEN, University of Bristol; JOHN PAPALOIZOU, University of London; and LEON SIMON, Stanford University. DONALD KNUTH, Stanford University, was elected as a foreign member.

—From a Royal Society announcement

AMS Menger Prizes at the 2003 ISEF

The 2003 Intel-International Science and Engineering Fair (ISEF) was held May 11–17 in Cleveland, Ohio. This year marked the fifty-fourth anniversary of the ISEF. More than 1,200 ninth- through twelfth-graders competed in the fair. The participants had qualified by winning competitions in local, regional, and state fairs in the United States or national science fairs abroad. In addition to the general awards of the ISEF, more than fifty organizations, including the AMS, participated by giving ISEF Special Awards. These prizes include cash prizes, scholarships, T-shirts, magazines, and books.

This was the sixteenth year of participation in ISEF by the AMS and the fourteenth year of presentation of the Karl Menger Memorial Awards. The AMS Menger Prize Committee served as the Special Awards Panel of Judges for the AMS; the members were Elwyn Berlekamp, University of California at Berkeley; Hugh Montgomery, University of Michigan, Ann Arbor; and Julian Palmore, University of Illinois at Urbana-Champaign (chair). The panel of judges reviewed more than fifty individual and team projects, all in mathematics. Finalists were interviewed by the panel.



AMS Menger Prize winners. Third row, left to right: Alexey Baran, Artem Viktorov, Evgeny Amosov, Robert Bracco, Brian Rice, Jeremy Warshauer, Alan Taylor. Second row (l. to r.): Hyeyoun Chung, Anatoly Preygel, Lester Mackey, Sergey Ivanov, Evgeniy Loharu, Hannah Chung. Front row (l. to r.): Julian Palmore, Raymund To, Andrew Leifer, Alexandr Medvedev, and Ethan Street. David Pothier is not in the photo.

The AMS gave one first-place award, two second-place awards, four third-place awards, and five honorable-mention awards.

The Karl Menger Memorial Prize winners were as follows:

First Place Award ($1,000): "Fractals, Power-Law and the Weibull Distribution: Mathematically Modeling Crumpled Paper", ANDREW M. LEIFER, RAYMOND CHUN HUNG TO, and DAVID G. POTHIER, Fairview High School, Boulder, Colorado.

Second Place Awards ($500): "Polynomial Maps from Z_n to Z_n", ALEXANDR V. MEDVEDEV, BSU Liceum, Minsk, Belarus; "Continued Fractions of Quadratic Laurent Series", ETHAN J. STREET, Winston Churchill High School, Livonia, Michigan.

Third Place Awards ($250): "Game Theory in Action: Proving and Computing Winning Strategies for 'Nim' and Its Variants", HYEYOUN CHUNG, Saint Paul's Girl's School, London, United Kingdom; "Computation of Quandle Cocycle Knot Invariants", ANATOLY PREYGEL, Montgomery Blair High School, Silver Spring, Maryland; "A Combinatorial Proof of Seymour's Conjecture for Regular Oriented Graphs with Almost Regular Outsets $O'a$ and $O''a$", LESTER W. MACKEY, Half Hollow Hills High School West, Dix Hills, New York; and "Multifractal Dimension Functions on R^n and Q_p Subsets", EVGENIY E. LOHARU and SERGEY O. IVANOV, St. Petersburg, Russia.

Honorable Mention Awards: "Mathematics Is Not Yet Ready for Such Problems: Collatz Conjecture Rationalized", ROBERT S. BRACCO, Dupont Manual Magnet High School, Louisville, Kentucky; "Random Walks and Handshakes", BRIAN T. RICE, Southwest Virginia Governor's School, Dublin, Virginia; "On Decompositions of Continuous and Differentiable Functions on Planar Sets", ALEXEY V. BARAN, AES Centre of MSU, Moscow, Russia; "Generalization of the Kuratovsky's Problem", EVGENY A. AMOSOV and ARTEM G. VIKTOROV, Continuous Math Education Center, St. Petersburg, Russia; and "New Bounds for the Diameters of k-Path Graphs", JEREMY T. WARSHAUER, ALAN C. TAYLOR, and HANNAH CHUNG, Lyndon B. Johnson High School, Austin, Texas.

The AMS's participation in the Intel-ISEF is supported in part by income from the Karl Menger Fund, which was established by the family of the late Karl Menger. For more information about this program or to make contributions to the fund, contact the AMS Development Office, 201 Charles Street, Providence, RI 02904-2294; send email to `development@ams.org`; or telephone 401-455-4111.

—Julian Palmore, University of Illinois at Urbana-Champaign

National High School Calculus Student Award

LESTER W. MACKEY, a senior at Half Hollow Hills High School West in Dix Hills, New York, has won the third annual National High School Calculus Student Award. He has twice received final averages of 100 in Advanced Placement calculus and a top grade of 5 on the AP exam. He has done research in graph theory at the Massachusetts Institute of Technology. He received an Intel Science Talent Search scholarship and a Karl Menger Memorial Prize in 2003. He is also a 2003 Presidential Scholar.

The $1,000 prize is awarded by Calculus.org, based at the University of California at Davis, Williams College, and Wake Forest University.

—Elaine Kehoe

Mathematics Opportunities

American Mathematical Society Centennial Fellowships

Invitation for Applications for Awards for 2004–2005
Deadline December 1, 2003

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

The primary selection criterion for the Centennial Fellowship is the excellence of the candidate's research. Preference will be given to candidates who have not had extensive fellowship support in the past. Recipients may not hold the Centennial Fellowship concurrently with another research fellowship such as a Sloan or National Science Foundation Postdoctoral Fellowship. Under normal circumstances, the fellowship cannot be deferred. A recipient of the fellowship shall have held his or her doctoral degree for at least three years and not more than twelve years at the inception of the award (that is, received between September 1, 1992, and September 1, 2001). Applications will be accepted from those currently holding a tenured, tenure-track, postdoctoral, or comparable (at the discretion of the selection committee) position at an institution in North America.

The stipend for fellowships awarded for 2004–2005 is expected to be approximately $60,000, with an additional expense allowance of about $1,700. Acceptance of the fellowship cannot be postponed.

The number of fellowships to be awarded is small and depends on the amount of money contributed to the program. The AMS trustees have arranged a matching program from general funds. At most two fellowships will be awarded for the 2004–2005 academic year. A list of previous fellowship winners can be found at `http://www.ams.org/prizes/centennial-fellowship.html`.

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

The deadline for receipt of applications is **December 1, 2003**. Awards will be announced in February 2004 or earlier if possible.

Application forms are available via the Internet at `http://www.ams.org/employment/centflyer.html`. For paper copies of the form, write to the Professional Services Department, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294; or send electronic mail to `prof-serv@ams.org`; or call 401-455-4107.

—AMS announcement

Enhancing the Mathematical Sciences Workforce in the 21st Century

The National Science Foundation (NSF) has launched a new program called Enhancing the Mathematical Sciences Workforce in the 21st Century (EMSW21). The long-range goal of the program is to increase the number of U.S. citizens, nationals, and permanent residents who are well-prepared in the mathematical sciences and who pursue careers in the mathematical sciences and in other NSF-supported disciplines. EMSW21 builds on the VIGRE (Vertical Integration of Research and Education in the Mathematical Sciences) program and now includes a broadened VIGRE activity, an additional component for Research Training Groups (RTG) in the Mathematical Sciences, and an additional component for Mentoring through Critical Transition Points (MCTP) in the Mathematical Sciences.

The program solicitation is available at `http://www.nsf.gov/pubsys/ods/getpub.cfm?nsf03575`. This program solicitation replaces NSF 02-120 (VIGRE). The proposal deadline is **September 16** each year.

—From an NSF announcement

NSA Grant and Sabbatical Programs

The Mathematical Sciences Program of the National Security Agency (NSA) provides grants and sabbatical opportunities to support research by academic mathematical scientists.

The NSA makes grants to universities and nonprofit institutions to support self-directed research in the following areas of mathematics (including possible computational aspects): algebra, number theory, discrete mathematics, probability, statistics, and cryptology. The NSA also accepts proposals for small grants for conferences, workshops, and special academic endeavors. Research grants are designed principally to provide summer salaries for professors and limited support for their graduate students. The deadline for submission of all grant proposals is **October 15, 2003.** Grants begin in the fall of the following year.

The sabbatical opportunities offered by the NSA provide support for academic mathematical scientists to visit the NSA for periods ranging from nine to twenty-four months. Visitors' sabbatical stipends will be supplemented with funds to equal their regular monthly salaries. A choice is offered between an allowance for moving expenses or a housing supplement. Applicants and their immediate family members must be U.S. citizens. Because a complete background investigation is required, applications should be submitted well in advance of the requested starting date.

Further information may be obtained from the NSA's website: `http://www.nsa.gov/programs/msp/grants.html`. The telephone number is 301-688-0400, the email address is `msp@math.umbc.edu`, and the postal address is: Mathematical Sciences Program, National Security Agency, ATTN:R51A, Suite 6557, Ft. George G. Meade, MD 20755-6557.

—From an NSA announcement

NSF Mathematical Sciences Postdoctoral Research Fellowships

The Mathematical Sciences Postdoctoral Research Fellowship program of the Division of Mathematical Sciences (DMS) of the National Science Foundation (NSF) awards fellowships each year for research in pure mathematics, applied mathematics and operations research, and statistics. The deadline for this year's applications is **October 17, 2003.** Applications must be submitted via FastLane on the World Wide Web at `http://www.fastlane.nsf.gov/jsp/homepage/postdoc_fel.jsp`. For more information, telephone the DMS at 703-306-1870 or send email to `msprf@nsf.gov`.

—From an NSF announcement

NSF Distinguished International Postdoctoral Research Fellowships

The Distinguished International Postdoctoral Research Fellowships Program of the Mathematical and Physical Sciences (MPS) Directorate of the National Science Foundation (NSF) provides opportunities for postdoctoral investigators to conduct research projects abroad as MPS Distinguished International Postdoctoral Research Fellows (MPS-DRF). The objective of the program is to provide talented recent doctoral recipients in the mathematical and physical sciences an effective means of establishing international collaborations in the early stages of their careers.

Applicants must be citizens or permanent residents of the United States who have fulfilled the requirements for the doctoral degree between June 1 of the year of submission and September 30 of the year following submission. NSF expects to fund up to twenty awards that will provide up to $100,000 per year for up to twenty-four months.

The deadline for full proposals is **October 8, 2003.** For technical and scientific information, contact Lynne Walling, Program Director, Division of Mathematical Sciences, Room 1025, National Science Foundation, 4201 Wilson Boulevard, Arlington, VA 22230; telephone 703-292-8104; email `lwalling@nsf.gov`. The program announcement is available at `http://www.nsf.gov/pubs/2001/nsf01154/nsf01154.txt`.

—From an NSF announcement

NSF International Research Fellow Awards

The International Research Fellow Awards Program of the National Science Foundation (NSF) provides support for postdoctoral and junior investigators to do research in basic science and engineering for three to twenty-four months in any country in the world. The goal of the program is to establish productive, long-term relationships between U.S. and foreign science and engineering communities. Applicants must be U.S. citizens or permanent residents who have earned their doctoral degrees within six years before the date of application or who expect to receive their degrees by the date of the award.

The deadline for applying is **November 1, 2003**. For further information contact the program officer, Susan Parris, 703-292-8711, sparris@nsf.gov; or visit the website http://www.nsf.gov/sbe/int/fellows/start.htm.

—From an NSF announcement

NSF Graduate Fellowships

The National Science Foundation (NSF) awards Graduate Research Fellowships to graduating seniors and first-year graduate students. These are three-year fellowships awarded to U.S. students for full-time graduate study at the institutions of their choice. The fellowships include a stipend, tuition coverage, and possible international travel allowances. Awards are made based on the candidates' intellectual merit and potential for research achievement. More information and applications for the 2004 competition will be available early in August 2003 at http://www.orau.org/nsf/nsffel.htm. Further information may be obtained by calling toll-free 866-353-0905 or by sending email to nsfgrfp@orau.gov.

—From an NSF announcement

AWM Travel Grants for Women

The National Science Foundation (NSF) and the Association for Women in Mathematics (AWM) sponsor two travel grant programs for women mathematicians.

AWM Travel Grants enable women to attend research conferences in their fields, thereby providing scholars valuable opportunities to advance their research activities and their visibility in the research community. A travel grant provides full or partial support for travel and subsistence for a meeting or conference in the grantee's field of specialization.

AWM Mentoring Travel Grants are designed to help junior women develop long-term working and mentoring relationships with senior mathematicians. A mentoring travel grant funds travel, subsistence, and other expenses for an untenured woman mathematician to travel to an institute or a department to do research with a specified individual for one month.

The final deadline for the Travel Grants program for 2003 is **October 1, 2003**; the deadlines for 2004 are **February 1, 2004**; **May 1, 2004**; and **October 1, 2004**. For the Mentoring Travel Grants program the deadline is **February 1, 2004**. For further information and details on applying, see the AWM website, http://www.awm-math.org/travelgrants.html; or telephone 301-405-7892; or send email to awm@math.umd.edu. The postal address is: Association for Women in Mathematics, 4114 Computer and Space Sciences Building, University of Maryland, College Park, MD 20742-2461.

—From an AWM announcement

Research Experiences for Undergraduates

The Research Experiences for Undergraduates (REU) program supports active research participation by undergraduate students in any of the areas of research funded by the National Science Foundation (NSF). Student research may be supported in two forms: REU supplements and REU sites. REU supplements may be included in proposals for new or renewal NSF grants or cooperative agreements or as supplements to ongoing NSF-funded projects. REU sites are based on independent proposals to initiate and conduct undergraduate research participation projects for a number of students. REU site projects may be based in a single discipline or academic department or on interdisciplinary or multidepartment research opportunities with a strong intellectual focus. Proposals with an international dimension are welcomed. Undergraduate student participants supported with NSF funds in either supplements or sites must be citizens or permanent residents of the United States or its possessions.

The deadline for full proposals for REU sites is **September 15, 2003**. Deadline dates for REU supplements vary with the research program; contact the program director for more information. The full program announcement can be found at the website http://www.nsf.gov/pubsys/ods/getpub.cfm?nsf02136.

—From an NSF announcement

Call for Submissions for Sunyer i Balaguer Prize

Ferran Sunyer i Balaguer (1912–1967) was a self-taught Catalan mathematician who, despite a serious physical disability, was very active in research in classical analysis, an area in which he acquired international recognition. Each year, in honor of the memory of Ferran Sunyer i Balaguer, the Institut d'Estudis Catalans awards an international research prize bearing his name.

The prize is awarded for a mathematical monograph of an expository nature presenting the latest developments in an active area of research in mathematics in which the author has made important contributions. The monograph should be written in English and should be at least 150 pages.

The prize, amounting to 10,000 euros (about U.S.$8,600), is provided by the Ferran Sunyer i Balaguer Foundation. The winning monograph will be published in Birkhäuser-Verlag's series Progress in Mathematics, subject to the usual regulations concerning copyright and author's rights.

Submissions should be sent before **December 1, 2003**, to: Centre de Recerca Matemàtica, Fundació Ferran Sunyer i Balaguer, Apartat 50, E-08193 Bellaterra, Spain. For further information, visit the website `http://www.crm.es/home.htm` or send email to `crm@crm.es`.

—From an Insitut d'Estudis Catalans announcement

Call for Nominations for Information-Based Complexity Young Researcher Award

Nominations are being sought for the Information-Based Complexity Young Researcher Award. This new annual award will be given for significant contributions to information-based complexity by a young researcher. The prize will consist of $1,000 and a plaque.

Any researcher who has not reached his or her thirty-fifth birthday by September 30 of the year of the award is eligible. The award may be given for work done in a single year or over a number of years. The work may have been published in any journal or number of journals or as monographs. A person does not have to be nominated to win the award.

The deadline for nominations is **September 30, 2003**. Nominations should be sent to Joseph F. Traub, email: `traub@cs.columbia.edu`.

—Joseph F. Traub, Columbia University

News from MSRI

The Mathematical Sciences Research Institute in Berkeley, California, announces two workshops in support of its academic program in Discrete and Computational Geometry (fall semester, August 18–December 19, 2003) for the 2003–04 year. Registration for these workshops is available online at `http://www.msri.org/applications/applying/`.

Mathematical Foundations of Geometric Algorithms
October 13, 2003, to October 17, 2003
Organized by: Pankaj Agarwal, Herbert Edelsbrunner, Micha Sharir, and Emo Welzl

The workshop will focus on the design and analysis of geometric algorithms, and on the mathematical and algorithmic techniques needed to make these algorithms efficient. The emphasis will be on research topics that are currently active. These topics will be presented by key researchers who will survey the current state of the art in these areas, report on new research results, and facilitate discussions and collaboration among the participants.

Combinatorial and Discrete Geometry
November 17, 2003, to November 21, 2003
Organized by: Jesús A. De Loera, Jacob E. Goodman, János Pach and Günter M. Ziegler

The focus of this workshop will be on discrete geometric objects (e.g. polyhedra, geometric graphs, sphere packings, tilings, lattices, etc.) and their combinatorial structure, stressing the connections between discrete geometry and algebra, combinatorics, and topology.

For more information, send email to `workshops@msri.org`.

—MSRI announcement

News from AIM

The American Institute of Mathematics (AIM) Research Conference Center seeks proposals for focused workshops in all areas of the mathematical sciences. Applications are due **November 1, 2003**. For details visit `http://www.aimath.org/ARCC`.

—AIM announcement

UNIVERSITY OF BASLE

TENURE TRACK ASSISTANT PROFESSOR IN ANALYSIS

The Department of Mathematics at the University of Basle invites applications for a tenure track assistant professorship in analysis, starting 1st April 2004. Candidates must hold a Ph.D. degree in mathematics, and some postdoctoral teaching experience is preferred. The successful candidate is expected to perform independent research in areas related to partial differential equations, dynamical systems, numerical analysis, or applied analysis. A strong commitment to excellence in teaching and research is essential.

Applicants should provide a curriculum vitae, a publication list, copies of five papers, a statement of research interests, and reports on past teaching experience, together with the names and addresses of five potential referees. As the University of Basle would like to increase its female staff, women are strongly encouraged to apply.
Applications should be sent to

Prof. Dr. Marcel Tanner
Dean, Faculty of Science,
University of Basel
Klingelbergstrasse 50,
CH-4056 Basel,
Switzerland.

The deadline for receipt is 31th October 2003.

For additional information please contact

Prof. D. Masser
Mathematisches Institut,
Rheinsprung 21,
CH-4051 Basel,
Switzerland.
masser@math.unibas.ch
or
http://www.math.unibas.ch

UNI
BASEL

For Your Information

BMSA Ends Chairs' Colloquium

The Board on Mathematical Sciences and their Applications (BMSA) of the National Academies has decided to end its program of annual colloquia for heads of college-level mathematics and statistics departments. The chairs colloquia have been held every year since 1986 as an opportunity for department heads to learn about developments in the funding agencies, to share insights about their challenges, and to build up a network of colleagues. In recent years other opportunities have been developed to allow department heads to gather and share ideas, and so it is no longer necessary for the Board to continue these events.

Other opportunities for department heads to congregate include: (1) The Professional Enhancement Programs (PREP) of the Mathematical Association of America, described at `http://www.maa.org/pfdev/pfdev_index.html`. (2) AMS workshops for chairs held at each Joint Mathematics Meeting. These small workshops focus on the managerial and administrative aspects of being a department head. (3) The annual meeting of the AMS Committee on Science Policy, which is designed in part to provide department heads with an introduction to policy issues. In future years, a greater effort will be made to involve more chairs. These meetings are held each April in Washington, D.C. (4) American Statistical Association workshops for chairs that are held in conjunction with each Joint Statistics Meeting. (5) Meetings held by the Division of Mathematical Sciences of the National Science Foundation in spring 2002 and spring 2003. These meetings are aimed at increasing the dialogue between DMS and department heads.

The Board is confident, after discussions with AMS and NSF, that the community will not be harmed by the cancellation of the BMSA chairs colloquium series, and it extends gratitude to all who have contributed to past colloquia.

—BMSA announcement

Inside the AMS

Josephine Mitchell and Lowell Schoenfeld Memorial Garden Dedication

At a ceremony on May 16, 2003, the AMS dedicated the Josephine Mitchell and Lowell Schoenfeld Memorial Garden at the Society headquarters building in Providence. Executive Director John Ewing read a tribute to the two mathematicians and unveiled the plaque that dedicates their memorial garden and honors their bequest to the Society. Members of the AMS Executive Committee, Board of Trustees, and staff attended the dedication.

Josephine Mitchell's field was several complex variables; the field of her husband, Lowell Schoenfeld, was analytic number theory. They were both on the faculty of the University of Buffalo at the time of their retirement in 1980. Mitchell passed away in 2000, and her husband passed away a little more than a year afterward. Their work spanned half a century and continues to live on through their papers, reviews, students, and book collection, which was recently sent to Charles University in the Czech Republic, where floods destroyed the university's library. Their generous gift to the AMS will be part of the Society's Endowment, with its income to be used to support mathematics and scholarship.

Ewing's tribute may be found on the AMS website at `http://www.ams.org/ams/Mitchell-Schoenfeld-dedication.pdf`.

—AMS announcement

Photographs by Mike Breen.

Left, members of the AMS Executive Committee and Board of Trustees attending the dedication of the Mitchell and Schoenfeld Memorial Garden. At right, a closeup of the memorial plaque.

Reference and Book List

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

Contacting the *Notices*

The preferred method for contacting the *Notices* is electronic mail. The editor is the person to whom to send articles and letters for consideration. Articles include feature articles, memorial articles, communications, opinion pieces, and book reviews. The editor is also the person to whom to send news of unusual interest about other people's mathematics research.

The managing editor is the person to whom to send items for "Mathematics People", "Mathematics Opportunities", "For Your Information", "Reference and Book List", and "Mathematics Calendar". Requests for permissions, as well as all other inquiries, go to the managing editor.

The electronic-mail addresses are notices@math.tamu.edu in the case of the editor and notices@ams.org in the case of the managing editor. The fax numbers are 979-845-6028 for the editor and 401-331-3842 for the managing editor. Postal addresses may be found in the masthead.

Upcoming Deadlines

August 15, 2003: Applications for National Research Council Research Associateship Program. See http://www4.nationalacademies.org/pga/rap.nsf; or contact the National Research Council, Associateship Programs (TJ 2114), 2101 Constitution Avenue, NW, Washington, DC 20418; telephone 202-334-2760; fax 202-334-2759; email: rap@nas.edu.

August 19, 2003: Letters of intent for NSF Focused Research Groups. See http://www.nsf.gov/pubs/2002/nsf02129/nsf02129.htm.

August 25, 2003: Proposals for COBASE Collaborative Grants. See http://www7.nationalacademies.org/dsc/COBASE_Grants_Program.html; telephone: 202-334-2644; fax: 202-334-2614; email: ocee@nas.edu.

September 15, 2003: Full proposals for REU sites. See "Mathematics Opportunities" in this issue.

September 15, 2003: Nominations for Sloan Research Fellowships.

Where to Find It

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

AMS Bylaws—*November 2001, p. 1205*

AMS Email Addresses—*November 2002, p. 1275*

AMS Ethical Guidelines—*June/July 2002, p. 706*

AMS Officers 2002 and 2003 (Council, Executive Committee, Publications Committees, Board of Trustees)—*May 2003, p. 594*

AMS Officers and Committee Members—*October 2002, p. 1108*

Backlog of Mathematics Research Journals—*September 2003, p. 961*

Conference Board of the Mathematical Sciences—*September 2003, p. 945*

Information for *Notices* Authors—*June/July 2003, p. 706*

Mathematics Research Institutes Contact Information—*August 2003, p. 821*

National Science Board—*January 2003, p. 64*

New Journals for 2002—*June/July 2003, p. 708*

NRC Board on Mathematical Sciences and Their Applications—*March 2003, p. 383*

NRC Mathematical Sciences Education Board—*April 2003, p. 489*

NSF Mathematical and Physical Sciences Advisory Committee—*February 2003, p. 261*

Program Officers for Federal Funding Agencies—*October 2002, p. 1103 (DoD, DoE); November 2002, p. 1278 (NSF Education Program Officers); December 2002, p. 1406 (DMS Program Officers)*

Contact the Alfred P. Sloan Foundation, 630 Fifth Avenue, Suite 2550, New York, NY 10111; or see http://www.sloan.org.

September 16, 2003: Proposals for Enhancing the Mathematical Sciences Workforce in the 21st Century (EMSW21). See "Mathematics Opportunities" in this issue.

September 19, 2003: Full proposals for NSF Focused Research Groups. See http://www.nsf.gov/pubs/2002/nsf02129/nsf02129.htm.

September 30, 2003: Nominations for Information-Based Complexity Young Researcher Award. See "Mathematics Opportunities" in this issue.

October 1, 2003: Applications for AWM Travel Grants. See "Mathematics Opportunities" in this issue.

October 1, 2003: Nominations for AWM Hay Award and Schafer Prize. Contact The Hay Award Selection Committee or The Alice T. Schafer Award Selection Committee, Association for Women in Mathematics, 4114 Computer & Space Sciences Building, University of Maryland, College Park, MD 20742-2461; telephone 301-405-7892; email: awm@math.umd.edu; website: http://www.awm-math.org.

October 8, 2003: Full proposals for NSF Distinguished International Postdoctoral Research Fellowships. See "Mathematics Opportunities" in this issue.

October 15, 2003: Applications for spring semester of Math in Moscow and for AMS scholarships. See http://www.mccme.ru/mathinmoscow or contact Math in Moscow, P.O. Box 524, Wynnewood, PA 19096; fax +7095-291-65-01; email: mim@mccme.ru. For information about and application forms for the AMS scholarships, see http://www.ams.org/careers-edu/mimoscow.html or contact Math in Moscow Program, Membership and Programs Department, American Mathematical Society, 201 Charles Street, Providence RI 02904; email: prof-serv@ams.org.

October 15, 2003: Proposals for NSA Grant and Sabbatical Programs. See "Mathematics Opportunities" in this issue.

October 17, 2003: Applications for NSF Mathematical Sciences Postdoctoral Research Fellowships. See http://www.fastlane.nsf.gov/jsp/homepage/postdoc_fel.jsp; telephone: 703-306-1870; email: msprf@nsf.gov.

November 1, 2003: Applications for 2004–2005 Fulbright spring/summer seminars in Germany, Korea, and Japan and for summer German Studies Seminar. Contact the Council for International Exchange of Scholars (CIES), 3007 Tilden Street, NW, Suite 5L, Washington, DC 20008-3009; telephone: 202-686-7877; email: apprequest@cies.iie.org; or see http://www.cies.org.

November 1, 2003: Applications for NSF International Research Fellow Awards. See "Mathematics Opportunities" in this issue.

November 1, 2003: Proposals for workshops at the AIM Research Conference Center. See "Mathematics Opportunities" in this issue.

December 1, 2003: Applications for AMS Centennial Fellowships. See "Mathematics Opportunities" in this issue.

December 1, 2003: Submissions for Sunyer i Balaguer Prize. See "Mathematics Opportunities" in this issue.

December 31, 2003: Entries for *Cryptologia* paper competitions. See http://www.dean.usma.edu/math/pubs/cryptologia/ or contact *Cryptologia,* Department of Mathematical Sciences, United States Military Academy, West Point, NY 10996; email: Cryptologia@usma.edu.

January 2, 2004: Applications for Fields Institute postdoctoral fellowships. See http://www.fields.utoronto.ca/proposals/postdoc.html.

February 1, 2004: Applications for AWM Travel Grants and AWM Mentoring Travel Grants. See "Mathematics Opportunities" in this issue.

May 1, 2004: Applications for AWM Travel Grants. See "Mathematics Opportunities" in this issue.

June 30, 2004: Proposals for DMS/NIGMS Program in Mathematical Biology. See http://www.nsf.gov/pubs/2002/nsf02125/nsf02125.htm.

Conference Board on the Mathematical Sciences

1529 Eighteenth Street, NW
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Member Societies:
American Mathematical Association of Two-Year Colleges (AMATYC)
American Mathematical Society (AMS)
American Statistical Association (ASA)
Association for Symbolic Logic (ASL)
Association for Women in Mathematics (AWM)
Association of Mathematics Teacher Educators (AMTE)
Association of State Supervisors of Mathematics (ASSM)
Benjamin Banneker Association (BBA)
Institute for Operations Research and the Management Sciences (INFORMS)
Institute of Mathematical Statistics (IMS)
Mathematical Association of America (MAA)
National Association of Mathematicians (NAM)
National Council of Supervisors of Mathematics (NCSM)
National Council of Teachers of Mathematics (NCTM)
Society for Industrial and Applied Mathematics (SIAM)
Society of Actuaries (SOA)

Book List

The Book List highlights books that have mathematical themes and are aimed at a broad audience potentially including mathematicians, students, and the general public. When a book has been reviewed in the Notices, *a reference is given to the review. Generally the list will contain only books published within the last two years, though exceptions may be made in cases where current events (e.g., the*

death of a prominent mathematician, coverage of a certain piece of mathematics in the news) warrant drawing readers' attention to older books. Suggestions for books to include on the list may be sent to notices-booklist@ams.org.

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

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

Abel's Proof: An Essay on the Sources and Meaning of Mathematical Unsolvability, by Peter Pesic. MIT Press, May 2003. ISBN 0-262-16216-4.

All the Mathematics You Missed (But Need to Know for Graduate School), by Thomas A. Garrity. Cambridge University Press, December 2001. ISBN 0-521-79707-1.

The Annotated Flatland: A Romance of Many Dimensions, Edwin A. Abbott; introduction and notes by Ian Stewart. Perseus Publishing, November 2001. ISBN 0-7382-0541-9. (Reviewed November 2002.)

The Art of the Infinite: The Pleasures of Mathematics, by Robert Kaplan and Ellen Kaplan. Oxford University Press, March 2003. ISBN 0-195-14743-X.

Behind Deep Blue: Building the Computer That Defeated the World Chess Champion, by Feng-hsiung Hsu. Princeton University Press, November 2002. ISBN 0-691-09065-3.

Beyond the Limit: The Dream of Sofya Kovalevskaya, by Joan Spicci. Forge, August 2002. ISBN 0-765-30233-0.

Codebreakers: Arne Beurling and the Swedish Crypto Program During World War II, by Bengt Beckman. Translated by Kjell-Ove Widman. AMS, February 2003. ISBN 0-8218-2889-4. (Reviewed in this issue.)

The Colossal Book of Mathematics: Classic Puzzles, Paradoxes, and Problems, by Martin Gardner. W. W. Norton & Company, August 2001. ISBN 0-393-02023-1. (Reviewed October 2002.)

Conned Again, Watson! Cautionary Tales of Logic, Math, and Probability, by Colin Bruce. Perseus Publishing, January 2001. ISBN 0-7382-0345-9. (Reviewed November 2002.)

The Constants of Nature: From Alpha to Omega—The Numbers That Encode the Deepest Secrets of the Universe, by John D. Barrow. Jonathan Cape, September 2002; Pantheon Books, January 2003. ISBN 0-375-42221-8.

Correspondance Grothendieck-Serre, Pierre Colmez and Jean-Pierre Serre, editors. Société Mathematique de France, 2001. ISBN 2-85629-104-X.

Damned Lies and Statistics: Untangling Numbers from the Media, Politicians, and Activists, by Joel Best. University of California Press, May 2001. ISBN 0-520-21978-3. (Reviewed February 2003.)

Does God Play Dice? The New Mathematics of Chaos, by Ian Stewart. Blackwell, revised second edition, January 2002. ISBN 0-631-23251-6. (Reviewed December 2002.)

Doing Mathematics: Convention, Subject, Calculation, Analogy, by Martin H. Krieger. World Scientific, April 2003. ISBN 9-812-38200-3.

Emergence of the Theory of Lie Groups. An Essay in the History of Mathematics, 1869–1926, by Thomas Hawkins. Springer-Verlag, 2000. ISBN 0-387-98963-3. (Reviewed June/July 2003.)

Entanglement: The Greatest Mystery in Physics, by Amir D. Aczel. Four Walls Eight Windows, October 2002. ISBN 1-56858-232-3.

Four Colors Suffice: How the Map Problem Was Solved, by Robin Wilson. Princeton University Press, March 2003. ISBN 0-691-11533-8.

The Fractal Murders, by Mark Cohen. Muddy Gap Press, May 2002. 0-9718986-0-X.

Fragments of Infinity: A Kaleidoscope of Math and Art, by Ivars Peterson. John Wiley & Sons, October 2001. ISBN 0-471-16558-1. (Reviewed October 2002.)

Gamma: Exploring Euler's Constant, by Julian Havil. Princeton University Press, May 2003. ISBN 0-691-09983-9.

Geometrical Landscapes: The Voyages of Discovery and the Transformation of Mathematical Practice, by Amir R. Alexander. Stanford University Press, September 2002. ISBN 0-804-73260-4.

Geometry: Our Cultural History, by Audun Holme. Springer, April 2002. ISBN 3-540-41949-7.

The Glass Wall: Why Mathematics Can Seem Difficult, by Frank Smith. Teachers College Press, July 2002. ISBN 0-807-74241-4 (paperback), 0-807-74242-2 (cloth).

God in the Equation: How Einstein Became the Prophet of the New Religious Era, by Corey S. Powell. Free Press, August 2002. ISBN 0-684-86348-0.

Gödel's Proof, by Ernest Nagel and James R. Newman. New York University Press, revised edition, February 2002. ISBN 0-8147-5816-9.

The Golden Ratio: The Story of Phi, the World's Most Astonishing Number, by Mario Livio. Broadway Books, October 2002. ISBN 0-767-90815-5.

Hinged Dissections: Swinging and Twisting, by Greg N. Frederickson. Cambridge University Press, September 2002. ISBN 0-521-81192-9.

How the Universe Got Its Spots, by Janna Levin. Princeton University Press, April 2002. ISBN 0-691-09657-0.

Imagining Numbers (particularly the square root of minus fifteen), by Barry Mazur. Farrar, Straus and Giroux, February 2003. ISBN 0-374-17469-5.

In Code: A Mathematical Journey, by Sarah Flannery and David Flannery. Workman Publishing, May 2001. ISBN 0-761-12384-9. (Reviewed April 2003.)

Indra's Pearls: The Vision of Felix Klein, by David Mumford, Caroline Series, and David J. Wright. Cambridge University Press, January 2002. ISBN 0-521-35253-3. (Reviewed January 2003.)

It Must Be Beautiful: Great Equations of Modern Science, Graham Farmelo, editor. Granta Books, February 2002. ISBN 1-862-07479-8. (Reviewed March 2003.)

Janos Bolyai, Euclid, and the Nature of Space, by Jeremy J. Gray. MIT Press, May 2003. ISBN 0-262-57174-9.

Linked: The New Science of Networks, by Albert-László Barabási. Perseus Publishing, May 2002. ISBN 0-738-20667-9.

Mathematical Apocrypha: Stories and Anecdotes of Mathematicians and the Mathematical, by Steven G. Krantz. Mathematical Association of America, July 2002. ISBN 0-883-85539-9.

Mathematical Reflections, by Peter Hilton, Derek Holton, and Jean Pedersen. Springer, December 1996. ISBN 0-387-94770-1. (Reviewed February 2003.)

Mathematical Vistas, by Peter Hilton, Derek Holton, and Jean Pedersen. Springer-Verlag, January 2002. ISBN 0-387-95064-8. (Reviewed February 2003.)

Mathematics and the Roots of Postmodern Thought, by Vladimir Tasić. Oxford University Press, 2001. ISBN 0-195-13967-4. (Reviewed August 2003.)

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

Mathematics Elsewhere: An Exploration of Ideas across Cultures, by Marcia Ascher. Princeton University Press, September 2002. ISBN 0-691-07020-2. (Reviewed May 2003.)

The Mathematics of Juggling, by Burkard Polster. Springer, November 2002. ISBN 0-387-95513-5.

The Mathematics of Oz: Mental Gymnastics from beyond the Edge, by Clifford Pickover. Cambridge University Press, October 2002. ISBN 0-521-01678-9.

M. C. Escher's Legacy: A Centennial Celebration, edited by Doris Schattschneider and Michele Emmer. Springer, January 2003. ISBN 3-540-42458-X. (Reviewed April 2003.)

The Millennium Problems: The Seven Greatest Unsolved Mathematical Puzzles of Our Time, by Keith J. Devlin. Basic Books, October 2002. ISBN 0-465-01729-0. (Reviewed in this issue.)

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

The Music of the Primes: Searching to Solve the Greatest Mystery in Mathematics, by Marcus Du Sautoy. HarperCollins, April 2003. ISBN 0-066-21070-4.

A New Kind of Science, by Stephen Wolfram. Wolfram Media, Inc., May 2002. ISBN 1-579-55008-8. (Reviewed February 2003.)

Nexus: Small Worlds and the Groundbreaking Science of Networks, by Mark Buchanan. W. W. Norton & Company, May 2002. ISBN 0-393-04153-0.

The One True Platonic Heaven: A Scientific Fiction of the Limits of Knowledge, by John L. Casti. Joseph Henry Press, May 2003. ISBN 0-309-08547-0.

Origami^3, edited by Thomas Hull. A K Peters, July 2002. ISBN 1-568-81181-0.

Prime Obsession: Bernhard Riemann and the Greatest Unsolved Problem, by John Derbyshire. Joseph Henry Press, March 2003. ISBN 0-309-08549-7.

The Rainbow Bridge: Rainbows in Art, Myth, and Science, by Raymond L. Lee Jr. and Alistair B. Fraser. Pennsylvania State University Press and SPIE Press, 2001. ISBN 0-271-01977-8. (Reviewed December 2002.)

Remarkable Mathematicians, by Ioan James. Cambridge University Press, February 2003. ISBN 0-521-52094-0.

The Riemann Hypothesis: The Greatest Unsolved Problem in Mathematics, by Karl Sabbagh. Farrar Straus & Giroux, April 2003. ISBN 0-374-25007-3.

The Search for Certainty: A Philosophical Account of Foundations of Mathematics, by Marcus Giaquinto. Oxford University Press, October 2002. ISBN 0-198-75244-X.

Six Degrees: The Science of a Connected Age, by Duncan J. Watts. W. W. Norton & Company, February 2003. ISBN 0-393-04142-5.

Sync: The Emerging Science of Spontaneous Order, by Steven Strogatz. Hyperion, February 2003. ISBN 0-786-86844-9.

Wavelets through a Looking Glass: The World of the Spectrum, by Ola Bratteli and Palle Jorgensen. Birkhäuser/Springer, 2002. ISBN 0-8176-4280-3.

What Are the Odds? The Chances of Extraordinary Events in Everyday Life, by Jefferson Hane Weaver. Prometheus Books, February 2002. ISBN 1-573-92933-6.

What Shape Is a Snowflake?, by Ian Stewart. W. H. Freeman & Co., November 2001. ISBN 0-716-74794-4. (Reviewed December 2002.)

The Zen of Magic Squares, Circles, and Stars: An Exhibition of Surprising Structures across Dimensions, by Clifford A. Pickover. Princeton University Press, January 2001. ISBN 0-691-07041-5. (Reviewed March 2003.)

REFERENCE & BOOK LIST

Stipends for Study and Travel

Graduate Support

American Association for the Advancement of Science

Mass Media Summer Fellowship

(AMS supports at least one Fellow per year under this program)

Description: Fellows work for radio and television stations, newspapers, magazines, and online sites and have their travel expenses and stipends paid by the AAAS. Fellows have the opportunity to: observe and participate in the process by which events and ideas become news, improve their communication skills by learning to describe complex technical subjects in a manner understandable by the public, and increase their understanding of editorial decision making and the manner in which information is effectively disseminated. Each fellow will: attend an orientation and evaluation session in Washington, DC; begin the internship in mid-June; and submit an interim and final report to AAAS to help evaluate the program.
Eligibility: Provides support for 20–30 outstanding graduate students in mathematics, the natural and social sciences, and engineering as reporters, researchers, and production assistants in the mass media. (Exceptional undergraduate or postdoctoral students also considered.)
Grant amount: $450/week stipend for ten weeks.
Deadline: January 15, 2004.
Application information: Katrina Malloy, Program Coordinator, Mass Media Science and Engineering Fellows Program, American Association for the Advancement of Science, 1200 New York Avenue, NW, Washington, DC 20005; `http://ehrweb.aaas.org/massmedia.htm`.

American Association of University Women (AAUW) Educational Foundation

Selected Professions Fellowships

Description: These fellowships are awarded to women of outstanding academic ability who are citizens or permanent residents of the U.S. for full-time graduate study in designated fields where women's participation has traditionally been low. Eligible fields currently include mathematics and statistics.
Eligibility: Fellowships are for the final year of the master's degree. Fellowship year is July 1–June 30. Degree must be earned at the end of the fellowship year.
Grant amount: $5,000–$12,000.
Deadline: Must be postmarked by January 10 (applications are available August 1–December 20).
Application information: For more information contact: AAUW Educational Foundation, 2201 Dodge Street, Iowa City, IA 52243-4030; tel: 319-337-1716; or visit our website at `http://www.aauw.org/`.

Burroughs Wellcome Fund

Career Awards at the Scientific Interface

Description: The complexity inherent in biological research has always provided a fertile field for the development of new mathematical and physical approaches to biological problems. But now, with advances in genomics, quantitative structural biology, and modeling of complex systems, the possibilities for an exciting research career at the interface between the physical/computational sciences and the biological sciences have never been greater. Tackling key problems in biology will require scientists trained in areas such as chemistry, physics, applied mathematics, computer science, and engineering. In recognition of the vital role such cross-trained scientists will play in furthering biomedical science, the Burroughs Wellcome Fund has developed Career Awards at the Scientific Interface. These grants are intended to foster the early career development of researchers with backgrounds in the physical/computational sciences whose work addresses biological questions and who are dedicated to pursuing a career in academic research. Candidates are expected to draw from their training in a scientific field other than biology to propose innovative approaches to answer important questions in the biological sciences. Examples of approaches include, but are not limited to, physical measurement of biological phenomena, computer simulation of complex processes in physiological systems, mathematical modeling of self-organizing behavior, building probabilistic tools for medical diagnosis, developing novel imaging tools or biosensors, applying nanotechnology to manipulate cellular systems, predicting cellular responses to topological clues and mechanical forces, and developing a new conceptual understanding of the complexity of

living organisms. Proposals that include experimental validation of theoretical models are particularly encouraged.

Eligibility: Candidates must hold a Ph.D. degree in the fields of mathematics, physics, chemistry (physical, theoretical, or computational), computer science, statistics, or engineering. Exceptions will be made only if the applicant can demonstrate significant expertise in one of these areas, evidenced by publications or advanced course work. Candidates must have completed at least six months but not more than 48 months of postdoctoral training at the time of application and must not hold or have accepted a faculty appointment as a tenure-track assistant professor at the time of application. Candidates who are not citizens of the United States or Canada must provide documentation of their visa status at the time of application.

Grant amount: Career Awards at the Scientific Interface provide $500,000 over five years to support up to two years of advanced postdoctoral training and the first three years of a faculty appointment. During both the postdoctoral and the faculty periods, grants must be made to degree-granting institutions in the United States or Canada on behalf of the award recipient.

Deadline: May 1, 2004.

Application information: Full application information is available on the Burroughs Wellcome Fund website at `http://www.bwfund.org` or write to Burroughs Wellcome Fund, Interfaces Program, 21 T. W. Alexander Dr., P.O. Box 13901, Research Triangle Park, NC 27709-3901.

Florida Education Fund

The McKnight Doctoral Fellowship Program

Description: A McKnight Doctoral Fellowship provides funds for up to twenty-five African American citizens annually to pursue Ph.D. degrees at participating Florida universities. Contingent upon successful academic progress, the maximum length of the award is five years. The Florida Education Fund provides the first three years, and the student's university continues funding at the same level of support for an additional two years.

Eligibility: Applicants must hold or be receiving a bachelor's degree from a regionally accredited college or university.

Grant amount: Up to $5,000 in tuition and fees plus an annual stipend of $12,000. Tuition and fees over $5,000 will be waived.

Deadline: The deadline for applications for fall 2004 is January 15, 2004.

Application information: Detailed information and application packets can be obtained by writing or calling: The Florida Education Fund, 201 E. Kennedy Boulevard, Suite #1525, Tampa, FL 33602; 813-272-2772; `mdf@fl-educ-fd.org`; or visit our website at: `http://www.fl-educ-fd.org/`.

Ford Foundation Dissertation Fellowships for Minorities

Description: Approximately 40 dissertation fellowships will be awarded in a national competition administered by the National Research Council (NRC) of the National Academies for the Ford Foundation. The awards will be made to those individuals who, in the judgment of the review panels, have demonstrated superior scholarship and show the greatest promise for future achievement as scholars, researchers, and teachers in institutions of higher education.

Eligibility: Available to minorities who are Ph.D. or Sc.D. candidates at U.S. institutions studying mathematics, engineering, of one of several other fields. The fellowships will be offered on a competitive basis to individuals who are citizens or nationals of the U.S. and who are members of the following groups: Alaska Natives (Eskimo or Aleut), Native American Indians, Black/African Americans, Mexican Americans/Chicanas/Chicanos, Native Pacific Islanders (Polynesian or Micronesian), Puerto Ricans.

Grant amount: Annual stipend of $24,000.

Deadline: Early December.

Application information: For more information, contact: Fellowship Office/FF, TJ 2041, National Research Council, 2101 Constitution Avenue, Washington, DC 20418; tel: 202-334-2872; email: `infofell@nas.edu`; website: `http://national-academies.org/fellowships/`.

Ford Foundation Predoctoral Fellowships for Minorities

Description: Approximately 60 predoctoral fellowships will be awarded in a national competition administered by the National Research Council (NRC) of the National Academies for the Ford Foundation. The awards will be made to those individuals who, in the judgment of the review panels, have demonstrated superior scholarship and show the greatest promise for future achievement as scholars, researchers, and teachers in institutions of higher education.

Eligibility: Available to minorities enrolled in or planning to enroll in research-based doctoral programs in mathematics, engineering, and other fields. The fellowships will be offered on a competitive basis to individuals who are citizens or nationals of the U.S. and who are members of the following groups: Alaska Natives (Eskimo or Aleut), Native American Indians, Black/African Americans, Mexican Americans/Chicanas/Chicanos, Native Pacific Islanders (Polynesian or Micronesian), Puerto Ricans.

Grant amount: Annual stipend of $16,500, plus an allowance of $7,500 to the awardee's university in lieu of tuition and fees.

Deadline: Mid-November.

Application information: For more information, contact: Fellowship Office/FF, TJ 2041, National Research Council, 2101 Constitution Avenue, Washington, DC 20418; tel: 202-334-2872; email: `infofell@nas.edu`; website: `http://national-academies.org/fellowships/`.

Georgia Institute of Technology

President's Fellowships

Description: These stipends are awarded to a selected number of highly qualified U.S. nationals who intend to pursue doctoral degrees. The fellowships are intended to supplement other forms of support and can be extended for three additional years based on academic performance and research potential.
Eligibility: The awards are highly competitive; selection is based on academic criteria and evidence of scholarship. Participants are expected to maintain high academic standing.
Grant amount: $5,500 for twelve months.

Graduate Research/Teaching Assistantships

Eligibility: Appointments are based primarily on scholarship and ability to contribute to ongoing programs of the college.
Assistantship amount: $18,161 per twelve months, plus waiver of most tuition and fees.
Application information: Prospective students should write to the Ph.D. Coordinator, College of Computing, Georgia Institute of Technology, Atlanta, GA 30332-0280; or e-mail to phd-info@cc.gatech.edu. For additional information: http://www.cc.gatech.edu/.

National Academies

Christine Mirzayan Science and Technology Policy Internship Program

Description: The Christine Mirzayan Science and Technology Policy Internship Program of the National Academies is designed to engage graduate and postdoctoral science, engineering, medical, veterinary, business, and law students in science and technology policy and to familiarize them with the interactions between science, technology, and government. As a result, students develop essential skills different from those attained in academia and make the transition from being a graduate student to a professional.
Eligibility: Applications for the internships are invited from graduate students through postdoctoral candidates in any physical, biological, or social science field or any field of engineering, medicine/health, or veterinary medicine, as well as business and law students.
Grant amount: The stipend for the 12-week January program is $5,700. The stipend for the 10-week June program is $4,800. The stipend for the September program is $5,700. In addition, travel expenses of up to $500 will be provided.
Deadline: Deadline for the receipt of materials is November 1 for the January program, March 1 for the June program, and June 1 for the September program.
Application information: For program details and a link to the online application, please visit the website at http://national-academies.org/internship. For further information, email: internship@nas.edu (preferred) or phone 202-334-2455. Résumés are not accepted.

National Science Foundation

Graduate Research Fellowships

Description: Three-year awards available to U.S. citizens or nationals, or permanent resident aliens of the U.S. Fellowships are awarded for graduate study leading to research-based master's or doctoral degree in the fields of science, mathematics, and engineering supported by the NSF. Women in Engineering and Computer and Information Science: Additional awards will be offered to encourage women to undertake graduate study in engineering and computer and information science.
Eligibility: Fellowships are intended for individuals in the early stages of their graduate study in science, mathematics, or engineering.
Grant amount: $27,500 stipend for twelve-month tenure. A one-time research travel allowance of $1,000. No dependency allowances. A cost-of-education allowance of $10,500 is paid to the fellowship institution.
Deadline: Application deadline is early November.
Application information: Apply to NSF Graduate Research Fellowship Program, Oak Ridge Associated Universities, P. O. Box 3010, Oak Ridge, TN 37831-3010; tel: 865-241-4300; fax: 865-241-4513; email: nsfgrfp@orau.gov; website: http://www.orau.org/nsf/nsffel.htm.

State of California

Graduate Assumption Program of Loans for Education

Eligibility: Residents of California who attend accredited graduate or professional schools in program leading to a graduate degree with the intent to become college or university faculty members in California.
Assumption benefits: May assume up to $6,000 in loan balances in return for teaching service at a college or university in California.
Priority filing date: June 30, 2003, or until all awards are filled.
Deadline: June 30, 2004.
Application information: California Student Aid Commission, P. O. Box 419029, Rancho Cordova, CA 95741-9029; tel: 916-526-7599; email: custsvcs@csac.ca.gov; applications on Web: http://www.csac.ca.gov/.

Zonta International Foundation

Amelia Earhart Fellowship Awards

Description: Established in 1938 in honor of Amelia Earhart, Zonta member from 1928 to 1937, the fellowships recognize excellence and encourage and support women pursuing graduate degrees in aerospace-related sciences and/or engineering.
Eligibility: To qualify for the fellowship, a woman must have by the time of her application: a bachelor's degree in a qualifying area of science or engineering closely related to advanced studies in aerospace-related science or aerospace-related engineering; a superior academic record and evidence of potential at a recognized institute of higher learning, as demonstrated by transcripts,

recommendations, and acceptance or verification by an institute of higher learning with accredited courses in aerospace-related studies; evidence of a well-defined research program in aerospace-related sciences or engineering; and completion of one year of aerospace-related graduate studies.

Grant amount: The scholarship award of $6,000 may be used for tuition, books and fees, or living expenses. Awards may be renewed for an additional year by a current fellow.

Deadline: November 15. Announcement of awards will be made by May 15.

Application information: Zonta International Foundation, 557 W. Randolph St., Chicago, IL 60661-2206; tel: 312-930-5848; fax: 312-930-0951; email: Zontafdtn@Zonta.org; website: http://www.Zonta.org/.

Postdoctoral Support

Air Force Office of Scientific Research

Research Contracts and Grants

Description: Mathematicians and computer scientists are encouraged to submit through their organizations proposals for research support. Research areas include mathematics of dynamics and control, physical mathematics and applied analysis, computational mathematics, optimization and discrete mathematics, signal processing, probability and statistics, software and systems, intelligent software agents, and electromagnetics.

Application information: Research proposals should be forwarded to the Mathematics and Space Sciences Directorate, Air Force Office of Scientific Research (AFOSR NM), 4015 Wilson Blvd., Room 713, Arlington, VA 22203-1954.

American Mathematical Society Centennial Fellowships

Postdoctoral Fellowships

Description: The AMS Centennial Research Fellowship Program makes awards annually to outstanding mathematicians to help further their careers in research. 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. At most, two fellowships will be awarded for the 2004–05 academic year. A list of previous fellowship winners can be found at http://www.ams.org/prizes-awards.

Eligibility: The eligibility rules are as follows. The primary selection criterion for the Centennial Fellowship is the excellence of the candidate's research. Preference will be given to candidates who have not had extensive fellowship support in the past. Recipients may not hold the Centennial Fellowship concurrently with another research fellowship such as a Sloan or NSF Postdoctoral Fellowship. Under normal circumstances the fellowship cannot be deferred. A recipient of the fellowship shall have held his or her doctoral degree for at least three years and not more than twelve years at the inception of the award (that is, received between September 1, 1992, and September 1, 2001). Applications will be accepted from those currently holding a tenured, tenure-track, postdoctoral, or comparable (at the discretion of the selection committee) position at an institution in North America. Applications should include a cogent plan indicating how the fellowship will be used. The plan should include travel to at least one other institution and should demonstrate that the fellowship will be used for more than reduction of teaching at the candidate's home institution. The selection committee will consider the plan in addition to the quality of the candidate's research and will try to award the fellowship to those for whom the award would make a real difference in the development of their research careers. Work in all areas of mathematics, including interdisciplinary work, is eligible.

Grant amount: The stipend for fellowships awarded for 2004–05 is expected to be approximately $60,000, with an additional expense allowance of about $1,700. Acceptance of the fellowship cannot be postponed.

Deadline: The deadline for receipt of applications is December 1, 2003. Awards will be announced in February 2004 or earlier if possible.

Application information: Application forms are available via the Internet at http://www.ams.org/employment/centflyer.html. For paper copies of the form write to the Membership and Programs Department, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294; or send electronic mail to prof-serv@ams.org; or call 401-455-4107. Please note that completed applications and references should be sent to the AMS at the address given above, marked "Centennial Fellowships".

American Philosophical Society

Description: Postdoctoral research grants to aid specific research projects. The purpose of the program is to connect scholars with the objects of their research. Tenable abroad and in the U.S. The Committee on Research meets in January and in March.

Eligibility: For candidates with Ph.D. for at least one year.

Grant amount: Up to $6,000. Grants contribute toward travel expenses, food and lodging, and photoduplication. No funds are available for attending conferences or consulting with colleagues.

Deadline: October 1, December 1.

Application information: For application forms please consult the website at http://www.amphilsoc.org/. If electronic access is denied, briefly describe your project and proposed budget in a letter to: Committee on Research, American Philosophical Society, 104 South Fifth Street, Philadelphia, PA 19106; or to eroach@amphilsoc.org.

California Institute of Technology

Harry Bateman Research Instructorships in Mathematics

Description: Appointments are for two years. The academic year runs from approximately October 1 to June 1. Instructors are expected to teach one course per quarter for the full academic year and to devote the rest of their time to research. During the summer months there are no duties except research.
Eligibility: Open to persons who have recently received their doctorates in mathematics.
Grant amount: The annual salary for academic year 2004–05 is $49,200.
Deadline: January 1, 2004.
Application information: Please send applications to Instructorship Search Committee, 253–37 Sloan Laboratory, California Institute of Technology, Pasadena, CA 91125. Include a C.V. and a statement of anticipated research. The candidate is requested to ensure that at least three letters of recommendation be sent to Caltech. To avoid duplication of paperwork, your application may also be considered for an Olga Taussky and John Todd Instructorship. Caltech is an Affirmative Action/Equal Opportunity Employer. Women, minorities, veterans, and disabled persons are encouraged to apply.

California Institute of Technology

Olga Taussky and John Todd Instructorships in Mathematics

Description: Appointments are for three years. There are three terms in the Caltech academic year, and instructors are expected to teach one course in all but two terms of the total appointment. These two terms will be devoted to research. During the summer months there are no duties except research.
Eligibility: Offered to persons within three years of having received the Ph.D. who show strong research promise in one of the areas in which Caltech's mathematics faculty is currently active.
Grant amount: The annual salary for 2004–05 is $52,200 plus a $2,000 per year research fund.
Deadline: January 1, 2004.
Application information: Apply to the Instructorship Search Committee, 253–37 Sloan Laboratory, California Institute of Technoloy, Pasadena, CA 91125. Include a C.V. and a statement of anticipated research. Please ensure that at least three letters of recommendation are sent to Caltech. To avoid duplication of paperwork, your application may also be considered for the Harry Bateman Research Instructorship. Caltech is an Affirmative Action/Equal Opportunity Employer. Women, minorities, veterans, and disabled persons are encouraged to apply.

Ford Foundation Postdoctoral Fellowships for Minorities

Description: Approximately 30 postdoctoral fellowships will be awarded in a national competition sponsored by the Ford Foundation and administered by the National Research Council.
Eligibility: U.S. citizens or nationals who are Native American Indian, Mexican American/Chicana/Chicano, Alaska Native (Eskimo or Aleut), Native Pacific Islander (Polynesian or Micronesian), Black/African American, or Puerto Rican and who are currently in or planning a career in teaching and research at the college or university level.
Grant amount: $35,000 for one year; $3,000 travel and relocation allowance; $2,000 cost-of-research allowance; $2,500 employing institution allowance, to be matched by employing institution.
Deadline: Early January.
Application information: For further information and applications, contact: Fellowship Office, TJ-2041, National Research Council, 2101 Constitution Avenue, Washington, DC 20418; tel: 202-334-2872; fax: 202-334-3419; email: infofell@nas.edu; website: http://national-academies.org/fellowships.

John Simon Guggenheim Memorial Foundation Fellowships

Description: Fellowships are on an advanced professional level. Approximately 230 awards are made.
Eligibility: U.S. or Canadian citizenship or permanent residence is required. Fellowships are also offered to citizens or permanent residents of Latin America and the Caribbean.
Grant amount: Approximately $36,000 in 2001.
Deadline: Application deadline: October 1 for the U.S. and Canada competition, December 1 for the Latin American and Caribbean competition.
Application information: For more information write to John Simon Guggenheim Memorial Foundation, 90 Park Avenue, New York, NY 10016; tel: 212-687-4470; fax: 212-697-3248; email: fellowships@gf.org; World Wide Web: http://www.gf.org/.

IBM Herman Goldstine Postdoctoral Fellowship in Mathematical Sciences

Description: The 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 work on technical problems arising in industry. Close interaction with permanent department members is expected, but fellows will be free to pursue their own research interests. The fellowship has a period of one year and may be extended by another year by mutual agreement. One fellowship will be awarded yearly. Please see http://www.research.ibm.com/math/goldstine.html for further information.
Eligibility: Candidates must have a doctorate and no more than five years of postdoctoral professional experience (with a preference for less) when the fellowship commences.

Grant amount: Salary: $87,000 to $107,000, depending on experience, plus an allowance for moving expenses.
Deadline: December 2003 (check website above).
Application information: Please visit website above.

Institute for Advanced Study Memberships

Description: The School of Mathematics will grant a limited number of memberships, some with financial support, for research in mathematics at the institute during the academic year 2004–05.
Eligibility: Candidates must give evidence of ability in research comparable at least with that expected for the Ph.D. degree.
Deadline: December 1, 2003.
Application information: Application blanks may be obtained from The School of Mathematics, Institute for Advanced Study, Princeton, NJ 08540, and should be returned (whether or not funds are expected from some other source) by December 1. Forms may also be downloaded but not submitted via Web connection at `http://www.math.ias.edu/`. An Equal Opportunity/Affirmative Action Employer.

Institute for Mathematics and its Applications (IMA)

General Memberships

Description: The Institute for Mathematics and its Applications at the University of Minnesota announces the availability of general memberships in connection with its 2004–05 thematic program *Mathematics of Materials and Macromolecules: Multiple Scales, Disorder, and Singularities.* General memberships provide an excellent opportunity for mathematicians and scientists employed elsewhere to spend a period of one month to one year in residence at the IMA and to participate in the 2004–05 thematic program. The program runs from September 2004 through June 2005, and the residency period should fall between June 1, 2004, and August 31, 2005. IMA members are provided with an excellent and extremely stimulating research environment within a large community of researchers.
Eligibility: Candidates must be recipients of a doctoral degree and have research interests related to the thematic program. Preference will be given to supplementary support for persons with sabbatical leaves, fellowships, or other stipends.
Grant amount: Local expenses and travel costs may be requested.
Deadline: Applications will be accepted continuously through the end of the program or until funds are exhausted.
Application information: Application forms and instructions are available at `http://www.ima.umn.edu/docs/genmemap.html`. The IMA website is `http://www.ima.umn.edu`. Questions should be directed to `applications@ima.umn.edu` or by phone to 612-624-6066. The University of Minnesota is an Equal Opportunity Educator and Employer.

Institute for Mathematics and its Applications (IMA)

Industrial Postdoctoral Memberships

Description: The Institute for Mathematics and its Applications at the University of Minnesota announces the availability of several industrial postdoctoral memberships. IMA industrial postdoctoral positions are funded jointly by the IMA and an industrial sponsor, and holders devote 50% effort to their own research and the IMA program and 50% effort working with industrial scientists. Industrial postdoctoral memberships run one or two years at the option of the holder, starting September 1, 2004. The 2004–05 thematic program at the IMA is *Mathematics of Materials and Macromolecules: Multiple Scales, Disorder, and Singularities*, and the 2005–06 program is *Imaging.* Industrial Postdoctoral positions are designed to prepare mathematicians for research careers in industry or involving industrial interaction.
Eligibility: Candidates must have completed the Ph.D. in mathematics or a related area by the start of the appointment and within the last three years.
Grant amount: The annual salary for 2004 will be approximately $45,000, and a travel stipend will be furnished.
Deadline: January 15, 2004.
Application information: Application forms and instructions are available at `http://www.ima.umn.edu/docs/postdocapp.html`. The IMA website is `http://www.ima.umn.edu`. Questions should be directed to `applications@ima.umn.edu` or by phone to 612-624-6066. The University of Minnesota is an Equal Opportunity Educator and Employer.

Institute for Mathematics and its Applications (IMA)

New Directions Visiting Professorships

Description: The IMA invites applications by established mathematicians for two Visiting Professorships for a period of 9 to 12 months, including the 2004–05 thematic program *Mathematics of Materials and Macromolecules: Multiple Scales, Disorder, and Singularities* (`http://www.ima.umn.edu/matter`), which runs from September 2004 through June 2005. Visiting Professors will enjoy an excellent research environment and stimulating scientific program with broad mathematical connections, including partial differential equations, probability and statistics, topology and geometry, dynamical systems, representation theory, and scientific computation. New Directions Visiting Professors are expected to be resident and active participants in the program but are not assigned formal duties.
Eligibility: Established mathematical scientists with permanent university employment.
Grant amount: The New Directions program will supply 50% of faculty salary up to $45,000 maximum. The

Visiting Professor's home institution must commit to providing a minimum of 50% of academic year salary and all health and other relevant fringe benefits.
Deadline: April 15, 2004.
Application information: Application forms and instructions are available at http://www.ima.umn.edu/docs/newdirapp.html. The IMA website is http://www.ima.umn.edu. Questions should be directed to ndprof@ima.umn.edu or by phone to 612-624-6066. The University of Minnesota is an Equal Opportunity Educator and Employer.

Institute for Mathematics and its Applications (IMA)

Postdoctoral Memberships

Description: The Institute for Mathematics and its Applications at the University of Minnesota announces the availability of postdoctoral memberships in connection with its 2004–05 thematic program *Mathematics of Materials and Macromolecules: Multiple Scales, Disorder, and Singularities.* Postdoctoral memberships provide an excellent opportunity for mathematical scientists near the beginning of their career who have a background in and/or an interest in learning about materials science and its mathematical underpinnings. IMA postdoctoral memberships run one to two years, at the option of the holder, starting September 1, 2004. In the second year of the appointment there are a variety of options to enhance career development, including teaching, working on an industrial project, and participation in the 2005–06 academic year program *Imaging.*
Eligibility: Candidates must have completed the Ph.D. in mathematics or a related area by the start of the appointment and within the last three years.
Grant amount: The annual salary for 2004 will be approximately $45,000, and a travel stipend will be furnished.
Deadline: January 15, 2004.
Application information: Application forms and instructions are available at http://www.ima.umn.edu/docs/postdocapp.html. The IMA website is http://www.ima.umn.edu. Questions should be directed to applications@ima.umn.edu or by phone to 612-624-6066. The University of Minnesota is an Equal Opportunity Educator and Employer.

Los Alamos National Laboratory

Postdoctoral Appointments and Fellowships

Description: Research opportunities are granted in many areas of chemistry, mathematics, computer science, materials science, biological sciences, environmental science, geoscience, and many engineering fields. Appointments are available for two years, subject to renewal for a third year. A postdoctoral committee meets to review candidates for postdoctoral fellowships in February, May, August, and December.
Eligibility: Candidates must be recipients of a doctoral degree within the past five years.
Grant amount: Starting salary: $59,300–$67,300.
Application information: Los Alamos National Laboratory is an Equal Opportunity Employer. For more information: email: postdoc-info@lanl.gov; tel: 505-667-0872; fax: 505-665-4562; see details and apply online at: http://www.hr.lanl.gov/postdoc/.

Los Alamos National Laboratory

J. Robert Oppenheimer, Richard P. Feynman, and Frederick Reines Distinguished Fellowships

Description: Research opportunities are granted in many areas of chemistry, mathematics, computer science, materials science, biological sciences, environmental science, geoscience, and many engineering fields. Appointments are for three years.
Eligibility: Candidates must be recipients of a doctoral degree within the past five years and must show clear and definite promise of becoming outstanding leaders in scientific research.
Grant amount: Starting salary: $91,000.
Deadline: Submission deadline for sponsored candidates: mid-October each year.
Application information: Los Alamos National Laboratory is an Equal Opportunity Employer. See details and apply online at: http://www.hr.lanl.gov/postdoc/.

Mathematical Sciences Research Institute (MSRI)

General Memberships

Description: The Institute will invite an undetermined number of general members for stays of 1 month or more during 2004–05, when three half-year programs will be featured: *Hyperplane Arrangements and Applications* (August 16 to December 17, 2004); *Probability, Algorithms and Statistical Physics* (January 3 to May 13, 2005); and *Mathematical, Computational and Statistical Aspects of Image Analysis* (January 3 to May 13, 2005). Some invitations will be made in other areas, so applications from candidates in all fields are welcome.
Eligibility: For mathematicians postdoctoral and above.
Grant amount: While there is no stipend for general members, MSRI may offer partial expense reimbursement of up to $2,340/month and may offer travel expense reimbursement. General members are expected to visit with at least some outside financial support.
Deadline: Files must be complete by November 14, 2003.
Application information: Please complete online application form at: http://www.msri.org/applications/applying/.

Mathematical Sciences Research Institute (MSRI)

Microsoft Research Postdoctoral Grant

Description: The Mathematical Sciences Research Institute announces the availability of a postdoctoral fellowhip combined with an internship at Microsoft Research in Redmond, Washington. Because of the variety

of mathematical work done at Microsoft Research, no particular fields of mathematics have been specified. However, an essential prerequisite is a strong interest in the applications of mathematics as well as in the research environment at MSRI. This postdoctoral fellowship is normally a two-year award, with the recipient spending one year at MSRI and the second year at Microsoft Research.
Eligibility: For new and recent Ph.D.'s (Ph.D. earned in 1999 or later). Applicants should apply through the usual process for MSRI Postdoctoral Fellowships, indicating their interest in this internship/fellowship and adding relevant documentation. Applications indicating interest in this program will be reviewed by Microsoft Research as well as by MSRI.
Deadline: Files must be completed by November 14, 2003.
Application information: Please complete online application form at: `http://www.msri.org/applications/applying/`.

Mathematical Sciences Research Institute (MSRI)

Postdoctoral Fellowships

Description: The Institute will award about 18 postdoctoral fellowships during 2004–05, when three half-year programs will be featured: *Hyperplane Arrangements and Applications* (August 16 to December 17, 2004); *Probability, Algorithms and Statistical Physics* (January 3 to May 13, 2005); and *Mathematical, Computational and Statistical Aspects of Image Analysis* (January 3 to May 13, 2005). Some awards will be made in other areas, so applications from candidates in all fields are welcome.
Eligibility: For new and recent Ph.D.'s (Ph.D. earned in 1999 or later).
Grant amount: The stipend will be $3,500/month for 5 months for each semester program.
Deadline: Files must be complete by November 14, 2003.
Application information: Please complete online application form at: `http://www.msri.org/applications/applying/`.

Mathematical Sciences Research Institute (MSRI)

Research Professorships

Description: The Institute will award about ten research professorships for stays of 3 months or more during 2004–05, when three half-year programs will be featured: *Hyperplane Arrangements and Applications* (August 16 to December 17, 2004); *Probability, Algorithms and Statistical Physics* (January 3 to May 13, 2005); and *Mathematical, Computational and Statistical Aspects of Image Analysis* (January 3 to May 13, 2005). Some awards will be made in other areas, so applications from candidates in all fields are welcome.
Eligibility: For midcareer mathematicians (Ph.D. earned in 1998 or earlier).
Grant amount: The stipend will be limited to a ceiling of $25,000 (for 5 months) and normally will not exceed half the applicant's salary.
Deadline: Files must be complete by September 26, 2003.
Application information: Please complete online application form at: `http://www.msri.org/applications/applying/`.

The Michigan Society of Fellows

Horace H. Rackham School of Graduate Studies, The University of Michigan

Description: The Michigan Society of Fellows was founded in 1970 through grants from the Ford Foundation and Horace H. Rackham Graduate School for the purpose of promoting academic and creative excellence in the arts, sciences, and professions. The objective of the program is to support individuals selected for outstanding achievement, professional promise, and interdisciplinary interests. We invite applications from qualified candidates for three-year postdoctoral fellowships at the University of Michigan. Fellows are appointed as assistant professors/postdoctoral scholars with departmental affiliations. They spend the equivalent of one academic year teaching; the balance of time is devoted to their own scholarly research and creative work. Applications will be screened by faculty in relevant University of Michigan departments. Final selections will be made by the senior fellows of the society. New fellows will be selected for three-year terms beginning September 2004.
Eligibility: Candidates must have received the Ph.D. degree between June 1, 2001, and September 1, 2004.
Grant amount: The annual stipend will be $44,558.
Deadline: Completed applications due October 3, 2003.
Application information: Please see the application on our website or send requests for application materials to: Michigan Society of Fellows, 3572 Rackham Building, University of Michigan, 915 E. Washington St., Ann Arbor, MI 48109-1070; tel: 734-763-1259; email: `society.of.fellows@umich.edu`; Web: `http://www.rackham.umich.edu/Faculty/society.html`.

Michigan State University

MSU Postdoctoral Instructorships

Description: Several three-year positions will be available beginning fall 2003 for new or recent Ph.D.'s who show strong promise in research and teaching. The teaching load is four semester courses per year, and participation in the research activities of the department is expected.
Grant amount: A starting salary of $40,000 per year. Additional income from summer teaching is usually available if desired.
Deadline: Completed applications (including letters of recommendation) received by November 15, 2003, are assured of consideration.
Application information: An applicant should send a vita as well as a brief statement of research interests and arrange for at least four letters of recommendation to be sent, one of which must specifically comment on

the applicant's ability to teach. Application via email is strongly encouraged. To receive an electronic application and information, send an email to: jobs@math.msu.edu with the message "send application info". Application materials can also be mailed to The Hiring Committee, Department of Mathematics, Michigan State University, East Lansing, MI 48824-1027. Application should be made as soon as possible. Women and minorities are strongly encouraged to apply. MSU is an Affirmative Action/Equal Opportunity Institution.

National Center for Atmospheric Research

Advanced Study Program

Description: Postdoctoral fellowships are offered for highly qualified atmospheric scientists and scientists from related disciplines who wish to continue basic research in the atmospheric sciences. Appointments are for a one-year period with a possible extension for an additional year.
Eligibility: For recent recipients of the Ph.D. with no more than 4 years' experience past their Ph.D.
Grant amount: Stipends are $43,500 and are adjusted annually in June.
Deadline: The application deadline is January 5, 2004.
Application information: Tel: 303-497-1601; email: barbm@ucar.edu; or Barbara Hansford, NCAR, ASP, P. O. Box 3000, Boulder, CO 80307-3000; fax: 303-497-1646.

National Science Foundation

Mathematical Sciences Postdoctoral Research Fellowships (with Research Instructorship Option)

Description: The format of the 2003 Fellowship program has not been changed from that of 2002. The stipend portion of the awards will consist of support for eighteen academic-year months or their equivalent and six summer months. Awardees have two options for academic year stipends, subject to the constraints that their academic-year support begin by October 1 of the award year and be configured in intervals no shorter than three consecutive months. An awardee may have full-time support for any eighteen academic-year months in a 3-year period (the Research Fellowship Option) or have a combination of full-time and half-time support over a period of three academic years, usually as one academic year full-time and two academic years half-time (the Research Instructorship Option). Summer month stipends are limited to two per calendar year.
Grant amount: Stipend amounts are $4,000 per full-time month and $2,000 per half-time month, plus institutional and special allowances, for a total award of $108,000 to be used within 48 months.
Deadline: Deadline for applications is October 17, 2003; applicants will be notified of decisions on or about March 1, 2004.
Application information: For further details write to the Mathematical Sciences Infrastructure Program, Division of Mathematical Sciences, Room 1025, National Science Foundation, 4201 Wilson Boulevard, Arlington, VA 22230; call 703-306-1870; send an inquiry to email: msprf@nsf.gov; or under "Postdoctoral Fellowships" at http://www.fastlane.nsf.gov/.

National Security Agency

Grants Program

Description: Standard research proposals designed principally to provide summer salary for professors and limited support for their graduate students in areas of interest listed below. The National Security Agency (NSA) awards grants to universities in support of self-directed research in the following areas of the mathematical sciences (including possible computational aspects): algebra, number theory, discrete mathematics, probability, and statistics. The NSA also accepts proposals for small grants for conferences, workshops, and special academic endeavors.
Deadline: October 15 each year for all grant and conference proposals. Grants awarded from this funding can expect to incur expenses in the fall of the following year.
Application information: For further information about the program, please call 301-688-0400. All correspondence should be addressed to: Dr. Charles F. Osgood, Director, Mathematical Sciences Program, National Science Agency, Suite 6557, Ft. George G. Meade, MD 20755-6557. Queries can also be made by email to msp@math.umbc.edu.

National Security Agency

Sabbatical Program

Description: The National Security Agency (NSA) has a program supporting sabbaticals for academic mathematical scientists to visit the NSA, usually from 9 to 24 months.
Eligibility: American citizenship for the applicant and all immediate family members is required. Because a complete background investigation is required, applications should be submitted as soon as possible.
Grant amount: (Compensation) A supplement to the university's stipend to bring the visitor's salary up to his or her regular monthly salary and a choice of either an allowance for moving expenses or a housing supplement.
Application information: For further information on the sabbatical program, contact: Dr. Charles F. Osgood, Director, Mathematical Sciences Program, National Security Agency, Suite 6557, Ft. George G. Meade, MD 20755-6557; tel: 301-688-0400; email: msp@math.umbc.edu.

Radcliffe Institute Fellowship Program

Description: The Radcliffe Institute for Advanced Study is a scholarly community where individuals pursue advanced work across a wide range of academic disciplines, professions, or creative arts. Within this broad purpose, and in recognition of Radcliffe's historic contributions to the education of women, the Radcliffe Institute sustains

a continuing commitment to the study of women, gender, and society.
Eligibility: Radcliffe Institute Fellowships are designed to support scholars, scientists, artists, or writers of exceptional promise and demonstrated accomplishment who wish to pursue independent work in academic and professional fields and in the creative arts. Applications are judged on the quality and significance of the proposed project and on the applicant's record of accomplishment and promise. Women and men from across the United States and throughout the world, including developing countries, are encouraged to apply. Proposals are accepted from applicants in any field with the receipt of a doctorate or appropriate terminal degree at least two years prior to appointment or with comparable professional achievement in the area of the proposed project.
Grant amount: Stipends are funded up to $50,000 for one year, with additional funds for project expenses.
Deadline: Applications must be postmarked by October 1, 2003.
Application information: For more information visit http://www.radcliffe.edu/. Write, call, or e-mail for an application: Application Office, 34 Concord Avenue, Cambridge, MA 02138; tel: 617-496-1324; fax: 617-495-8136; or e-mail: fellowships@radcliffe.edu.

Rice University

Griffith Conrad Evans Instructorships

Description: Postdoctoral appointments for two to three years for promising research mathematicians with research interests in common with the active research areas at Rice. Rice University encourages applications from women and minority group members.
Deadline: Applications received by December 31, 2003, will receive thorough consideration.
Application information: Inquiries and applications should be addressed to: Chairman, Evans Committee, Department of Mathematics, Rice University, 6100 Main St.-MS 136, Houston, TX 77005.

Sloan Foundation

Research Fellowships

Description: Unrestricted grants made to selected university scientists in chemistry, physics, mathematics, computer science, economics, neuroscience or computational and evolutionary molecular biology, or in a related interdisciplinary field. Candidates do not apply, but are nominated by their department chairmen or other senior scientists.
Eligibility: Candidates must be members of the regular (i.e., tenure-track) faculty, though not necessarily in a tenured position, at a recognized college or university in the United States or Canada.
Deadline: Nominations are due by September 15 for awards to begin the following September.
Application information: For information write to the Sloan Research Fellowships, Alfred P. Sloan Foundation, Suite 2550, 630 Fifth Ave., New York, NY 10111; email: teitelbaum@sloan.org; Web: http://www.sloan.org/.

Trinity College

Harold L. Dorwart Visiting Assistant Professorship

Description: The Department of Mathematics solicits applications for the fifth Harold L. Dorwart Visiting Assistant Professorship. This three-year, nonrenewable position offers a competitive salary and monetary support for research-related travel. The normal teaching load is five semester courses per year ("3/2"), one of which is a research seminar to be taught with a senior member of the faculty.
Eligibility: We are seeking applicants with a Ph.D. in mathematics and a specialization in classical harmonic analysis or the application of harmonic analysis to the study of PDEs. Anticipated fields in future years include complex analysis, graph theory, and functional analysis.
Deadline: There is no closing date for applications; however, the department will begin to read applications in early December, and those completed by December 1, 2003, will be assured full consideration.
Application information: Please send a letter of application; curriculum vitae; a statement of teaching philosophy; and three letters of reference, one of which addresses teaching, to: Search Committee, Department of Mathematics, Trinity College, 300 Summit Street, Hartford, CT 06106. Be sure to include email contact information. Representatives of the Search Committee will be at the Joint Mathematics Meetings in Phoenix, Arizona, to participate in the Employment Center. Trinity College is an Affirmative Action/Equal Opportunity Employer. Women and members of minority groups are encouraged to apply. Applicants with disabilities should request in writing any needed accommodations in order to participate more fully in the application process.

University of Michigan, Ann Arbor

Assistant Professorships, VIGRE Assistant Professorships, and T. H. Hildebrandt Research Assistant Professorships

Description: These positions for up to three years are designed to provide mathematicians with favorable circumstances for academic career development in research and teaching. Assistant professorships have a teaching responsibility of two courses per semester; the VIGRE and T. H. Hildebrandt positions have a responsibility of one course per semester. These positions may be combined with other postdoctoral fellowships, giving additional reductions in teaching responsibility.
Eligibility: Preference is given to candidates who receive the Ph.D. degree in 2002 or later and who submit a completed application by December 15, 2003.
Grant amount: Salary is competitive, and there are opportunities for supplemental summer salary.
Application information: Application forms and further important information are available at http://www.math.lsa.umich.edu/information/positions.shtml;

by e-mail at math.chair@math.lsa.umich.edu; or by mail to: Hiring Committee, Department of Mathematics, University of Michigan, 2074 East Hall, 525 E. University, Ann Arbor, MI 48109-1109.

University of Wisconsin-Madison

Van Vleck Assistant Professorship

Description: The Department of Mathematics invites applications for possible Van Vleck assistant professorships to begin on August 23, 2004. Appointments are for a fixed term of two or three years. The usual teaching load is two courses per semester.
Eligibility: Ordinarily only those applicants who have received their doctorates since 2001 will be considered. Promise of excellence in research and teaching is important. Preference will be given to candidates who are likely to interact well with other members of the department.
Deadline: The application deadline is December 15, 2003, although applications will continue to be considered until all available positions are filled.
Application information: Applicants should send a completed AMS Standard Cover Sheet, a curriculum vitae that includes a publication list, and a brief statement of research plans to: Hiring Committee, Dept. of Mathematics, Van Vleck Hall, University of Wisconsin-Madison, 480 Lincoln Drive, Madison, WI 53706-1388. Applicants should also arrange to have three or four letters of recommendation sent to the above address. At least one of these letters must discuss the applicant's teaching experience and capabilities. Other evidence of good teaching will be helpful. The University of Wisconsin is an Affirmative Action/Equal Opportunity Employer and encourages applications from women and minorities.
Note: The department also expects to have available one or more VIGRE Van Vleck assistant professorships, partially funded by an NSF VIGRE grant, with a reduced teaching load; only U.S. citizens and permanent residents are eligible for these.

Yale University

Josiah Willard Gibbs Instructorships/Assistant Professorships

Description: Offered to men and women with the doctorate who show definite promise in research in pure mathematics. Applications from women and members of minority groups are welcome. Appointments are for two/three years. The teaching load is kept light to allow ample time for research. This will consist of 3 one-semester courses. Part of the teaching duties over the term of the appointment may consist of a one-semester course at the graduate level in the general area of the instructor's research.
Grant amount: The 2004–05 salary will be at least $52,800.
Deadline: January 1, 2004.
Application information: Applications are available at http://www.math.yale.edu/. Inquiries and application supporting documents should be sent to the Gibbs Committee, Department of Mathematics, Yale University, via email: gibbs.committee@math.yale.edu. Yale University is an Affirmative Action/Equal Opportunity Employer.

Travel and Study Abroad

Alexander von Humboldt Foundation

Research Fellowships

Description: The Humboldt Foundation grants up to 600 Humboldt Research Fellowships annually to highly qualified scholars under the age of 40 holding doctorates, enabling them to undertake long-term periods of research (6–12 months) in Germany. Applications are decided upon by a selection committee which is composed of eminent German scholars from all disciplines. Candidates' academic attainments are the only criterion for selection; there are no limitations in respect to specific countries or subjects.
Eligibility: Application requirements include high academic qualifications, academic publications, a specific research plan, and for humanities scholars a good command of the German language. As part of the Humboldt Research Fellowship Program, U.S. citizens and residents from all disciplines may also apply for these variations: Summer Research Fellowship for U.S. Scientists and Scholars (3 months per year in 3 consecutive years), http://www.humboldt-foundation.de/en/programme/stip_aus/tshp2.htm; 2-year Post-Doctoral Fellowship for U.S. Scientists and Scholars (24 consecutive months), http://www.humboldt-foundation.de/en/programme/stip_aus/tshp1.htm.
Grant amount: Monthly stipends range from 2,100 to 3,000 euros. Family allowances, travel expenses, and language courses are covered by the fellowship.
Deadline: Applications may be submitted at any time; however, the actual selection committees meet in March, July, and November. Applications should be submitted 5 months before the meeting at which the candidate wishes to be considered.
Application information: Interested scholars may contact the Alexander von Humboldt Foundation, Jean-Paul-Str. 12, D-53173 Bonn, Germany; tel: +49-228-833-0; fax: +49-228-833-212; email: select@avh.de; homepage: http://www.humboldt-foundation.de; or, U.S. Liaison Office, 1012–14th Street, NW, Suite 1015, Washington, DC 20005; tel: 202-783-1907; fax: 202-783-1908; email: avh@bellatlantic.net.

Fulbright Teacher & Administrator Exchange Program

Description: Sponsored by the United States Department of State, this program offers international exchange

opportunities for two-year college faculty members and elementary and secondary school teachers and administrators. Currently the program conducts exchanges with over 30 countries in Eastern and Western Europe, Latin America, Africa, and Canada. (The list of countries is subject to change.) Most exchanges are for the full academic year; however, some are for a semester or six weeks. In most cases both the U.S. and international teacher remain on the payroll of their respective home institutions. The Fulbright Teacher & Administrator Exchange Program also offers six- to eight-week summer seminars in Italy and Greece which are open to four-year and two-year college faculty and teachers (grades 9–12) of Latin, Greek, and the Classics.

Eligibility: Eligibility requirements are U.S. citizenship, fluency in English, a bachelor's degree or higher, three years' full-time teaching/administrative experience, a current full-time teaching/administrative position, approval of school administration, and no participation in a Fulbright Program longer than eight weeks in the last two years. In addition to the general eligibility requirements, each applicant must meet the specific subject, level, and language fluency requirements for the countries to which he/she applies; these requirements are detailed in the application booklet.

Deadline: The application deadline is October 15 for the following year's program.

Application information: The application booklet should be requested from the Fulbright Teacher Exchange Program, 600 Maryland Ave., SW, Room 320, Washington, DC 20024-2520; tel: 800-726-0479.

Marshall Scholarships

Description: Marshall Scholarships finance young Americans of high ability to study for a degree in the United Kingdom. The scholarships are tenable at any British university and cover two years of study in any discipline, at either undergraduate or graduate level, leading to the award of a British university degree.

Eligibility: Open only to United States citizens who (by the time they take up their scholarship) hold a first degree from an accredited four-year college or university in the United States with a minimum GPA (after freshman year) of 3.7. To qualify for awards tenable from October 2004, candidates must have graduated from their undergraduate college or university after April 2001 (although this restriction may be waived in the case of those wishing to read business studies or an allied subject). N.B. Persons already studying for or holding a British degree or degree-equivalent qualification are **not** eligible to apply for a Marshall Scholarship.

Deadline: October 7 (postmarked), to commence the following September.

Application information: Apply through British Consulates General in the following regions: Atlanta, 404-954-7708; Boston, 617-245-4513; Chicago, 312-346-1810; Houston, 713-659-6270; Los Angeles, 310-996-3028; New York, 212-745-0252; San Francisco, 415-617-1300; Washington, DC, 202-588-7854.

National Academy of Sciences (NAS)

Collaboration in Basic Science and Engineering (COBASE)

Description: The NAS invites applications from American scientists who wish to visit or to host foreign scientists from Armenia, Azerbaijan, Bosnia (hosting only), Bulgaria, Croatia, Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, former Yugoslav Republic of Macedonia, Moldova, Poland, Romania, Russia, Serbia and Montenegro (hosting only), Slovakia, Slovenia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan. The grants will support travel in either or both directions for up to 8 weeks in total duration. Applicants for the visits need to demonstrate that a joint proposal for collaborative research will be prepared during their visits for submission to the National Science Foundation for funding.

Eligibility: Applicants must be U.S. citizens or permanent residents and have doctoral degrees or their equivalent. Acceptable topics include physics; chemistry; mathematics and computer sciences; earth, atmospheric, and oceanographic sciences; biological sciences; environmental sciences; engineering; archaeology and anthropology; economics; linguistics; or the history and philosophy of science. Young investigators within 10 years of receipt of the Ph.D. receive special consideration. In addition, special emphasis is placed on the following topics for 2003: (1) social sciences, (2) any projects involving collaboration with the former Soviet countries of Central Asia.

Application information: Email: `ocee@nas.edu`; tel: 202-334-2644; Web: `http://www7.nationalacademies.org/dsc/OCEE_Grants_Index.html`.

U.S. Department of State Fulbright U.S. Student Program

Fulbright and Related Grants for Graduate Study and Research Abroad

Description: For graduate study or research in any field in which the project can be profitably undertaken abroad. If an applicant is already enrolled in a U.S. university, he must apply directly to the Fulbright Program adviser on his campus. Unenrolled students may apply to the Institute of International Education.

Eligibility: Applicant must be a U.S. citizen, hold a B.A. degree or the equivalent, and have language proficiency sufficient to carry out the proposed study and to communicate with the host country.

Deadline: Application deadline is October 21.

Application information: Further details may be obtained from the U.S. Department of State Fulbright U.S. Student Program, U.S. Student Programs Division, Institute of International Education, 809 United Nations Plaza, New York, NY 10017; tel: 212-984-5330; website: `http://www.iie.org.fulbright/us`.

Winston Churchill Foundation of the United States

Description: A scholarship program for graduate work in engineering, mathematics, and science at Churchill College, Cambridge University.
Grant amount: Tuition and living allowance worth approximately $27,000, depending upon course of study.
Application information: Application forms are available from representatives on campuses of colleges and universities participating in the program. For further information write to the Winston Churchill Foundation, P. O. Box 1240, Gracie Station, New York, NY 10028; or see foundation homepage, `http://www.thechurchillscholarships.com/`.

Study in the U.S. for Foreign Nationals

Many of the programs in the "Graduate Support" and "Postgraduate Support" sections are also applicable to foreign nationals.

American Association of University Women (AAUW) Educational Foundation

International Fellowships

Description: These are awarded to women of outstanding academic ability who are not citizens or permanent residents of the U.S. for full-time graduate or postgraduate study in the U.S. Six of the 46 awards are available to members of the International Federation of University Women to study in any country other than their own. Upon completion of studies, fellowship recipients are expected to return to their home countries to pursue professional careers. Previous and current recipients of AAUW fellowships are not eligible.
Eligibility: Applicants must hold the equivalent of a U.S. bachelor's degree by December 31.
Grant amount: The fellowships provide $18,000 for master's/first professional degree, $20,000 for predoctoral study, and $30,000 for postdoctoral study.
Deadline: The deadline is December 15 (postmark deadline). *If an application postmark deadline falls on a weekend or holiday, applications may be postmarked the next business day.
Application information: For more information contact: AAUW Educational Foundation, P.O. Box 4030, Iowa City, IA 52243-4030; tel: 319-337-1716; fax: 319-337-1204.

Kennedy Scholarships

Description: These grants are for postgraduate study at Harvard University or the Massachusetts Institute of Technology.
Eligibility: For citizens of the United Kingdom.
Deadline: Application deadline is October 22, 2003.
Application information: Write to Secretary, Kennedy Memorial Trust, 48 Westminster Palace Gardens, Artillery Row, London SWIP 1RR, England.

Sources of Fellowship Information

Some of the publications listed below are available at school or college and university libraries or in the reference room of a good public library.

Financial Aid for Minorities in Engineering and Science

Financial assistance, scholarship and fellowship programs, resources for further information (1999); Garrett Park Press, P. O. Box 190, Garrett Park, MD 20896. $5.95 + $1.50 shipping.

Graduate School and You: A Guide for Prospective Graduate Students

Council of Graduate Schools, Revised Edition, 1999. Available from the Council of Graduate Schools, 1 Dupont Circle, NW, Suite 430, Washington, DC 20036-1173; or call 202-223-3791. This publication is $10 plus S&H. It can be obtained by calling CGS for an order form or downloading order form from website `http://www.cgsnet.org/`.

Pathways to Career Success for Minorities

(2000, 378 pages), Garrett Park Press, Garrett Park, MD 20896. $29.95 plus $3 shipping. Tel: 301-946-2863; fax: 301-949-3955.

Backlog of Mathematics Research Journals

Journal (Print and Electronic)	Number issues per Year	Approximate Number Pages per Year	2002 Median Time (in Months) from: Submission to Final Acceptance	Acceptance to Print	Acceptance to Electronic Posting	Editor's Current Estimate of Waiting Time between Submission and Publication (in Months) Print	Electronic
Abstr. Appl. Anal.	24	1500	6	6	6	10	10
Acta Inform.	9	720	12	2.8	2.8	12	12
Acta Math.	4	600	10	15	NR	16	16
Aequationes Math.	6	640	12	12	12	14	14
Algorithmica	12	1100	24	7.25	6.25	25	5
Amer. J. Math.	6	1200	NR	8.42	7.42	14	13
Ann. Appl. Prob.	4	1500	10	10	NA	17	8
Ann. Mat. Pura Appl.	4	512	12.1	24.2	11.6	12	24
Ann. Sci. Ecole Norm. Sup.	NR	NR	NR	NR	NR	NR	NR
Ann. Statist.	6	1800	14	8	8	22	22
Anziam J.	5	849	8.84	21.87	.82	20	12
Appl. Math. Lett.	12	1560	6	5	3	9	8
Appl. Math. Optim.	6	650	23	6.6	4.9	23	21
Arch. Hist. Exact Scis.	6	480	6	5.5	5.5	6.5	6.5
Arch. Math. Logic	8	800	20	13	10	20	15
Arch. Rational Mech. Anal.	20	1800	NR	8	6	NR	NR
Balkan J. Geom. Appl.	2	250–300	3	6	7	6	7
Bull. London Math. Soc.	6	864	6	12	12.5	14	14.5
Bull. Soc. Math. France	4	620	5	10	8	6	8
Calc. Var. Partial Diff. Equations	12	1345	6.6	12	4.3	13	11.4
Canad. J. Math.	6	1500	3–6	6–15	3–6	6–15	6
Canad. Math. Bull.	6	1536	NA	NA	NA	NA	NA
Combinatorica	4	680	6	15	12	18	12
Comm. Algebra	12	5300	19	13	12	17	16
Comm. Math. Phys.	27	5800	5	2.5*	1.5*	3.5	2.5
Comm. Partial Diff. Equations	6	2200	8	6	4	12	6
Comm. Pure Appl. Anal.	4	600	3	5	2	8	5
Comput. Math. Appl.	24	4100	6	5	4	10	9
Computing	8	768	14.7	5.4	5	12	11
Constr. Approx.	4	155	8	6	3	10	7
Discrete Comput. Geom.	8	1280	8	9	8	13	12
Discrete Contin. Dyn. Syst.	10	1600	4	6	4	10	8
Discrete Contin. Dyn. Syst. Ser. B	4	600	3	5	3	8	6
Duke Math. J.	15	600	18	11	11	18	18
Found. Comp. Math.	4	440	15.3	7.7	2.1	14	8
Graphs Combin.	4	600	18	10	10	12	12
Houston J. Math.	4	950	10	15	13	20	18
Illinois J. Math.	4	1400	5	11	9	14	12
IMA J. Appl. Math.	6	624	NR	5	4.5	NR	NR
IMA J. Math. Control Inform.	4	500	5	8	3	7	4
IMA J. Numer. Anal.	4	720	11	6	6	16	16
Indiana Univ. Math. J.	6	1500–1600	4	9	8	9	8
Inst. Hautes Études Sci. Publ. Math.	2	500	3	6	3	3	3
Internat. J. Math. Math. Sci.	72	4500	4	4	4	8	8
Internat. Math. Res. Not.	80	4500	3	2	2	4	4
Invent. Math.	12	2736	10	6.8	3.6	15	16.5
J. Algebraic Geometry	4	800	8	12	6	16	20
J. Algorithms	8	1580	17	3	1	NA	NA
J. Amer. Math. Soc.	4	1000	13.4	4.1	1.5	14.8	12

Journal (Print and Electronic)	Number issues per Year	Approximate Number Pages per Year	2002 Median Time (in Months) from: Submission to Final Acceptance	Acceptance to Print	Acceptance to Electronic Posting	Editor's Current Estimate of Waiting Time between Submission and Publication (in Months) Print	Electronic
J. Appl. Math.	12	650	6	4	4	8	8
J. Assoc. Comput. Mach.	6	1100	19	4-5	few days	18	14
J. Classification	2	320-384	10	5	5	12	12
J. Comput. System Sci.	6	1800	9	3	3	16	NR
J. Cryptology	4	300	6	6	6	12	12
J. Differential Geom.	NR	NR	NR	NR	NR	NR	NR
J. Engrg. Math.	12	1200	6	1.5	.75	6	5
J. Eur. Math. Soc.	4	396	7.8	11.6	1.8	22	12.5
J. Lie Theory	2	620	5	7	5	12	10
J. London Math. Soc.	6	1632	6.5	8	9	13	13.5
J. Math. Biol.	12	1152	10.8	6.8	4.7	15.1	12.3
J. Math. Phys.	NR	NR	NR	NR	NR	NR	NR
J. Symbolic Logic	4	1400	11	10	NA	15	12
Linear Algebra Appl.	18	5400	12	8	6	12	12
Manuscripta Math.	12	1632	7.7	6.6	3.2	13.6	10.2
Math. Ann.	12	2496	13.1	7.3	4.2	9.7	13
Math. Biosci.	12	1200	10	3-4	3	12	11-12
Math. Comp.	4	2000	12.7	16.8	8.9	28.2	19.6
Math. Comput. Modelling	24	3500	6	5	3	9	8
Math. Control Signals Systems	4	381	16	7	5	23	20
Math. Oper. Res.	4	860	20	6	4	18	16
Math. Programming	9	1648	21.6	7.3	7	21.5	19.5
Math. Social Sci.	6	750	13	7	7	18	18
Math. Z.	12	2650	13.5	9	4.6	17.2	16.5
Michigan Math. J.	3	672	6	11	10	12	12
Monatsh. Math.	12	1058	7-8	6	6	12	11
New York J. Math.	1	300	5	3	.3	6-18	6
Nonlinear Anal.	36	3600	18	9	6	6	4
Numer. Funct. Anal. Optim.	8	1000	6	5	5	10	9
Numer. Math.	12	2400	13	12.7	11.3	20	15.6
Oper. Res.	6	1000	14	12	12	14	14
Pacific J. Math.	10	2000	8-10	14-16	NR	14-16	NR
Probab. Theor. Relat. Fields	12	1824	11	8.9	6.4	15.7	12.2
Proc. Amer. Math. Soc.	12	3720	5.4	14.1	9.1	20.2	13.8
Proc. London Math. Soc.	6	1632	8	11	11	19	19
Quart. J. Math.	4	512	8	5	5	10	10
Quart. J. Mech. Appl. Math.	4	650	5	6	6	12	12
Reliab. Comput.	6	510	7	8	7	12	11
Rocky Mountain J. Math.	4	1600	7	18	17	26	25
Semigroup Forum	6	960	10	8	2	18	12
SIAM J. Appl. Math.	6	2200	10.8	9.89	5.29	18	12
SIAM J. Comput.	6	1980	16.09	7.59	4.6	16	13
SIAM J. Control Optim.	6	1980	14.7	14.25	6.09	22	12
SIAM J. Discrete Math.	4	680	22.53	4.14	1.84	20	16
SIAM J. Math. Anal.	6	1500	9.54	10.23	5.29	17	12
SIAM J. Matrix Anal. Appl.	4	1200	11.49	10.8	5.06	17	12
SIAM J. Numer. Anal.	6	2200	12.41	15.4	5.75	24	14
SIAM J. Optim.	4	1150	12.87	13.33	5.98	22	15
SIAM J. Sci. Comput.	6	2200	12.07	12.41	5.52	20	15
SIAM Rev.	4	800	9.29	6.03	4.75	14	12
Smarandache Notions J.	1	350	1	5-6	1	5-6	1
Theory Comput. Syst.	6	650	10	7	5	17	15
Topology	6	1300	10	20	12	24	18
Topology Appl.	27	5000	9	9	5	12	12
Trans. Amer. Math Soc.	12	5000	8.3	6	3.3	13.6	10.5

Journal (Print)	Number issues per Year	Approximate Number Pages per Year	2002 Median Time (in Months) from: Submission to Final Acceptance	2002 Median Time (in Months) from: Acceptance to Final Publication	Editor's Current Estimate of Waiting Time between Submission and Publication (in Months)
Algebras Groups Geom.	4	550	2	2	2
Ann. of Math.	6	2000	12	12	12
Bull. Austral. Math. Soc.	6	1056	6	10	9
Circuits Systems Signal Proc.	6	720	10	5	14
Indag. Math.	4	550	3	6	9
Israel J. Math.	6	2280	6	11	12
J. Amer. Statist. Assoc.	4	1228**	10	10	15–20
J. Appl. Math. Stochastic Anal.	4	420	12	8	10
J. Austral. Math. Soc.	6	860	26	15	23
J. Complexity	6	1000	8	9	14
J. Geom. Anal.	4	720	8	12	12
J. Integral Equations Appl.	4	500	6	8	14
J. Operator Theory	5***	1100***	9.7	24	24
J. Theoret. Probab.	4	1000	12 or less	6	18
Linear Multilinear Algebra	4	432	8	8	16
Math. Res. Let.	6	830	5.3	2.6	7.5
Mem. Amer. Math. Soc.	6	3200	12.9	16.1	19.3
Methods Appl. Anal.	4	800	3–6	2–6	7–8
Quart. Appl. Math.	4	800	10.4	12.3	32.1
Results Math.	4	800	10	3	9

Journal (Electronic)	Number of Articles Posted in 2002	2002 Median Time (in days) from: Submission to Final Acceptance	2002 Median Time (in days) from: Acceptance to Posting	Format(s)
Acta Math. Acad. Paedagog. Nyházi. (www.emis.de/journals/AMAPN)	13	162	99	pdf, ps
Algebr. Geom. Topol. (www.maths.warwick.ac.uk/agt/index.html)	47	134	10	pdf, ps
Algebra Montpellier Announcements (www.emis.ams.org/journals/AMA/)	2	60	20	pdf, ps, dvi
Appl. Sci. (www.mathem.pub.ro/apps)	5	30	90	pdf, ps, dvi
Cent. Eur. J. Math. (www.cesj.com/mathematics.html)	NA	NA	NA	html, tex, other
Chicago J. Theoret. Comp. Sci. (www.cs.uchicago.edu/publications/cjtcs/)	NR	NR	NR	NR
Conform. Geom. Dyn. (www.ams.org/ecgd)	4	256	42	pdf, ps, dvi, tex
Diff. Eq. Contr. Process (www.neva.ru/journal)	19	21	7	html, pdf, tex
Differ. Geom. Dyn. Syst. (www.mathem.pub.ro/dgds)	5	30	90	pdf, ps, dvi
Discrete Math. Theor. Comput. Sci. (dmtcs.loria.fr/)	15	180	10	pdf, ps
Doc. Math. (www.mathematik.uni-bielefeld.de/documenta/)	20	158	13	pdf, ps, dvi
Electron. Comm. Probab. (www.math.washington.edu/~ejpecp/)	22	133	77	html, pdf, ps, dvi
Electron. J. Combin. (www.combinatorics.org)	61	172	18	pdf, ps
Electron. J. Differential Equations (ejde.math.unt.edu; ejde.math.swt.edu)	103	102	8	pdf, ps, dvi, tex

Journal (Electronic)	Number of Articles Posted in 2002	2002 Median Time (in days) from: Submission to Final Acceptance	2002 Median Time (in days) from: Acceptance to Posting	Format(s)
Electron. J. Linear Algebra (www.math.technion.ac.il/iic/ela/)	24	111	22	pdf, ps, tex, other
Electron. J. Probab. (www.math.washington.edu/~ejpecp/)	23	193	117	html, pdf, ps, dvi
Electron. J. Qual. Theory Differ. Equ. (www.math.u-szeged.hu/ejqtde/)	18	180	10	pdf, ps, dvi
Electron. Res. Announc. Amer. Math. Soc. (www.ams.org/era)	6	99	18	pdf, ps, dvi, tex
Electron. Trans. Numer. Anal. (etna.mcs.kent.edu)	8	283	14	pdf, ps
ESAIM Control Optim. Calc. Var. (www.emath.fr/cocv/)	24	500	500	pdf, ps, dvi, tex
ESAIM Probab. Statist. (www.smai.emath.fr/)	15	214	137	pdf, ps, tex
Forum Geom. (forumgeom.fau.edu)	23	21	28	pdf, ps
Geom. Topol. (www.maths.warwick.ac.uk/gt/)	28	262	4	pdf, ps
Homology Homotopy Appl. (www.rmi.acnet.ge/hha/)	NR	NR	NR	NR
Integers. Electron. J. Combin. Numb. Th. (www.integers-ejcnt.org)	17	147	3	pdf, dvi, tex
J. Artificial Intelligence Res. (www.jair.org/)	27	86	NR	html, pdf, ps
J. Funct. Logic Programming (www.danae.uni-muenster.de/lehre/kuchen/JFLP/)	4	60	14	pdf, ps
J. Graph Algorithms Appl. (www.cs.brown.edu/publications/jgaa/)	14	300	80	pdf, ps
J. Inequal. Pure Appl. Math. (jipam.vu.edu.au)	84	122	15	pdf
J. Integer Seq. (www.math.uwaterloo.ca/JIS/)	15	79	9	html, pdf, ps, dvi, tex
JoT J. Turbul. (www.iop.org/EJ/journal/JoT)	65	35	64	html, pdf, other
LMS J. Comput. Math. (www.lms.ac.uk/jcm/)	12	208	38	html, pdf, other
Lobachevskii J. Math. (ljm.ksu.ru)	10	80	20	pdf, ps, dvi
Math. Phys. Electron. J. (www.maia.ub.es/mpej)	5	100	17	ps
Represent. Theory (www.ams.org/ert)	11	152	266	pdf, ps, dvi, tex
Sem. Lothar. Combin. (euler.univ-lyon1.fr/home/slc)	11	116.9	4.5	pdf, ps, dvi, tex
Southwest J. Pure Appl. Math. (rattler.cameron.edu/swjpam/swjpam.html)	20	216	93	dvi, tex
Theory Appl. Categ. (www.tac.mta.ca/tac/)	23	163	12	pdf, ps, dvi

NR means no response received. NA means not available or not applicable. * From arrival of final manuscript at the publisher to print and electronic posting. **In 2002. *** Normally, this journal has 4 issues per year with a total number of 900 printed pages. In order to reduce the backlog, a supplementary issue of 200 pages has been published in 2002, and in 2001 as well, and distributed free of charge to all subscribers. The year 2003 will be regular: 4 issues with a total number of 900 printed pages.

American Mathematical Society

Election of Officers for 2004

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2003 AMS Elections Special Section

Dear Colleagues:

Once again members of the Society are invited to vote for candidates for several of the Society's governing bodies. This year, for the first time, AMS members will have the opportunity to vote electronically or by paper ballot. The candidates for election and their biographies are presented in the September 2003 issue of the *Notices*. This information and the official ballot will be available to you in early September. Consult the October 2003 *Notices*, From the AMS Secretary section, for the list of current holders of office. Also this year you will be asked to ratify a change to the AMS bylaws, intended to grant flexibility in setting eligibility criteria for life membership in the Society. The choices you make in these elections directly affect the direction that the Society takes. This may not be obvious to the casual member, so let me take a few lines to explain.

The president of the Society (whom you elect every other year) is the most important officer. The president strongly influences, either directly or indirectly, most of the scientific policies of the Society. A direct effect comes through the president's personal interactions both with members of the Society and with outside organizations, for example, in testimony before Congressional committees. In addition, the president sits as member of all five policy committees, is the chair of the Council's Executive Committee, and serves ex-officio as a trustee. Indirect influence occurs as the president appoints chairs and members of almost all committees of the Society, including the policy committees. The president works closely with all officers and administrators of the Society, especially the executive director and the secretary, to insure the orderly transaction of Society business. Finally, the president nominates candidates for the Nominating Committee and the Editorial Boards Committee. Consequently, the president also has a long-term effect on Society affairs.

The vice president and the members at large of the AMS Council you select will serve for three years on the Council. That body determines all scientific policy of the Society, creates and oversees numerous committees, appoints the treasurers and members of the Secretariat, makes nominations of candidates for future elections, and determines the chief editors of several key editorial boards. Typically each of these new members of the Council will serve on one of the Society's policy committees.

The trustees, of whom you will be selecting one for a five-year term, have complete fiduciary responsibility for the Society. Among other activities the trustees determine the annual budget of the Society, prices of journals, salaries of employees, dues (in cooperation with the Council), registration fees for meetings, and investment policy for the Society's reserves. The person you select will serve as chair of the Board of Trustees during the fourth year of the term.

You should have received either a traditional paper ballot or email with instructions for voting online by September 20. If you have not received this information, please contact the AMS (preferably before October 1) to request a ballot. Send email to `ballot@ams.org` or call the AMS at 1-800-321-4267 (within the U.S. and Canada) or 401-455-4000 (worldwide) and ask to speak with Member Services.

The candidates presented to you were suggested to the Council either by the Nominating Committee or by petition from members. While the Council has the final nominating responsibility, the groundwork is laid by the Nominating Committee. New members of this committee will be elected in this coming election. The candidates were nominated by the current president, David Eisenbud. The three elected will serve three-year terms. The main work of the Nominating Committee takes place during the annual meeting of the Society, during which it has four sessions of face-to-face meetings, each lasting about three hours. The Committee then reports its suggestions to the Council, which makes the final nominations.

The Editorial Boards Committee is responsible, as you might suspect, for the staffing of the editorial boards of the Society. Members are elected for three-year terms from a list of candidates named by the president. The Editorial Boards Committee makes recommendations for almost all editorial boards of the Society. Chief or managing editors of eight specific journals named in the AMS bylaws are officially appointed by the Council, upon recommendation of the Editorial Boards Committee; in virtually all other cases, the editors are appointed by the president, again upon recommendation by the Editorial Boards Committee.

Elections to the Nominating Committee and the Editorial Boards Committee are conducted by the method of approval voting. In the approval voting method, you can vote for as many or as few of the candidates as you wish. The candidates with the greatest number of the votes win the election.

It is suggested that names for write-in votes be given in exactly the form that the names occur in the *Combined Membership List*. Otherwise the identity of the individual for whom the vote is cast may be in doubt and the vote may not be properly credited.

According to the Society's bylaws, amendments to them are recommended by the Council and approved by its members. To gain approval an amendment must have an affirmative vote of two-thirds of those voting in this ballot. The item here, endorsed by both the AMS Committee on the

Profession and the Council, concerns a category of membership called life membership. The current bylaws set forth very explicit regulations for this category, and the officers believe the Society would be better served if more flexibility were permitted so that the Society could find an appealing but cost-effective means of increasing the number of Life Members, which might need to change over the course of years. The bylaws, specifically Article IX, Section 11, must be changed in order to allow this. The Council urges you to vote on the matter and recommends an affirmative vote. If you return a ballot and do not vote on the amendment, the effect is to vote "NO".

As an aside, if you inadvertently spoil your ballot, you may return it to the Secretary, care of the Providence office, and request a new ballot. The September 2003 *Notices* contains instructions about replacement ballots.

If past elections were a reliable measure, about 12 percent of you would vote in this election. However, a prediction of a 12% return could turn out to be far from accurate this year with the introduction of electronic voting. When other professional societies have taken similar steps, the percentage of voters has increased, and the AMS hopes to see a significant increase in returned ballots this year. The other officers and members of the Council join me in urging you to take a few minutes to review the election material, fill out your ballot, and submit it by some means, either by regular mail or electronically. The Society belongs to its members. You can influence the policy and direction it takes by voting.

Finally, let me urge anyone still reading to consider other ways of participating in Society activities. The Nominating Committee, the Editorial Boards Committee, and the Committee on Committees are always interested in learning of members who are willing to serve the Society in various capacities. Names are always welcome, particularly when accompanied by a few words detailing the person's background and interests. Self-nominations are probably the most useful. Recommendations can be transmitted from the Web (`http://www.ams.org/committee-nominate`, also linked from the AMS website home page via the Secretary's page) or sent directly to the secretary (`secretary@ams.org`), who will forward them to the cognizant body.

PLEASE VOTE.

—Robert J. Daverman
Secretary

List of Candidates–2003 Election

President
(one to be elected)
James G. Arthur
Donald G. Saari

Vice President
(one to be elected)
Vaughan F. R. Jones
Nolan R. Wallach

Board of Trustees
(one to be elected)
Lenore Blum
Linda Keen

Member at Large of the Council
(five to be elected)
James W. Cannon
Sylvain E. Cappell
Beverly E. J. Diamond
Mark Goresky
Jacques Hurtubise
Kevin P. Knudsen
Michael T. Lacey
Fred Stephen Roberts
Alexandro Uribe

Nominating Committee for 2004
(three to be elected)
Annalisa Crannell
Dennis DeTurck
Arthur M. Jaffe
Robion C. Kirby
Thomas G. Kurtz
Joel H. Spencer

Editorial Boards Committee for 2004
(two to be elected)
David L. Colton
Emma Previato
Daniel Ruberman
Karl Rubin

Election Information

The ballot for election of officers, members of the Council, a trustee, and committee members will be available, either online or by mail, on or shortly after August 25, 2003, in order for members to have the opportunity to vote well in advance of the November 7, 2003, deadline. A list of members of the Council and Board of Trustees serving terms during 2003 will appear in the "AMS Officers and Committee Members" section of the October issue of the *Notices*.

Replacement Ballots

For those who wish to vote by paper ballot, the following replacement procedure has been devised: A member who has not received a ballot by October 1, 2003, or who has received a ballot but has accidentally spoiled it may write after that date to the Secretary of the AMS, 201 Charles St., Providence, RI 02904-2294, USA, , asking for a second ballot. The request should include the individual's member code and the address to which the replacement ballot should be sent. Immediately upon receipt of the request in the Providence office, a second ballot, which will be indistinguishable from the original, will be sent by first class or airmail. Although a second ballot will be supplied on request and will be sent by first class or airmail, the deadline for receipt of ballots cannot be extended to accommodate these special cases.

Suggestions for 2004 Nominations

Each year the members of the Society are given the opportunity to propose for nomination the names of those individuals they deem both qualified and responsive to their views and needs as part of the mathematical community. Candidates will be nominated by the Council to fill positions on the Council and Board of Trustees to replace those whose terms expire January 31, 2004. See the "AMS Officers and Committee Members" section of the October issue for the list of current members of the Council and Board of Trustees. Members are requested to write their suggestions for such candidates in the appropriate spaces below.

COUNCIL AND BOARD OF TRUSTEES

Vice President *(1)*

_____

Members at Large of the Council *(5)*

_____

_____

_____

_____

_____

Member of the Board of Trustees *(1)*

_____

The completed form should be addressed to AMS Nominating Committee, Office of the Secretary, American Mathematical Society, 312D Ayres Hall, University of Tennessee, Knoxville, TN 37996-1330, to arrive no later than **November 7, 2003.**

Proposed Amendments to AMS Bylaws

According to the Society's Bylaws, amendments are recommended by the AMS Council and approved by the members. To gain approval an amendment must have an affirmative vote of two-thirds of those voting.

The following proposed amendment was endorsed by the Council upon the recommendation of the AMS Committee on the Profession. It provides much greater flexibility in determining eligibility criteria for life membership; the current section of the Bylaws treating this is quite limiting. The Committee on the Profession, the Council, and the Board of Trustees have shown interest in expanding those eligibility criteria. The Council urges you to vote on the matter and recommends an affirmative vote; if you return a ballot and do not vote on the amendment, the effect is the same as voting against it.

The complete Bylaws can be viewed at `http://www.ams.org/secretary/bylaws.html`. The Bylaws were published most recently in the November 2001 issue of the *Notices*, pp. 1205–1209.

Current Article IX, Section 11

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

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

Proposed Article IX, Section 11

An eligible member may become a life member by making a one-time payment of dues. The criteria for eligibility and the amount of dues shall be established by the Council, subject to approval by the Board of Trustees. A life member is subsequently relieved of the obligation of paying dues. The status and privileges are those of ordinary members.

An eligible member of the Society by reciprocity who asserts the intention of continuing to be a member by reciprocity may purchase a life membership by a one-time payment of dues. The criteria for eligibility and the amount of dues shall be established by the Council, subject to approval by the Board of Trustees.

Nominations for President Elect

Nomination for James G. Arthur

Robert Langlands

Although the choice of James Arthur as a candidate for the presidency of the AMS came as a surprise to me, I did not hesitate for an instant when asked by the Nominating Committee to write a statement supporting his nomination. I could accept immediately, without reflection, for I have enormous admiration for Jim as a mathematician and as a human being, and my admiration continues to grow. Only now, when setting pen to paper, or my fingers to the keyboard, do I ask myself what the relation is between those qualities that command my respect and the qualifications necessary to be the President of the American Mathematical Society.

There is no question that members of the Nominating Committee will have known what they were about, will have assessed Jim's abilities and capacities, and will have reflected carefully on what he would offer the Society as President. Now it is my turn. Since Jim has been active in the Society for many years, its officers, and a large number of members as well, have had ample time to come to know him. He was a member of the Council of the Society from 1986 to 1988, of the Program Committee from 1989 to 1991, of the Committee on Committees in 1991–92, and was Vice President from 1999 to 2001. I like to think that what weighed above all with the Committee was Jim's stature, stature as a mathematician and as a human being, his judgment and the largeness of his views.

His varied experience in the councils of mathematics in the USA, in Canada, and internationally, will certainly have been taken into account. Chairman of the Panel to Select Speakers in Group 7 (Lie groups and representations) at the International Congress in Kyoto in 1990, he was a member of the Executive Committee of the International Mathematical Union from 1991 to 1998 and of the Selection Committee for the Fields Medals in 2002. Moreover, he has been active in the governance of a number of mathematical institutes, the Centre de recherches mathématiques in Montreal, the Fields Institute, and the Clay Mathematical Institute and, while still finding time for his own research, served on the editorial boards of a number of journals.

I believe that in nominating Jim, the Society is appealing to a tradition that is as old as the Society itself and that has resulted in a list of past-presidents that is almost a roster of the most distinguished of our mathematicians over the past century. Times have changed of course. The Society has grown enormously; mathematics sprawls, so that it is much more of a challenge to sustain its coherence as a profession; the AMS membership is drawn from all its branches and consists of mathematicians with varied responsibilities in research, education, industry, and government. So one's first impulse is to believe that the principal skill of the Society's President must be managerial, and the major secondary criterion, personal involvement in one of the many enterprises—educational, industrial, or social—that sustain the integration of mathematics into modern society. On inquiry, I discover that this is not necessarily so.

On the contrary, as in the days of G. D. Birkhoff or von Neumann, the President still has a major representational function. In particular, he or she is elected to interpret mathematics in all its aspects to the public at large and, at times, to those parts of the public, especially the U. S. Congress, to which it appeals for funds. There is no prescribed type of personality for succeeding in such a task, but a manner that inspires trust, a clarity of views, an ability to articulate them, a patience that can dispense with overbearing arguments, and a willingness to listen carefully to the views and the needs of those represented can, especially when combined in a single individual, accomplish a great deal. These are all among Jim's virtues, as are a lack of pretension and a disarmingly dry sense of humor.

Robert Langlands is professor of mathematics at the Institute for Advanced Study. His email is rpl@ias.edu.

Beginning in 1997, and recently appointed for a second five-year term to end in 2007, he has been an Academic Trustee at the Institute for Advanced Study, responsible, in particular, for explaining mathematics and mathematicians to the other members of the Board of Trustees, who are largely drawn from the world of business and finance. He always carefully arms himself with a knowledge of the broad spectrum of scientific activities of the Institute's School of Mathematics and the details of its yearly programs, but his best weapon when articulating our needs and achievements before the Board has perhaps been his conviction of the importance of defending the place of mathematics in the academic world and in society as a whole. I suspect at the same time that he simply enjoys cultivating the art of persuasion.

Thus, although the scale at the Institute is much smaller than at the Society, I have had an opportunity to observe the care with which he listens, individually, to my views and those of each of my colleagues, tempering them or integrating them with his own and those of the larger community, and transmitting them when the opportune occasion arises to the Trustees as a whole. Our Trustees are, by and large, men and women with important positions in the business world, in politics and in large international organizations. Although well-disposed by temperament to the purposes of scientists and scholars, they also have substantial egos and considerable confidence in their own judgment. It is not easy to gain their respect or to change their views. Over the years, they have come, I believe, to trust Jim's wisdom, and on one or two critical occasions, with little else than gentle, patient dissuasion, he has warded off serious danger.

I confess that I have very little familiarity with the Society's organizational structure, but I understand that although the President is not unconcerned with the day-to-day affairs of the Society, responsibility for them lies largely with the Executive Director and the Secretary. The second major duty of the President is, I believe, not to manage the Society but to lead, or better guide, it. His hand will have to be light because, so far as I can see, there are scores of committees, on the order apparently of 150, that are responsible for the manifold policy decisions at various levels and in various domains. The President, acting on advice from within the Society, is responsible for appointments to most of these committees. To make the right appointments, to make the right decisions when they fall to him, he needs good judgment, as broad a knowledge of mathematics and mathematicians as possible, and an understanding of the manifold functions and responsibilities of the Society combined with a genuine respect for their value.

Within the Society itself, as Vice President and as a member of the Committee on Committees, Jim has been a part of the advisory process. It is also clear from his curriculum vitae that at the University of Toronto, where he has served on a large number of interdepartmental committees—a Presidential Search Committee, Presidential Advisory Committee, and many others—the President and the administration in general have had great confidence in Jim's ability to offer sound advice on appointments to important positions and on other matters.

To confirm this, I wrote to Robert Pritchard, the former President of the University, asking him why Jim was so often asked to serve. From his response it is manifest that his view of Jim is similar to mine, for he writes:

"Jim has served on many of the University's most important special committees ... Why is he chosen? Because he ... personifies our highest aspirations, has superb academic and scholarly judgement, has very high standards, is utterly reliable, is highly courteous, is practical and not just a theorist, always acts in a principled way, and conducts himself with dignity in all situations.

"He is a very special person quite apart from being a superb mathematician. He is extremely considerate of others and listens hard to competing views. He's fair and will always work to do the right thing."

So the answer to my question is that those qualities that have made Jim an admired friend and an exceptionally fine colleague are in large part just the qualities that will also make him a superb President. Jim is an excellent mathematician, with important contributions that have had a major impact on contemporary mathematics to his credit, so that when he speaks for mathematics he speaks with authority. There is no abatement in his scientific activity. He has a long-term program of research underway on which he continues to make progress at the same time as he serves the mathematical community in a large number of other ways. He is fair, with considerable experience in interpreting and defending mathematics, so that all of us, no matter what our interests or responsibilities, can be confident that he will, when the occasion arises, represent our needs forcefully and without bias, and that within the Society he will appoint the right people to formulate its policies—people who are informed, competent, and responsible.

I conclude with a brief biography and a brief description of his mathematics. Jim was educated at the University of Toronto and took his Ph.D. at Yale in 1970. After teaching at Princeton, where he met his wife Dorothy (Penny), a Kentucky native, and at Yale, he became a Professor at Duke, but in 1979 returned to Toronto, where he became a University Professor in 1987. His two sons are at present studying in the U.S.A. His older son James is a graduate student in Creative Writing at the University of Washington, and David, who has won gold medals in Olympiads in mathematics (2000) and in computer science (1999, 2000), is now an undergraduate in mathematics and computer science at Duke.

Jim is a fellow of the Royal Society of London and of the Royal Society of Canada. A speaker at the International Congress, both in Warsaw and in Berlin, he has been awarded a number of prizes, in particular the Henry Marshall Tory Medal of the Royal Society of Canada and the Canada Gold Medal for Science and Engineering of the National Science Engineering and Research Council in Canada.

Jim's name is attached to the formula or technique in the theory of automorphic forms that is referred to either simply as the trace formula or, frequently, as the Arthur-

Selberg trace formula. He has devoted the bulk of his mathematical efforts to it. On the website www.sunsite.ubc.ca/DigitalMathArchive/Langlands the interested reader can find a short, historically oriented general introduction to automorphic forms, the trace formula, and Arthur's work that was written as a supplement to the all too brief sketch that follows, as well as a much longer appreciation that appeared in the *Canad. Math. Bull.* (vol. 44, 2001, pp. 160–209) on the occasion of the award of the Canada Gold Medal and that attempts a survey less of the area as a whole than of Arthur's many contributions to it. Here I shall say no more than is necessary to underline the scope and difficulty of his work and its great importance for number theory at the present time and in the future.

The role of the theory of automorphic forms in modern number theory is more familiar than it once was because of the famous Taniyama-Shimura-Weil conjecture, its proof by Wiles, and its application to the Fermat theorem. The deep questions with which we are confronted when attempting to classify and understand algebraic irrationalities and the strikingly beautiful answers to them suggested by the theory are none the less hardly as familiar as they might be. The origins of the modern theory of automorphic forms lie to a considerable degree in the extension not only of quadratic reciprocity to the higher reciprocity laws but also of Gauss's analysis of the arithmetic of roots of unity, thus of the construction of regular polygons, to more recondite irrationalities, those associated to the division of elliptic curves. However, it has other roots as well—quite different—in analysis, both real and complex, in geometry, and in representation theory. It is the sophistication of aims together with the sophistication of proposed techniques that render the subject difficult.

The trace formula itself is an analytic technique that is used to investigate the spectral theory of the homogeneous spaces that link the analysis and the number theory. It is not difficult analytically if the homogeneous space is compact but still very important as Selberg discovered. When the space is not compact but of rank one, the formula is not only important but also difficult and is due to Selberg. For groups of higher rank, where the analytic difficulties are much more severe, it is the work of Arthur.

At the core of the formula in higher rank is the simultaneous spectral theory of several commuting differential operators, whereas in rank one there is only a single operator. The problems to be solved, first of all to obtain a formula in higher rank and then to turn it into an effective tool, lie in many domains: Fourier transforms in several variables, ordinary differential equations, measure theory, convex bodies, local harmonic analysis on real and on p-adic groups.

Arthur has not only had to develop a variety of techniques to handle them but has been led to some deep and important conjectures in representation theory—one global, related to the Ramanujan conjecture, and one local, related to the classification of unitary representations of reductive groups over a local field. Both these conjectures have had a great influence on the work of a number of imortant mathematicians such as Vogan, Waldspurger, and Moeglin.

Although much work and many deep discoveries remain before the full arithmetic depth of the trace formula reveals itself, Arthur has already explored profoundly many aspects of the trace formula, especially invariance and stabilization, and in part in collaboration with Clozel, has made a number of important applications to the transfer of automorphic forms from one form of the general linear group to another or from symplectic and orthogonal groups to a general linear group. His papers will, I believe, be essential reading for those in the field for a long time to come.

Others, too, have found striking applications of the trace formula to major arithmetical conjectures. Kottwitz's proof of an important conjecture of Weil on the volumes of arithmetic quotients exploited the first forms of Arthur's trace formula. The formula of Arthur, but over function fields and not number fields, was an essential tool in the work for which Lafforgue was recently awarded the Fields Medal.

Nomination for Donald G. Saari

Eric Friedlander

Donald Saari would prove to be an excellent president of the American Mathematical Society. He is a fantastic expositor and would be able to explain the role of mathematics to the outside world. His high-quality research encompasses core mathematics, applied mathematics, and economics. As a member of the National Academy of Sciences, he has the stature and credentials expected of someone representing the Society. Don's commitment to advancing the appreciation and understanding of mathematics by the general public should bring considerable benefit to our discipline.

Don's research centers around dynamical systems: the dynamics of celestial mechanics, of voting, and of economic systems. Surely, the best person to explain the role and significance of Don's work is Don himself, and the interested reader can consult his May 1995 *Notices* article (co-authored by Don's former student Jeff Xia) on celestial mechanics, his February 1995 *Notices* article on economic theory, and his expository book *Chaotic Elections! A Mathematician Looks at Voting*, published by the AMS in 2001.

Don's early work revived the study of singularities in celestial mechanics (part of what Don calls "mankind's second oldest profession"). Among his achievements are the solution of the Littlewood conjecture, which asserts

Eric Friedlander is professor of mathematics at Northwestern University. His e-mail address is eric@math.nwu.edu.

that collisions are improbable; further work showing "non-collision singularities" are improbable; and the first asymptotic description of the expansion of the N-body problem for any N (extending Newton's work for $N = 2$) as time goes to infinity. Don initiated various aspects of modern work in celestial mechanics associated to classification of systems and singularity theory. Although Don continues to work in this subject, he has dynamically expanded his research (and its popular appeal) into seemingly disparate areas.

Using symmetry as well as dynamics, Don has greatly improved our understanding of the imperfections of voting systems. Don investigated and characterized all possible "voting paradoxes". Don writes of his recent work:

"It is now possible to construct examples illustrating any possible paradox for all standard methods, all paradoxes can be explained and understood...the mathematical structure of the voting methods which give some consistency to election outcomes now is known..."

The best voting method, as Don has explained, is the Borda Count, which is the scheme in which each voter rank-orders all candidates.

In economics Don has used mathematics to argue that one cannot prove the validity of Adam Smith's "Invisible Hand" with current mathematical models. One important contribution of Don's to economic theory is a "benign interpretation" and extension of Arrow's seminal theorem in decision analysis. Recognizing the importance of the information required to reach "economic equilibria", Don has cogently argued that much of current theory does not lead to convergent approaches to equilibria. He continues to investigate "demand and supply", studying vector fields of "excess demand" resulting in foliations of representing foliations. As in the case of voting systems, chaos appears to reign.

Throughout his career, Don has placed great importance on clarity of exposition. Indeed, Don has told me that his overarching ambition in his research is to change the way people think about issues and to encourage a more positive view of mathematics. The MAA has awarded Don the Lester R. Ford Award, the Chauvenet Prize, and the Allendoerfer Award for his well-written articles. Don was tickled to learn that the (now former) president of Mexico was reading one of his economics papers. He has corresponded with members of Congress about voting paradoxes and has been quoted in Chicago newspapers about the force of one of Glenallen Hill's homeruns and the likelihood of space junk causing problems with our space station.

Before he left the wonderful Chicago climate for the hardships of southern California, Don was considered the best teacher in the Northwestern University mathematics department. Indeed, we present to new graduate students and faculty videotapes of Don's calculus lectures. He was prouder of the level of achievement of his students than he was of his student evaluations, which led to many teaching awards. Don would go to elementary schools, to high schools, and to community colleges to demonstrate the fun as well as the challenge of mathematics.

Don inherited the leadership talent of his father, a bold union and community leader. At Northwestern, Don chaired the mathematics department, the General Faculty Committee, and numerous faculty committees. Whether he was taking a strong stand in the Big Ten about the role of academics in athletics or whether he was confronting the administration at Northwestern to provide better health benefits to faculty and staff, Don played an active and constructive role. Don is the director of the Institute for Mathematical Behavioral Sciences at the University of California at Irvine.

Biographies of Candidates 2003

Biographical information about the candidates has been verified by the candidates, although in a few instances prior travel arrangements of the candidate at the time of assembly of the information made communication difficult or impossible. A candidate had the opportunity to make a statement of not more than 200 words on any subject matter without restriction and to list up to five of her or his research papers.

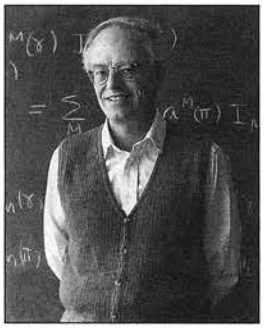
Abbreviations: American Association for the Advancement of Science (AAAS); American Mathematical Society (AMS); American Statistical Association (ASA); Association for Computing Machinery (ACM); Association for Symbolic Logic (ASL); Association for Women in Mathematics (AWM); Canadian Mathematical Society, Société Mathématique du Canada (CMS); Conference Board of the Mathematical Sciences (CBMS); Institute of Mathematical Statistics (IMS); International Mathematical Union (IMU); London Mathematical Society (LMS); Mathematical Association of America (MAA); National Academy of Sciences (NAS); National Academy of Sciences/National Research Council (NAS/NRC); National Aeronautics and Space Administration (NASA); National Council of Teachers of Mathematics (NCTM); National Science Foundation (NSF); Operations Research Society of America (ORSA); Society for Industrial and Applied Mathematics (SIAM); The Institute of Management Sciences (TIMS).

Each candidate had the opportunity to supply a photograph to accompany her or his biographical information.

A candidate with an asterisk (*) beside her or his name was nominated in response to a petition.

President

James G. Arthur



University Professor of Mathematics, University of Toronto.

Born: May 18, 1944, Hamilton, Ontario.

Ph.D.: Yale University, 1970.

AMS Offices: Member at Large of the Council, 1986–1988; Vice President, 1999–2001.

AMS Committees: Program Committee for National Meetings, 1989–1991; Committee on Committees, 1991–1992; Committee on Meetings and Conferences, 1999–2001.

Selected Addresses: Invited Speaker, International Congress of Mathematicians, Warsaw, 1983; Symposium on the Mathematical Heritage of Hermann Weyl, Durham, 1983; Jeffery-Williams Lecture, AMS-CMS-MAA Joint Mathematics Meetings, Vancouver, August 1993; Invited Speaker, International Congress of Mathematicians, Berlin, August 1998; Invited Address, AMS Conference on Mathematical Challenges of the 21st Century, Los Angeles, August 2000.

Additional Information: Alfred P. Sloan Fellowship, 1975–1977; Elected Fellow, Royal Society of Canada, 1980; E.W.R. Steacie Memorial Fellowship, 1982; Synge Award, Royal Society of Canada, 1987; Elected Fellow, Royal Society of London, 1992; CRM-Fields Institute Prize, 1997; Henry Marshall Tory Medal, Royal Society of Canada, 1997; Canada Gold Medal for Science and Engineering, Natural Sciences and Engineering Research Council of Canada, 1999; Wilbur Lucius Cross Medal, Yale University Graduate School Alumni Association, 2000; Guggenheim Fellowship, 2000–2001; Elected Fellow, American Academy of Arts and Sciences, 2003.

Selected Publications: 1. The trace formula in invariant form, *Ann. of Math.* **114** (1981), 1–74. MR **84a:**10031; 2. A Paley-Wiener theorem for real reductive groups, *Acta Math.* **150** (1983), 1–89. MR **84k:**22021; 3. with L. Clozel, Simple algebras, base change, and the advanced theory of the trace formula, *Ann. of Math. Stud.*, vol. 120, Princeton University Press, Princeton, NJ, 1989. MR **90m:**22041; 4. The L^2-Lefschetz numbers of Hecke operators, *Invent. Math.* **97** (1989), 257–290. MR **91i:**22024; 5. A local trace formula, *Inst. Hautes Études Sci. Publ. Math.* **73** (1991), 5–96. MR **92f:**22029.

Statement: In some ways, mathematics is flourishing more than ever. Discoveries are being made across a wide range of seemingly unrelated mathematical areas, reinforcing the fundamental beauty and unity of the subject. Sophisticated mathematical ideas are being applied to all

parts of science and beyond in ways that would not have been thought possible. Highly motivated undergraduate and graduate students, inspired by recent advances, are bringing new energy to the subject. We are even the beneficiaries of newfound public sympathy for mathematics, which seems to stem from an intrinsic curiosity and fascination with the subject.

However, mathematics also faces serious challenges. Despite all of the recent advances in the subject, we continue to struggle for adequate support from granting agencies, universities, and industry. Support often comes at the price of increased demands upon the time of mathematicians, sometimes limiting their capacity to participate fully in the development of the subject. There remain talented students of mathematics, particularly among women and minorities, who do not receive the encouragement they deserve. For the majority of students who do not gravitate naturally toward mathematics, we need to do much more to help them meet increasing standards of mathematical literacy. The public goodwill we presently enjoy cannot be taken for granted. It will have to be nurtured by all of us if it is not to depend solely on the latest images from Hollywood.

The American Mathematical Society is the largest and most ambitious mathematical organization in the world. It is a major contributor to the vitality of mathematics on the national and international stages. In playing this role, the Society is dependent at any given time on very real contributions from many hundreds of mathematicians. That some of our most talented colleagues are prepared to commit their time and energy is a tribute to their pride in the Society and their belief in its ability to strengthen mathematics. The president has a responsibility to encourage all members to take pride in the Society and, indeed, in the enormous achievements of mathematics itself. With its large membership, the AMS can be a powerful force for bringing mathematical concerns to the attention of the broader community.

I feel deeply honored to have been nominated to stand for election as president. If I am elected, I will serve the AMS to the utmost of my ability. I would enjoy the opportunity to work within the Society on the challenges we face. I would also welcome the chance to represent mathematics to other scientists, as well as leaders of government, business, and education.

Donald G. Saari

Distinguished Professor and Director, Institute for Mathematical Behavioral Sciences, University of California, Irvine.

Born: March 9, 1940, Ironwood, Michigan.

Ph.D.: Purdue University, 1967.

AMS Offices: Member at Large of the Council, 1999–2001.

AMS Committees: Publications Committee, 1999–2001; *Bulletin* Editorial Committee, 1999– (chief editor); Committee on Science Policy, 2000–2001; AMS-MAA-SIAM Joint Policy Board for Mathematics, 2000–2002; AMS-SIAM Committee to Select the Winner of the Birkhoff Prize, 2002 (chair).

Selected Addresses: AMS Invited Address, South Bend, March 1991; Invited Address, MAA Mathfest, Toronto, July 1998; Plenary Speaker, Mathematical and Experimental Physics, El Colegio Nacional, Mexico, 2001; 37th Nederlands Mathematisch Congress, Amsterdam, 2001; Inaugural Duncan Black Lecture, Public Choice Society, 2001; Principal Lecturer, CBMS Conference on the N-Body Problem, June 2002; N-Body Problem, Banff Research Center Opening Ceremony, 2003; Invited Address, MAA Mathfest, Boulder, August 2003.

Additional Information: ***Academic positions:*** Yale University Astronomy Department, 1967–1968 (postdoctoral); Northwestern University Mathematics Department: Assistant Professor, 1968–1970; Associate Professor, 1970–1974; Professor, 1974–2000; Department Chair, 1981–1984; Pancoe Professor of Mathematics, 1995–2000. ***Visiting positions:*** Instituto Nacional de Matematica Pura e Aplicada, Université de Caen, Université de Paris, and numerous others; ***Awards and honors:*** MAA Ford Prize, 1985; Duncan Black Research Prize, Public Choice Society, 1991; Chauvenet Prize, 1995; Honorary Professor, Nanjing University, Nanjing, China, 1995; Guggenheim Fellow, 1998–1999; Allendoerfer Prize, 1999; Member, National Academy of Sciences, 2001; ***Honorary doctorates:*** Purdue University, 1989; Université de Caen, Caen, France, 1998; Michigan Technological University, 1999; ***Editor:*** *Celestial Mechanics and Dynamical Astronomy* (associate editor, 1972–1985, 1989–1996); *SIAM Journal on Mathematical Analysis*, 1973–1978 (associate editor), 1981–1986 (editor); *Economic Theory* Editorial Board, 1990; *Social Choice and Welfare*, 1997–2003 (associate editor). ***American Astronomical Society:*** Council, Division on Dynamical Astronomy, 1985–1987; Consultant, Commission on Celestial Mechanics, International Astronomical Union, 1985–1991. ***MAA:*** Chauvenet Prize Committee, 1996–1999 (chair, 1998–1999). ***NRC:*** U.S. National Committee on Mathematics for IMU, 1997–2002 (chair, 2000–2002); U.S. Delegation to the 2002 IMU General Assembly (chair); Mathematical Sciences Education Board, 2001– ; Board on International Scientific Organizations, 2001–2003. ***SIAM:*** Publication Committee, 1981–1986; Organizing Committee, 1988 National Meeting (chair); Committee on Committees, 1995–1997. ***Social Choice & Welfare:*** Council, 2000–. Trustee: MSRI; Member: AMS, MAA, SIAM.

Selected Publications: 1. Improbability of collisions in Newtonian gravitational systems. II, *Trans. Amer. Math. Soc.* **181** (1973), 351–368. MR **47:**9919; 2. with Z. Zia, Off to infinity in finite time, *Notices Amer. Math. Soc.* **42** (1995), 538–546. MR **95m:**70002; 3. A chaotic exploration of aggregation paradoxes, *SIAM Rev.* **37** (1995), 37–52. MR **97a:**90008; 4. Mathematical structure of voting paradoxes. I: Pairwise votes, and II: Positional voting, *Econom. Theory* **15** (2000), 1–53, 55–102; MR **2001e:**91063 and MR **2001e:**91064; 5. *Chaotic Elections! A Mathematician Looks*

at Voting, Amer. Math. Soc., Providence, RI, 2001. MR 2002g:91001.

Statement: What an exciting time to be a mathematician! Consider what has happened over the last couple of decades: Several named problems have been answered and new mathematical areas and directions have been developed. Beyond important advances in core mathematics, applied mathematics has blossomed in previously unimaginable directions while other parts of the scientific and engineering establishments are becoming mathematically more sophisticated.

Thanks to the efforts of the AMS and its sister organizations working with the NSF Division of Mathematical Sciences, there is encouraging news about funding. However, as the evening news consistently reminds us, this is also a time of changing needs and priorities within society. So to ensure that this period of mathematical growth and excitement continues, it is crucial that the AMS remain strong, active, and alert.

To meet the shifting challenges of the time while seeking new opportunities, our objectives must be clear. As demonstrated by my activities, my concerns include: addressing the need for better support for fundamental research in core and applied mathematics; encouraging mathematical extensions and connections to other sciences and applications; finding ways to redirect highly talented undergraduates, women, and minorities toward the study of mathematics; enhancing the public image, understanding, and support of mathematics; paying more attention to the funding and future employment needs of our graduate students; working to improve mathematics education at all levels.

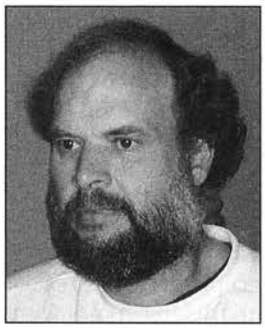
As the AMS's international membership illustrates, mathematics is a discipline without boundaries. The free flow of ideas and people must be promoted—and protected. Although we welcome the lead taken by organizations outside of mathematics on issues of importance to us (e.g., electronic publication and suggested changes in graduate education), I agree with concerns expressed at our recent AMS Council meeting that mathematicians must remain in control of that part of the agenda that pertains to us.

Perhaps it is because mathematics has been very good to me (so I try to repay her whenever and however I can) or perhaps it is my family background of community activism, but I have always enjoyed working with the three main professional mathematical societies to advance these goals. In addition to gaining leadership experience, I have had the opportunity to discuss these issues with mathematicians from a wide variety of departments across North America and throughout the world. What I have learned is encouraging: There is so much talent and so many good ideas within our community, and it all must be used. When promoting mathematics to the general public, whether on TV, radio, or in print, I've learned that the public wants to know more about what we do; they are curious. It is important to our discipline that we work harder to explain who we are, what we do, and why it is so crucial.

The AMS, perhaps the leading group in the mathematical sciences in the world, has done an excellent job in advancing our field. I am deeply honored to have been nominated for the presidency. But rather than a ceremonial post, this position is a responsibility and promised commitment to the mathematical community. If elected, I hope that my love affair with mathematics, my experience in promoting mathematics professionally and to the general public, my experience in working both in core and applications, my work within the AMS and other organizations, and my interests in education will help advance our Society.

Vice President

Vaughan F. R. Jones



Professor of Mathematics, University of California, Berkeley.

Born: December 31, 1952, Gisborne, New Zealand.

Ph.D.: Université de Geneve, Switzerland, 1979.

AMS Committees: *Transactions* and *Memoirs* Editorial Committee, 1986–1987; Committee on Science Policy, 1987; Committee on Steele Prizes, 1992–1993; Nominating Committee, 1993–1995.

Selected Addresses: International Association of Mathematical Physicists, Swansea, 1988; Plenary Address, International Congress of Mathematicians, Kyoto, 1990; International Association of Mathematical Physicists, Brisbane, 1997.

Additional Information: F. W. W. Rhodes Memorial Scholarship, 1973; Alfred P. Sloan Research Fellowship, 1983; Guggenheim Fellowship, 1986; Fellow of the Royal Society, 1990; Fields Medal, 1990; New Zealand Government Science Medal (now Rutherford Medal), 1991; Honorary Fellow, Royal Society of New Zealand, 1991; Executive Committee, International Association of Mathematical Physics, 1991–1994; Honorary Vice President for Life, International Guild of Knot Tyers, 1992; Honorary D.Sc., University of Auckland, 1992; Corresponding Member, Australian Academy of Sciences, 1992; Elected Member, American Academy of Arts and Sciences, 1993; Honorary D.Sc., University of Wales, 1993; Elected Member, National Academy of Sciences, 1999; Onsager Medal, Trondheim University, 2000; Elected Foreign Member, Norwegian Royal Society of Letters and Sciences, 2001; Elected Honorary Member, London Mathematical Society, 2002; Director, New Zealand Mathematics Research Institute; ***Past or present editor or associate editor:*** *Advances in Mathematics*; *Annals of Mathematics*; *Geometry and Topology Journal*; *Journal of Mathematical Chemistry*; *Journal of Operator Theory*; *L'Enseignement Mathematique*; *New Zealand Journal of Mathematics*; *Pacific Journal of Mathematics*; *Reviews in Mathematical Physics*; *Russian Journal of Mathematical Physics*; ***Scientific advisory boards:*** Center for Communications Research; Erwin Schrödinger Institute; Fields Institute of Mathematics; Institut Henri Poincaré;

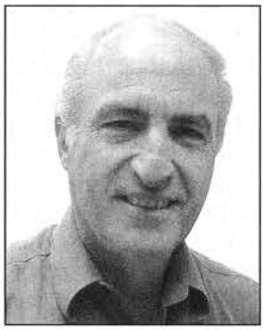
Mathematical Sciences Research Institute; Miller Institute for Basic Research in Sciences.

Selected Publications: 1. Index for subfactors, *Invent. Math.* **72** (1983), 1–25. MR **84d:**46097; 2. A polynomial invariant for knots via von Neumann algebras, *Bull. Amer. Math. Soc.* **12** (1985), 103–111. MR **86e:**57006; 3. with K. Schmidt, Asymptotically invariant sequences and approximate finiteness, *Amer. J. Math.* **109** (1987), 91–114. MR **88h:**28021; 4. On knot invariants related to some statistical mechanical models, *Pacific J. Math.* **137** (1989), 311–334. MR **89m:**57005; 5. Planar algebras, I, preprint, to appear in *New Zealand J. Math.*

Statement: I view mathematics as part of a continuous spectrum of science. Mathematics is important both in its own right and as a tool for the sciences. In chemistry and physics the role of mathematics is familiar to all. In biology its importance is increasing as the revealing of the genetic code in all its complexity creates a demand for a new branch of combinatorics and new algorithms to handle huge data sets.

I see it as important that the AMS should, in addition to looking after its members' interests in mathematics for its own sake and mathematics education, make all efforts to strengthen connections with the rest of science. This is not always easy, because questions as simple as vocabulary can create a huge gulf and a perception by the rest of the scientific community that mathematicians do not want to take time to think about anything other than mathematics.

Nolan R. Wallach



Professor of Mathematics, University of California, San Diego.

Born: August 3, 1940, Brooklyn, New York.

Ph.D.: Washington University, St. Louis, Missouri, 1966.

AMS Offices: Member at Large of the Council, 1999–2001.

AMS Committees: Editorial Boards Committee, 1991–1993 (chair, 1992); *Bulletin* Editorial Committee (associate editor, Research-Expository Surveys), 1995–1996; Committee on Science Policy, 1999–2001.

Selected Addresses: AMS Invited Address, Washington, DC, January 1975; International Congress of Mathematicians, Helsinki, August 1978; AMS-MAA Invited Address, Louisville, January 1990; Plenary Address, Japan Mathematical Society, September 1990; Invited Lecture, MSRI Special Session on Quantum Computing, June 2000.

Additional Information: Alfred Sloan Fellowship, 1972–1974; Visiting Professor, University of Paris, 1973; Linback Award for Research Excellence, Rutgers University, 1977; National Mathematics Committee, 1985–1992; Honorary Professor, University of Cordoba, Argentina, 1989; Visiting Professor, University of Tokyo, 1990; NSF Postdoctoral Selection Committee, 1992–1994 (chair, 1994); NSF Young Investigator Selection Committee, 1993; Associate Editor, *Annals of Mathematics*, 1997–2003; Visiting Professor, Poitiers University, 2001; Member: AMS.

Selected Publications: 1. with S. Aloff, An infinite family of distinct 7-manifolds admitting positively curved Riemannian structures, *Bull. Amer. Math. Soc.* **81** (1975), 93–97. MR **51:**6851; 2. The analytic continuation of the discrete series. I, II, *Trans. Amer. Math. Soc.* **251** (1979), 1–17, 19–37. MR **81a:**22009; 3. with B. Gross, On quaternionic discrete series representations, and their continuations, *J. Reine Angew. Math.* **481** (1996), 73–123. MR **98f:**22022; 4. with R. Goodman, *Representations and Invariants of the Classical Groups*, Encyclopedia Math. Appl., vol. 68, Cambridge University Press, Cambridge, 1998. MR **99b:**20073; 5. with D. Meyer, Global entanglement in multiparticle systems, *J. Math. Phys.* **43** (2002), 4273–4278.

Statement: The leadership of the AMS has become an excellent advocate for the mathematical sciences in society through tireless networking at all levels of government in cooperation with other scientific societies.

There is another advocacy that is just as important but does not necessarily affect directly the normal leadership of the AMS. Mathematics departments are the poor relations of the other sciences. Compared with other scientists, mathematicians have higher teaching loads, larger classes, and lower salaries. The AMS has done a commendable job of averting catastrophic problems (such as the situation at the University of Rochester). However, AMS policies have done little to improve the working environment of mathematicians. My appeal is not for my own generation but for future generations for whom the situation will almost certainly become worse without some intervention.

In my professional career there have been two types of success that have given me the greatest pleasure. The first is when a mathematical idea explodes in my mind. The second is when I see the gleam of understanding in a student. I hope that I can be of help to future generations so that they may sample the same pleasures.

Trustee

Lenore Blum

Distinguished Career Professor, Computer Science Department, Carnegie Mellon University.

Born: December 18, 1942, New York, New York.

Ph.D.: Massachusetts Institute of Technology, 1968.

AMS Offices: Member at Large of the Council, 1978–1980; Vice President, 1990–1992.

AMS Committees: Committee on Opportunities in Mathematics for Disadvantaged Groups, 1978– 1980; Committee on the Human Rights of Mathematicians, 1984–1986; Strategic Planning Task Force, 1991; Committee on Committees, 1991–1994 (chair, 1991–1992); Committee on International Affairs, 1993–1995; Liaison Committee with AAAS,

1995–2003; Short Course Subcommittee, 1996–1998; Program Committee for National Meetings, 2002– ; AMS-MAA Joint Program Committee for the January 2004 Phoenix Meeting.

Selected Addresses: AMS Invited Address, Phoenix, 1989; International Congress of Mathematicians, Kyoto, 1990; MAA Invited Address, San Francisco, 1995; European Logic Colloquium, Sorbonne, Paris, 2000; AWM Emmy Noether Lecture, San Diego, 2001.

Additional Information: Founding Head, Department of Mathematics and Computer Science, Mills College; President, AWM, 1975–1978; Founding Co-Director, Math/Science Network and its Expanding Your Horizons conferences, 1975–1981; Elected Fellow, AAAS, 1979; U.S. Delegate, International Mathematics Union, Kobe, 1990; AMS Representative, Pan-African Congress of Mathematicians, Nairobi, 1991; Deputy Director, MSRI, 1992–1996; Chair, Mathematics Section, AAAS, 1998–1999; Doctor of Law, Honoris Causa, Mills College, 1999.

Selected Publications: 1. Differentially closed fields: A model theoretic tour, *Contributions to Algebra: A Collection of Papers Dedicated to Ellis Kolchin* (Bass, Cassidy, and Kovacic, eds.), Academic Press, New York, 1977, pp. 37–61. MR **58:**10415; 2. with M. Blum and M. Shub, A simple unpredictable pseudorandom number generator, *SIAM J. Comput.* **15** (1986), 364–383. MR **87k:**65007; 3. with M. Shub, Evaluating rational functions: Infinite precision is finite cost and tractable on average, *SIAM J. Comput.* **15** (1986), 384–398. MR **87k:**68060; 4. with F. Cucker, M. Shub, and S. Smale, Algebraic settings for the problem $P \neq NP?$, *The Mathematics of Numerical Analysis*, Lectures in Appl. Math., vol. 32, Amer. Math. Soc., Providence, RI, 1996, pp. 125–144. MR **98a:**68064; 5. with F. Cucker, M. Shub, and S. Smale, *Complexity and Real Computation*, Springer-Verlag, New York, 1998. MR **99a:**68070.

Statement: The ongoing and future health of the mathematics community and the AMS, in particular, depends on the many multifaceted and diverse contributions and vision of its members—in research, education, communication, leadership, and public understanding. Throughout my own professional career, I have worked to create innovative and exciting ways to encourage broad appreciation of, and involvement in, mathematics.

As AWM president, I helped to create programs to increase women's participation in mathematics and served on panels on mathematics in government, business and industry. During my term as AMS vice president, I worked to open communication with the African mathematics community. As deputy director of MSRI I helped to establish the Human Resources Advisory Committee (HRAC) and the "Conversations" between mathematics researchers and mathematics teachers. My other outreach efforts to the public-at-large and to the wider science community include my involvement in MSRI's Fermat Fest and (while chair of the AAAS Mathematics section) my work as organizer of the AAAS sessions on the "Reasonable Effectiveness of Mathematics".

I would bring this experience and perspective, along with considerable enthusiasm for the enterprise, to the role of Trustee.

Linda Keen

Professor of Mathematics, Herbert H. Lehman College (CUNY).

Born: August 9, 1940, New York, New York.

Ph.D.: New York University, 1964.

AMS Offices: Member at Large of the Council, 1981–1983; Vice President, 1992–1995; Board of Trustees, 1999– (chair, 2002).

AMS Committees: Nominating Committee, 1983–1984 (chair, 1984); Committee on Professional Ethics, 1987–1989, 1999 (chair, 1988–1989); Program Committee for National Meetings, 1987–1988; Undergraduate Mathematics Education (UME) *Trends* Editorial Committee, 1989–1991; Editorial Boards Committee, 1989–1992 (chair, 1991); Committee to Select the Winner of the Satter Prize, 1991 (chair); Representative, Joint Policy Board on Mathematics, 1992–1995; Committee on Committees, 1992–1996; Science Policy Committee, 1993–1995; Advisory Committee on Professional Ethics, 1993–1994 (chair), and Committee on Procedures for the Committee on Professional Ethics, 1995 (chair); Meetings and Conferences Committee, 1994; Ad Hoc Committee on Governance, 1994; Federal Policy Agenda Statement, 1994–1995; *Proceedings* Editorial Committee, 1994– (coordinating editor); *Conformal Geometry and Dynamics*: An Electronic Journal of the AMS, 1997– (managing editor and chair of editorial committee); Committee on Publications, 2001–2003; Long Range Planning Committee, 2002; Investment Committee, Board of Trustees, 2003.

Selected Addresses: AMS Invited Address, Washington, DC, January 1975; MAA Invited Hour Address, Boulder, August 1989; Emmy Noether Lecturer, January 1993; AIM Conference in Honor of Lars Ahlfors, Stanford University, September 1997; London Mathematical Society-Irish Mathematical Society Invited Hour Address, May 1998.

Additional Information: AWM Executive Committee, 1978–1981; Charter Member, NYC Mayor's Commission for Science and Technology, 1985–1986; AWM President, 1985–1986; CBMS Executive Committee, 1985–1987; Steering Committee, International Congress of Mathematicians, 1986; U.S. National Committee on Mathematics, 1988–1993 (chair, 1990–1993); NSF Visiting Professorship for Women, 1989–1990; Edwin S. Webster-Abby Rockefeller Mauze Award, MIT, 1990; AWM Long Range Planning Committee, 1992–1993; AWM Nominating Committee, 1993.

Selected Publications: 1. Intrinsic moduli on Riemann surfaces, *Ann. of Math.* **84** (1966), 404–420. MR **34:**2859; 2. with L. Goldberg, The mapping class group of a generic quadratic rational map and automorphisms of the 2-shift, *Invent. Math.* **101** (1990), 335–372. MR **91h:**30041; 3. with P. Blanchard and R. Devaney, The dynamics of complex polynomials and automorphisms of the shift, *Invent. Math.* **104** (1991), 545–580. MR **92f:**58150; 4. with C. Series, Pleating coordinates for the Maskit embedding of the Teichmüller space of punctured tori, *Topology* **32** (1993), 719–749. MR **95g:**32030; 5. with C. Series, Pleating

invariants for quasifuchsian groups: punctured tori, *Topology*, 2003 (to appear).

Statement: The AMS is a multifaceted organization whose primary mission is to foster good mathematics. It does this primarily as a publisher and as a sponsor for meetings and conferences. Another of the AMS's very important responsibilities is to recognize mathematics as a profession by giving prizes and by reaching outside the profession to get support.

Finally, the AMS has a responsibility for encouraging all those who want to do mathematics to take part. This includes presenting ourselves and our work to the broadest possible audience.

I've been involved with the Society in many different roles over the years: as a Council member, as a member of committees (such as the one on professional ethics), and as an editor. I have worked hard to make the AMS effective on all fronts. As a trustee I have had the responsibility for making decisions on all matters with financial implications. The Society's finances reflect the complexity of its responsibilities, and in each year of my term, I have learned about new parts of that structure. As a second term trustee I will bring this knowledge and perspective to guide me in helping set policy that best supports both our people and our work as researchers and educators.

Member at Large of the Council

James W. Cannon

Orson Pratt Professor of Mathematics, Brigham Young University.
Born: January 30, 1943, Bellefonte, Pennsylvania.
Ph.D.: University of Utah, 1969.
Selected Addresses: AMS Invited Address, Seattle, August 1977; International Congress of Mathematicians, Helsinki, 1978; MAA Hedrick Lecturer, Toronto, 1982.
Additional Information: Professor, University of Wisconsin, Madison, 1977–1985; Trustee and Vice Chair, Board of Trustees, MSRI, 1994–1998; Governor, MAA Intermountain Section, 1999–2001.

Selected Publications: 1. with C. E. Burgess, Embeddings of surfaces in E^3, *Rocky Mountain J. Math.* **1** (1971), 259–344. MR **43:**4008; 2. The recognition problem: What is a topological manifold? *Bull. Amer. Math. Soc.* **84** (1978), 832–866. MR **58:**13043; 3. The combinatorial structure of cocompact discrete hyperbolic groups, *Geom. Dedicata* **16** (1984), 123–148. MR **86j:**20032; 4. The combinatorial Riemann mapping theorem, *Acta Math.* **173** (1994), 155–234. MR **95k:**30046; 5. with G. R. Conner and A. Zastrow, One-dimensional sets and planar sets are aspherical, *Topology Appl.* **120** (2002), 23–45.

Statement: Please bend my ear; I will listen. I love the mathematical enterprise. I want people of all sorts, nationalities, sizes, genders, and persuasions to know about it, appreciate it, and participate in it.

Sylvain E. Cappell

Professor, Courant Institute of Mathematical Sciences, New York University.
Born: September 10, 1946, Brussels, Belgium.
Ph.D.: Princeton University, 1969.
AMS Committees: Contemporary Mathematics Editorial Committee, 1989–1991; Committee on Steele Prizes, 1991–1992 (chair, 1992); Nominating Committee, 1996–1998; Committee on Professional Ethics, 1999–2001.
Selected Addresses: International Congress of Mathematicians, Helsinki, 1978; AMS Invited Address, Syracuse, October 1978; Principal Speaker, CBMS Lecture Series, Virginia Polytechnical University, 1987; Clifford Lectures, Tulane University, 1990; Conference on Symplectic Geometry and Its Applications, Cambridge University, 1994; AMS-MAA Invited Address, Seattle, August 1996.
Additional Information: Sloan Foundation Fellowship, 1971–1972; Guggenheim Foundation Fellowship, 1989–1990; Editor, *Communications in Pure and Applied Mathematics*, 1989– .

Selected Publications: 1. A splitting theorem for manifolds, *Invent. Math.* **33** (1976), 69–170. MR **55** #11274; 2. with J. Shaneson, Nonlinear similarity, *Ann. of Math.* **113** (1981), 315–355. MR **83h:**57060; 3. with R. Lee and E. Miller, The action of the Torelli group on the homology of representation spaces is nontrivial *Topology* **39** (2000), 851–871. MR **2001g:**57034; 4. with J. Shaneson, Genera of algebraic varieties and counting of lattice points, *Bull. Amer. Math. Soc. (N.S.)* **30** (1994), 62–69. MR **94f:**14018; 5. with S. Weinberger, Surgery theoretic methods in group actions, *Surveys on Surgery Theory* (S. Cappell, A. Ranicki, and J. Rosenberg, eds.), Ann. of Math. Stud., vol. 149, Princeton Univ. Press, Princeton, NJ, 2001, pp. 285–317. MR **2002a:**57046.

Statement: My experiences have familiarized me with some of the concerns of AMS members, and I hope that could help me if I serve as Member at Large. During my student years, I worked in both government and industrial labs. I have since been working in academic institutions where my experience includes chairing (now and for many years) Courant Institute's Math Appointments and Promotions Committee, chairing (now and for many years) my university's Research Challenge Fund Committee (awarding research support in all areas), chairing or serving on many math department external review committees at public and private institutions, and serving on public and private foundation review committees in the U.S. and abroad. I have long been coordinating the mathematics outreach efforts and faculty development workshops of the Faculty Resource Network (linked to the National Leadership Alliance) and have long been actively involved in mentoring in and aiding precollege math education programs in New York area schools.

Beverly E. J. Diamond

Professor of Mathematics, College of Charleston.
Born: July 5, 1956, Charlottetown, Prince Edward Island, Canada.
Ph.D.: University of Manitoba, 1982.
Selected Addresses: Six AMS Special Sessions, 1992–2000; Southeast Spring Topology Conference, 1996; Midwest Dynamics Conference, Florida, 2000; University of Maryland-Penn State Workshop on Dynamical Systems, 2001.
Additional Information: AAUW Fellowship, 1988; NSF Program Director, 1996–1998; Grant selection panels: AAUW, 1995; NSF, 1999; AWM, 2001; Associate Editor, *The American Mathematical Monthly*, 2001–.
Selected Publications: 1. with M. Barge, Dynamics on one-dimensional branched manifolds via inverse limit spaces, *Trans. Amer. Math. Soc.* **334** (1994), 773–790; 2. with M. Barge, Homeomorphisms of inverse limit spaces of one-dimensional maps, *Fund. Math.* **146** (1995), 171–187. MR **96b:**54048; 3. with M. Barge, Subcontinua of the closure of the unstable manifold at a homoclinic tangency, *Ergodic Theory Dynam. Systems* **19** (1999), 289–307. MR **2000f:** 37025; 4. with M. Barge, Stable and unstable manifold structures in the Hénon family, *Ergodic Theory Dynam. Systems* **19** (1999), 309–338. MR **2000i:**37057; 5. with M. Barge, A complete invariant for the topology of one-dimensional substitution tiling spaces, *Ergodic Theory Dynam. Systems* **21** (2001), 1333–1358. MR **2002k:**37026.
Statement: The AMS has the broad mandate of furthering the interests of mathematical research and scholarship. Over the last two decades, the organization has met that mandate in two ways. It has continued to contribute in traditional ways with its very successful meetings and publication programs. At the same time, it has met the challenge of communicating and integrating with several other communities.

With an uncertain economy in our immediate future, issues of policy and priorities, both internal and external, will arise. I would enjoy having an opportunity to contribute to that discussion and to the ongoing work of the AMS.

Mark Goresky

Member, Institute for Advanced Study, Princeton, New Jersey.
Born: December 27, 1950, Regina, Canada.
Ph.D.: Brown University, 1976.
AMS Committees: AMS representative, NSF Postdoctoral Selection Committee, 1996–1998 (chair, 1998).
Selected Addresses: AMS Invited Address, Atlanta, January 1988; Plenary Address, 50th Anniversary Meeting, Canadian Mathematical Society, 1995; Zabrodsky Memorial Lectures, Jerusalem, 1996.
Additional Information: Sloan Foundation Fellowship, 1981; Fellow of the Royal Society of Canada, 1986; Jeffery-Williams Prize, Canadian Mathematical Society, 1996; AMS Steele Prize for Seminal Contribution to Research (jointly received with Robert MacPherson), 2002; Member: European Mathematical Society, IEEE, International Association for Cryptologic Research, SIAM, SMF. Homepage: `http://www.math.ias.edu/~goresky`.
Selected Publications: 1. with R. MacPherson, Intersection homology theory, *Topology* **19** (1980), 135–162. MR **82b:** 57010; 2. with R. MacPherson, *Stratified Morse Theory*, Ergeb. Math. Grenzgeb. (3), vol. 14, Springer-Verlag, Berlin, 1988. MR **90d:**57039; 3. with R. Kottwitz and R. MacPherson, Equivariant cohomology, Koszul duality, and the localization theorem, *Invent. Math.* **131** (1998), 25–83. MR **99c:** 55009; 4. with A. Klapper, Fibonacci and Galois representations of feedback-with-carry shift registers, *IEEE Trans. Inform. Theory* **48** (2002), 2826–2836; 5. with R. MacPherson, The topological trace formula, *Crelle's Journal*, to appear.
Statement: The ability of an individual Council member to influence the direction of the AMS is somewhat less than epsilon. And there are so many things the AMS does really well. The computerization of *Mathematical Reviews*, for example, has changed the way we search the literature. The AMS is one of the few reliable and affordable mathematics publishers left in the world.

The program of AMS regional meetings is excellent. If elected, I will use whatever little influence I might have to see that the AMS continues to support and encourage high-quality basic research in mathematics, perhaps by reducing the cost of some of its pricier books, by maintaining the quality of its journals and their editorial boards, and by strengthening its ties to other mathematical organizations such as the European Mathematical Society, SIAM, MAA, NSF, NSA, and IEEE.

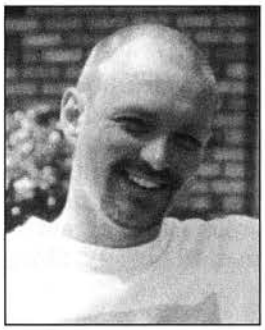
Jacques Hurtubise

Professor of Mathematics, McGill University.
Born: March 12, 1957, Montreal, Quebec, Canada.
Ph.D.: Oxford University, 1982.
Selected Addresses: Seven AMS Special Sessions, 1986–2003; Coxeter-James Lecture, 1993 Canadian Mathematical Society Winter Meeting; AMS Invited Address, Cincinnati, January 1994; Seminaire de Mathématiques Supérieures, 1995 and 1999.
Additional Information: Member, Institute for Advanced Study, 1987–1988; Visiting Professor, Stanford University, spring 1992; Associate Editor, *Canadian Mathematical Bulletin* and *Canadian Journal of Mathematics*, 1994–1999; Vice President, Canadian Mathematical Society, 1997–1999; Director, Centre de recherches mathématiques, Montreal, 1999–; President, Network for Computing and Mathematical Modelling, Montreal, 1999–.
Selected Publications: 1. with M. K. Murray, On the construction of monopoles for the classical groups, *Comm. Math. Phys.* **122** (1989), 35–89. MR **91d:**58037; 2. with

C. P. Boyer, B. M. Mann, and R. J. Milgram, The topology of instanton moduli spaces. I. The Atiyah-Jones conjecture, *Ann. of Math. (2)* **137** (1993), 561–609. MR **94h:**55010; 3. with C. P. Boyer, B. M. Mann, and R. J. Milgram, The topology of the space of rational maps into generalized flag manifolds, *Acta Math.* **173** (1994), 61–101. MR **95h:**55007; 4. Integrable systems and algebraic surfaces, *Duke Math. J.* **83** (1996), 19–50. MR **97c:**14032a; 5. with E. Markman, Rank 2-integrable systems of Prym varieties, *Adv. Theor. Math. Phys.* **2** (1998), 633–695. MR **99k:**14073.

Statement: These are exciting times for mathematics, with all sorts of new ties being forged, both within the discipline and with other fields. A professional society such as the AMS has an important role to play in developing the discipline. The AMS has a unique role in that it provides an essential service not only to American mathematicians but also to the world's. For all of these reasons it will be a pleasure and an honor to serve on the AMS Council.

Kevin P. Knudson*



Assistant Professor of Mathematics, Mississippi State University.

Born: October 7, 1969, Wausau, Wisconsin.

Ph.D.: Duke University, 1996.

Selected Addresses: Great Lakes K-Theory Conference, Evanston, April 1997; Colloquium, Department of Mathematics and Statistics, University of Nebraska-Lincoln, September 2001; Ontario Topology Seminar, London, ON, October 2001; AMS Special Sessions: Arrangements in Topology and Algebraic Geometry, and Algebraic Number Theory and K-Theory, Baton Rouge, March 2003.

Additional Information: Alfred P. Sloan Foundation Doctoral Dissertation Fellowship, 1995–1996; NSF Mathematical Sciences Postdoctoral Fellowship, August 1996–August 1999; Wayne State University Board of Governors Faculty Recognition Award, May 2002; Co-organizer, AMS Special Sessions: Algebraic K-Theory and Motivic Cohomology, Chicago, September 1998; and Group Cohomology in Algebra and Geometry, Chapel Hill, October 2003; Member: AMS.

Selected Publications: 1. The homology of special linear groups over polynomial rings, *Ann. Sci. École Norm. Sup. (4)* **30** (1997), 385–415. MR **98c:**20087; 2. On the K-theory of elliptic curves, *J. Reine Angew. Math.* **507** (1999), 81–91. MR **2000b:**20056; 3. Relative completions of linear groups over $\mathbb{Z}[t]$ and $\mathbb{Z}[t, t^{-1}]$, *Trans. Amer. Math. Soc.* **352** (2000), 2205–2216. MR **2000j:**20081; 4. Homology of linear groups, Progress in Mathematics, vol. 193, Birkhäuser-Verlag, Basel, 2001. MR **2001j:**20070; 5. Relative completions and the cohomology of linear groups over local rings, *J. London Math. Soc. (2)* **65** (2002), 183–203. MR **2002m:**20077.

Statement: As mathematicians we have two primary tasks—research and education. The AMS is no different. As government budgets shrink and student enthusiasm wanes, it is the Society's mission to remind everyone that mathematics is the queen of the sciences. This includes lobbying funding agencies to support mathematical research and reaching out to young people and their teachers to excite them about our field, to remind them that they loved to count once upon a time.

Getting people in the door is only part of the job, however. The AMS must take steps to retain them by promoting education at the undergraduate and graduate levels and by pushing for expanded job opportunities for young mathematicians. The 1990s were, by and large, a dismal time to be a new Ph.D. in mathematics; many talented individuals left the field. The Society's lobbying efforts should include an emphasis on this problem. A few programs (VIGRE, Centennial Fellowships, etc.) deal with this issue, but more needs to be done to ensure the future health of our discipline.

I am committed to improving the state of American mathematics. I would be honored to pursue this end as a Member at Large of the Council.

Michael T. Lacey

Professor and Associate Chair for Undergraduate Studies, Georgia Institute of Technology.

Born: September 26, 1959, Abilene, Texas.

Ph.D.: University of Illinois at Urbana-Champaign, 1987.

Selected Addresses: AMS Invited Address, Atlanta, October 1997; Invited Address, International Congress of Mathematicians, Berlin, 1998; Plenary Address, Young Analysts Meeting, Furman University, South Carolina, 2001; Invited Address, Oberwolfach, Germany, 2002; Short Course on Harmonic Analysis, Erwin Schrödinger Institute, Vienna, Austria, 2003.

Additional Information: Raphael Salem Prize (with Christoph Thiele), 1997.

Selected Publications: 1. with C. Thiele, L^p estimates on the bilinear Hilbert transform for $2 < p < \infty$, *Ann. of Math.* **146** (1997), 693–724. MR **99b:**42014; 2. with C. Thiele, On Calderón's conjecture, *Ann. of Math.* **149** (1999), 475–496. MR **2000d:**42003; 3. The bilinear maximal functions map into L^p for $2/3 < p \leq 1$, *Ann. of Math.* **151** (2000), 35–57. MR **2001b:**42015; 4. with C. Thiele, A proof of boundedness of the Carleson operator, *Math. Res. Lett.* **7** (2000), 361–370. MR **2001m:**42009; 5. with P. Auscher, S. Hofmann, A. McIntosh, and Ph. Tchamitchian, The solution of the Kato square root problem for second order elliptic operators on $\mathbb{R}^n$, *Ann. of Math.* **156** (2002), 633–654.

Statement: My central concerns as a member of the mathematics community are creating beautiful mathematics and fostering the next generation of mathematicians. Current issues and problems facing the American Mathematical Society are diverse. External funding for a broader range

of currently active research mathematicians remains at challenging levels. Funding of programs designed to promote graduate students through the Ph.D. are having an important effect on the manner and methods used to train these students. Fascinating applications of deep mathematics to a range of applied and computational areas continue to grow and point to solutions of new computationally difficult problems. The role of U.S. mathematicians in the development of a worldwide discipline should also be maintained and improved.

It would be a privilege to contribute to the Council's deliberations as a Member at Large of the Council.

Fred S. Roberts

Professor of Mathematics, Rutgers University, New Brunswick, and Director, DIMACS (Center for Discrete Mathematics and Theoretical Computer Science), a consortium of Rutgers and Princeton Universities, AT&T Labs, Bell Labs, NEC Laboratories America, and Telcordia Technologies.

Born: June 19, 1943, New York, New York.

Ph.D.: Stanford University, 1968.

AMS Committees: Cooperative Symposia Committee, 1991–1992; Liaison Committee with the AAAS, 1997– .

Selected Addresses: Invited Address, SIAM National Meeting, California Institute of Technology, 1974; MAA National Meeting, Biloxi, 1979; International Congress on Mathematics Education, Berkeley, 1980; Beijing Mathematical Society, 1985; Plenary Speaker and Organizing Committee Member, Second International Conference on Ordinal Data Analysis, Amherst, October 1993; Royal Nepal Academy of Science and Technology, Nepal, 1998.

Additional Information: ***Societal Institute for the Mathematical Sciences:*** Board of Directors, 1983–1992; Secretary, 1987–1992; ***Recent prizes:*** ACM-SIGACT Distinguished Service Award, 1999; NSF Science and Technology Centers Pioneer Award, 2001; ***Publications:*** Author of some 145 scientific articles and 4 books, and editor of 14 books covering such varied topics as energy modeling, reliability of computer and communication networks, mathematical psychology, computational biology, and precollege discrete mathematics.

Selected Publications: 1. *Discrete Mathematical Models with Applications to Social, Biological and Environmental Problems*, Prentice-Hall, Englewood Cliffs, 1976 (Russian Translation, "Nauka", Moscow, 1986). MR **88e:**00020; 2. *Graph Theory and Its Applications to Problems of Society*, CBMS-NSF Regional Conf. Ser. Appl. Math., vol. 29, SIAM, Philadelphia, 1979. MR **80g:**90036; 3. *Measurement Theory, with Applications to Decisionmaking, Utility and the Social Sciences*, Encyclopedia Math. Appl., vol. 7, Addison-Wesley, Reading, MA, 1979. MR **81b:**90003; 4. *Applied Combinatorics*, Prentice-Hall, Englewood Cliffs, 1984. MR **85h:**05001; 5. *Contemporary Trends in Discrete Mathematics* (R. Graham, J. Kratochvil, J. Nešetřil, and F. Roberts, eds.), DIMACS Ser. Discrete Math. Theoret. Comput. Sci., vol. 49, Amer. Math. Soc., Providence, RI, 1999. MR **2000d:**00009.

Statement: I would bring to the Council interests in a wide range of applications of mathematics in the social, behavioral, biological, and environmental sciences and to problems of communication and transportation. In the past two years, my own work has turned to uses of mathematical methods in homeland security, specifically defense against bioterrorist attacks, and more generally to problems of epidemiology and public health, and I believe that mathematics has a very useful role to play in these fields.

I have organized almost fifty scientific meetings and several multiyear programs of workshops and research working groups on mathematical support for molecular biology and computational and mathematical epidemiology, so I know a lot about what makes meetings work and also about interdisciplinary activities. I have extensive connections with mathematical sciences groups in industry and feel I understand both the needs of mathematicians in industry and the role that they can play in furthering the mathematical sciences enterprise. Having been involved in programs ranging from K–12 education to interdisciplinary postdoctoral training, I also have a long-standing interest in mathematics education at all levels and believe that AMS involvement in educational programs and activities is important.

Alejandro Uribe

Professor, Mathematics Department, University of Michigan, Ann Arbor.

Born: 1955, Mexico City, Mexico.

Ph.D.: Massachusetts Institute of Technology, 1982.

AMS Committees: Centennial Fellowships Committee, 2000–2002.

Selected Addresses: Colloquium, University of Wisconsin-Madison, November 1998; AMS Special Session on Hamiltonian Mechanics: Applications to Celestial Mechanics and Chemistry, San Antonio, January 1999; AMS Special Session on Functional Analysis and Its Applications, Denton, May 1999; Colloquium, University of Toronto, fall 1999; Colloquium, Purdue University, fall 1999; Invited Lecture Series Speaker, Aspects of Quantization, Centre de Recherches Mathématiques, Montreal, August 2001.

Additional Information: Invited Professor, École Normale Supérieure, Paris, June 2000; Associate Chair for Education, University of Michigan Mathematics Department, 2000–2001; Interim Chair, University of Michigan Mathematics Department, 2001–2002; Plenary Session Panelist, Michigan Mathematics Forum on the Mathematical Preparation of Elementary School Teachers, March 2002; Member: AMS, IAS (1989–1990), MSRI (fall 1998, March 2001, and May 2003), Societé Mathématique de France, Sociedad Matemática Mexicana.

Selected Publications: 1. with V. Guillemin, Circular symmetry and the trace formula, *Invent. Math.* **96** (1989), 385–423. MR **90e:**58159; 2. with D. Borthwick and T. Paul, Legendrian distributions with applications to relative Poincaré series, *Invent. Math.* **122** (1995), 359–402. MR **97a:**58188; 3. with D. Borthwick and T. Paul, Semiclassical spectral estimates for Toeplitz operators, *Ann. Inst. Fourier (Grenoble)* **48** (1998), 1189–1229. MR **2000c:**58048; 4. with D. Borthwick, Nearly Kählerian embeddings of symplectic manifolds, *Asian J. Math.* **4** (2000), 599–620. MR **2001m:**53166; 5. with A. Bloch, F. Golse, and T. Paul, Dispersionless Toda and Toeplitz operators, *Duke Math J.* **117** (2003), 157–196.

Statement: I consider excellence in research (both pure and interdisciplinary) and in education to be the fundamental goals of our profession. In these uncertain times it is especially important to work to maintain these goals sharply in focus, both within academia and in our society at large. I would work in the direction of these goals, if elected, especially in supporting the research of young mathematicians, promoting the development of sound pedagogical tools, and fighting against the "math phobia" so pervasive outside mathematics departments.

Nominating Committee

Annalisa Crannell

Associate Professor of Mathematics, Franklin & Marshall College.

Born: March 26, 1966, Palo Alto, California.

Ph.D.: Brown University, 1992.

AMS Committees: AMS-MAA-SIAM Joint Committee on Employment Opportunities, 1994 (consultant), 2003– ; Committee on the Profession, 1994–2000; Short Course Subcommittee, 2000–2002.

Selected Publications: 1. The role of transitivity in Devaney's definition of chaos, *Amer. Math. Monthly* **102** (1995), 788–797. MR **96j:**58107; 2. The existence of many periodic non-travelling solutions to the Boussinesq equation, *J. Differential Equations* **126** (1996), 169–183. MR **97a:**35197; 3. with M. Martelli, Dynamics of quasicontinuous systems, *J. Differ. Equations Appl.* **6** (2000), 351–361. MR **2001d:**37012; 4. with B. Shanfelder, Chaotic results for a triangular map of the square, *Math. Mag.* **73** (2000), 13–20. MR **2002c:**37063; 5. with R. Kopperman, Setwise quasicontinuity and Π-related topologies, *Real Anal. Exchange* **26** (2000/01), 609–622. MR **2002d:**54021.

Statement: The Nominating Committee has the task of proposing candidates for election to various offices of the Society. This means, of course, that the Nominating Committee should have a good knowledge of the membership and of potential candidates. It also means that the Nominating Committee should pay careful attention to balance and diversity—not merely in the sociological sense of "diversity" (although certainly that, too), but also to diversity among academic institutions, geography, academic rank, and previous service to the AMS. For example, experienced officers provide a sense of history that keeps committees from duplicating failed efforts; recruiting newer officers with a fresh perspective avoids the "usual suspects" problem and keeps the AMS from becoming cliquish. Above all, the Nominating Committee plays an important role in drawing together a pool of people who will continue to support and promote mathematics and mathematical research.

Dennis DeTurck

Professor, University of Pennsylvania.

Born: July 15, 1954, Philadelphia, Pennsylvania.

Ph.D.: University of Pennsylvania, 1980.

AMS Committees: Pi Mu Epsilon Liaison Committee, 1994–1997 (chair, 1995–1997); Task Force to Review AMS Primary Journals, 1996–1997; Contemporary Mathematics Editorial Committee, 1996– (chair); Centennial Fellowship Selection Committee, 2003–.

Selected Addresses: Special Session on Variational Problems in Riemannian Geometry, New York, April 1983; Special Session on Geometric Methods for Partial Differential Equations, San Luis Obispo, November 1983; AMS Invited Address, Mobile, May 1985; Special Session on Recent Results in Gauge Field Theory and Riemannian Geometry, San Antonio, January 1987; Special Session on Geometry, Physics and Nonlinear PDEs, Fayetteville, March 1990; Special Session on Ricci Curvature and Related Topics, Philadelphia, October 1991; AMS-MAA Invited Address, San Diego, January 2002.

Additional Information: Reviewer, *Mathematical Reviews*, 1982–1992; Sloan Fellow, 1985–1987; Associate Editor, *American Mathematical Monthly*, 1986–1991; Member, Institute for Advanced Study, 1989–1990; Editorial Board, *Studies in Advanced Mathematics*, 1990– ; CBMS Panelist, 1991–1992; JPBM Public Information Resources Committee, 1992– ; MAA Haimo Award for Distinguished Teaching, 2002; Director, "Access Science", an NSF-supported outreach program in West Philadelphia.

Selected Publications: 1. Existence of metrics with prescribed Ricci curvature: Local theory, *Invent. Math.* **65** (1981/1982), 179–207. MR **83b:**53019; 2. with C. Gordon, Isospectral Riemannian metrics and potentials, *Bull. Amer. Math. Soc. (N.S.)* **17** (1987), 137–139. MR **88m:**58185; 3. with H. Goldschmidt and J. Talvacchia, Connections with prescribed curvature and Yang-Mills currents: The semisimple case, *Ann. Sci. École Norm. Sup. (4)* **24** (1991), 57–112. MR **92a:**53034; 4. with H. Gluck, C. Gordon, and D. Webb, The inaudible geometry of nilmanifolds, *Invent. Math.* **111** (1993), 271–284. MR **93k:**58222; 5. with J. Cantarella and H. Gluck, Upper bounds for the writhing of knots and the helicity of vector fields, *Knots, Braids, and*

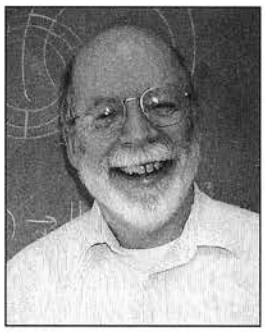
Mapping Class Groups—Papers Dedicated to Joan S. Birman (J. Gilman, X.-S. Lin, and W. Menasco, eds.), AMS/IP Stud. Adv. Math., vol. 24, Amer. Math. Soc., Providence, RI, 2001.
Statement: The Society must maintain its focus on the vitality of the mathematical research enterprise. At the same time, it should encourage the involvement of research mathematicians in K–12 education, and work to safeguard the status of the profession and to ensure that it welcomes and nurtures a diverse cohort of new members.

Arthur M. Jaffe

Landon T. Clay Professor of Mathematics and Theoretical Science, Harvard University.
Ph.D.: Princeton University, 1966
AMS Offices: Executive Committee of the Council, 1991–1994, 1996–1999; President, 1997–1998; Board of Trustees, 1997–1998.
AMS Committees: Committee to Monitor Problems in Communication, 1986–1991 (chair, 1991); Committee to Select the Gibbs Lecturers for 1987 and 1988 (chair); Committee on Steele Prizes, 1989–1992; Long Range Planning Committee, 1993 (chair), 1997–1998; Agenda and Budget Committee, 1994, 1997–1998; Rochester Task Force, 1996–1997 (chair); Science Policy Committee, 1996–2002 (chair, 1999–2000); Committee on Meetings and Conferences, 1997–1998; Committee on the Profession, 1997–1998; Committee on Publications, 1997–1998; Committee on Education, 1997– .
Selected Addresses: AMS Summer Research Institute on Partial Differential Equations, Berkeley, August 1971; AMS Invited Address, New York, April 1977; Invited Address, International Congress of Mathematicians, Helsinki, 1978; AMS Symposium on the Mathematical Heritage of Henri Poincaré, Bloomington, April 1980; AMS Retiring Presidential Address, Washington, DC, January 2000.
Additional Information: Guggenheim Fellow, 1977, 1992; New York Academy of Sciences Prize for the Mathematical and Physical Sciences, 1979; Dannie Heinemann Prize for Mathematical Physics, American Institute of Physics and the American Physical Society, 1980; Member, David Committee: Committee's work led to the report *Renewing American Mathematics* (1981–1984); Chief Editor, *Communications in Mathematical Physics*, 1981–2000, and associate editor for several other journals; Chair, Harvard University Mathematics Department, 1987–1990; Trustee, MSRI, Berkeley, 1991–1995; Founding Member and President, Clay Mathematics Institute, 1998–2002; Fellow: American Academy of Arts and Sciences, AAAS; Member, NAS.
Selected Publications: 1. with J. Glimm, The $\lambda(\phi^4)_2$ quantum field theory without cutoffs, III. The physical vacuum, *Acta Math.* **125** (1970), 203–267. MR **42:**4130; 2. with J. Glimm and T. Spencer, The Wightman axioms and particle structure in the $\mathcal{P}(\phi)_2$ quantum field model, *Ann. of Math.* **100** (1974), 585–632. MR **50:**15694; 3. with A. Lesniewski and K. Osterwalder, Quantum K-theory, I. The Chern character, *Comm. Math. Phys.* **118** (1988), 1–14. MR **90a:**58170; 4. Twist fields, the elliptic genus, and hidden symmetry, *Proc. Natl. Acad. Sci. U.S.A.*, **97** (2000), 1418–1422. MR **2001h:**58039; 5. Derivatives with twists, *Rev. Math. Phys.* **14** (2002), 887–895.
Statement: This has been a banner year for mathematics. Among many advances, we witnessed the discovery of a polynomial-time primality test and learned new ideas about gradient flows that appear to illuminate the Poincaré conjecture. This evidence suggests that we live in a golden age of mathematics.

In this environment the AMS remains a powerful force, assisting us to disseminate our results and to communicate both inside and outside our community. The AMS also helps inspire a new generation of students to develop their mathematical talents. It acts in various ways to help shape the profession and to explain mathematics to a wide audience. The Nominating Committee provides a link between the past and the future; it provides an opportunity to encourage participation and positive change.

Robion C. Kirby

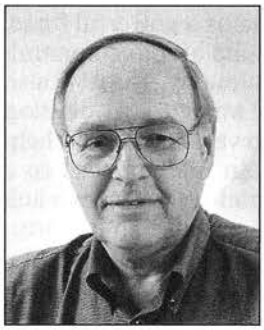


Professor of Mathematics, University of California, Berkeley.
Born: February 25, 1938, Chicago, Illinois.
Ph.D.: University of Chicago, 1965.
AMS Offices: Member at Large of the Council, 1974–1976, 1988–1990; Executive Committee of the Council, 1976–1977.
AMS Committees: Committee to Select the Winner of the Veblen Prize, 1976, 1999–2000; AMS-MAA-SIAM Joint Projects Committee for Mathematics, 1978–1980; Committee on Graduate Studies in Mathematics, 1993–1995; *Notices* Editorial Board, 2001–2003 (associate editor).
Selected Addresses: AMS Invited Address, Eugene, August 1969; Invited Address, International Congress of Mathematicians, Nice, 1970.
Additional Information: Veblen Prize, 1971; Deputy Director, Mathematical Sciences Research Institute, 1985–1987; Award for Scientific Reviewing, National Academy of Sciences, 1995; Member, National Academy of Sciences, 2001.
Selected Publications: 1. Stable homeomorphisms and the annulus conjecture, *Ann. of Math.* **89** (1969), 575–582. MR **39:**3499; 2. with L. C. Siebenmann, On the triangulation of manifolds and the Hauptvermutung, *Bull. Amer. Math. Soc.* **75** (1969), 742–749. MR **39:**3500; 3. A calculus for framed links in S^3, *Invent. Math.* **45** (1978), 35–56. MR **57:**7605; 4. *The Topology of* 4*-Manifolds*, Lecture Notes in Math., vol. 1374, Springer-Verlag, Berlin, 1989. MR **90j:**57012; 5. Editor, Problems in low dimensional topology, *Geometric Topology* (William Kazez, ed.), AMS/IP Stud.

Adv. Math., vol. 2.2, Amer. Math. Soc., Providence, RI, 1997, pp. 35-473.

Statement: As I write this during the early days of the conflict in Iraq, it is worthwhile to recall that the AMS was founded in 1888 to further the interests of mathematical research and scholarship. The AMS should do this with the participation of all mathematicians, irrespective of race, gender, citizenship, language, or political stance.

Thomas G. Kurtz



Professor of Mathematics and Statistics, University of Wisconsin-Madison.

Born: July 14, 1941, Kansas City, Missouri.

Ph.D.: Stanford University, 1967.

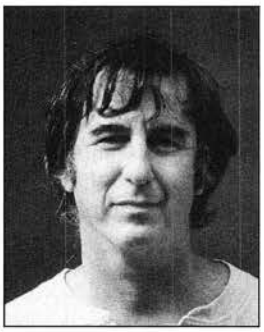
AMS Committees: *Proceedings* Editorial Committee, 1978–1982 (associate editor); Committee on Academic Freedom, Tenure, and Employment Security, 1988–1991; AMS-SIAM Birkhoff Prize Selection Committee, 1994 (chair).

Selected Addresses: Principal Lecturer, CBMS-NSF Regional Conference, Missoula, Montana, 1979; IMS Special Invited Paper, Davis, California, 1980; IMS Special Invited Paper, Washington, DC, 1989; Keynote Lecture, INFORMS Applied Probability Conference, Atlanta, 1995; AMS Special Session on Stochastic Models, San Diego, January 1997; AMS-SMM Special Session on Stochastic Analysis and Probability, Morelia, May 2001; AMS Special Session on Stochastic Analysis with Applications, Bloomington, April 2003.

Additional Information: NSF Division of Mathematical Sciences Advisory Committee, 1987–1990 (chair, 1988–1989); Council of the Bernoulli Society, 1987–1991, 2001– ; Committee on Conferences on Stochastic Processes, 1987–1999 (chair, 1995–1997); NRC Committee on Applied and Theoretical Statistics, 1998–2000; Editor, *Annals of Probability*, 2000–2002; IMA Board of Governors, 2001– (chair, 2003); Fellow, Institute of Mathematical Statistics; Member: AMS, IMS, INFORMS, ISI, MAA, SIAM.

Selected Publications: 1. *Approximation of Population Processes*, CBMS-NSF Regional Conf. Ser. Appl. Math., vol. 36, SIAM, Philadelphia, 1981. MR **82j:**60160; 2. with S. N. Ethier, *Markov Processes: Characterization and Convergence*, Wiley Ser. Probab. Math. Stat., John Wiley and Sons, Inc., New York, 1986. MR **88a:**60130; 3. with P. E. Protter, Weak convergence of stochastic integrals and differential equations. I and II, *Probabilistic Models for Nonlinear Partial Differential Equations* (D. Talay and L. Tubaro, eds.), Lecture Notes in Math., vol. 1627, Springer-Verlag, Berlin, 1996, pp. 1–41 and 197–285. MR **98h:**60073 and MR **98h:**60074; 4. with P. Donnelly, Particle representations for measure-valued population models, *Ann. Probab.* **27** (1999), 166–205. MR **2000f:**60108; 5. with R. H. Stockbridge, Stationary solutions and forward equations for controlled and singular martingale problems, *Elec. J. Probab.* **6** (2001), no. 17 (electronic). MR **2002j:**60128.

Joel H. Spencer



Professor of Mathematics and Computer Science and Chair, Department of Mathematics, New York University, Courant Institute of Mathematical Sciences.

Born: April 20, 1946, New York, New York.

Ph.D.: Harvard University, 1970.

AMS Offices: Member at Large of the Council, 1997–1999; Executive Committee of the Council, 1998–2001 (chair, 2000).

AMS Committees: Program Committee for National Meetings, 1994–1996 (chair, 1995–1996); Meetings and Conferences Committee, 1997–1999 (chair); Committee on Committees, 1999–2000; Interim Committee on the Young Scholars Program, 1999–2003 (chair).

Selected Addresses: Invited Speaker, International Congress of Mathematicians, Zurich, 1994; Plenary Speaker, Paul Erdős and His Mathematics, Budapest, 1999; AMS Invited Address, Chattanooga, October 2001; Invited Speaker, CombinaTexas: Combinatorics in the South-Central U.S., Denton, March 2002; Three Lecture Series, ICTP, Trieste, 2002.

Additional Information: Putnam Competition Winner, 1962; Sloan Fellow, 1977–1981; Ford Award, 1984; CBMS Lecturer, 1986. Extended Visits: Budapest (1976–1977, 1984), Rehovot (1980), Reading (1981), MIT (1987, 1990, 2001), IAS (1997, 1998), Melbourne (1998). Member: AMS, MAA, SIAM.

Selected Publications: 1. with R. L. Graham and B. L. Rothschild, *Ramsey Theory*, John Wiley & Sons, New York, 1980. MR **82b:**05001; Second Edition, 1990. MR **90m:**05003; 2. with N. Alon, *The Probabilistic Method*. With an appendix by Paul Erdős, John Wiley & Sons, New York, 1992. MR **93h:**60002; Second Edition, 2000; 3. with S. Shelah, Zero-one laws for sparse random graphs, *J. Amer. Math. Soc.* **1** (1988), 97–115. MR **89i:**05249; 4. with B. Pittel and N. Wormald, Sudden emergence of a giant k-core in a random graph, *J. Combin. Theory Ser. B.* **67** (1996), 111–151. MR **97e:**05176; 5. *The Strange Logic of Random Graphs*, Springer-Verlag, Berlin, 2001. MR **2003d:**05196.

Statement: I am continually impressed by the commitments of time and energy of so many mathematicians in their work for the AMS. We have an enormous pool of talent in our membership. The key function of the Nominating Committee, as I see it, is to find the right person for the right position so that this talent may be best used for the betterment of our profession as a whole.

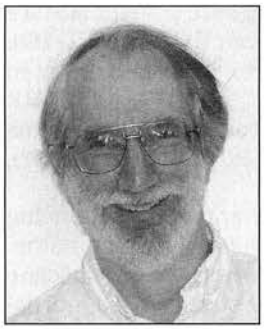
Editorial Boards Committee

David L. Colton

Unidel Professor of Mathematical Sciences, University of Delaware.

Born: March 14, 1943, San Francisco, California.

Ph.D.: University of Edinburgh, 1967; D.Sc.: University of Edinburgh, 1977.



Selected Addresses: Plenary Lecture, GAMM Annual Meeting, Göttingen, Germany, 2000; Four lectures, MSRI Introductory Workshop in Integral Geometry and Inverse Problems, Berkeley, 2001; Four lectures, INRIA School on Direct and Inverse Scattering Problems, Paris, 2003.

Additional Information: Editorial Boards: *SIAM Journal on Applied Mathematics*; *Inverse Problems*; Society for the Interaction of Mathematics and Mechanics Book Series, Springer-Verlag, 2003– .

Selected Publications: 1. *Analytic Theory of Partial Differential Equations*, Monogr. Stud. Math., vol. 8, Pitman Publishing, Boston–London, 1980. MR **82j:**35001; 2. with R. Kress, *Integral Equation Methods in Scattering Theory*, Wiley-Interscience, New York, 1983. MR **85d:**35001; Russian translation, "Mir", Moscow, 1987. MR **88g:**35002; 3. *Partial Differential Equations: An Introduction*, The Random House/Birkhäuser Math. Ser., Random House, New York, 1988. MR **89j:**35002; 4. with R. Kress, *Inverse Acoustic and Electromagnetic Scattering Theory*, Appl. Math. Sci., vol. 93, Springer-Verlag, Berlin, 1992. MR **93j:**35124; Second Edition, 1998. MR **99c:**35181; 5. with J. Coyle and P. Monk, Recent developments in inverse acoustic scattering theory, *SIAM Rev.* **42** (2000), 369–414. MR **2001f:**76066.

Statement: I am a firm believer in the need for mathematics to have a close connection with applications and have served on the editorial boards of a variety of journals, both pure and applied, over the past twenty years. I would hope to bring this type of expertise to the AMS Editorial Boards Committee.

Emma Previato

Professor of Mathematics, Boston University.

Ph.D.: Harvard University, 1983.

AMS Committees: Committee on Human Rights of Mathematicians, 2003–.

Selected Addresses: AMS Invited Address, Williamstown, October 2001.

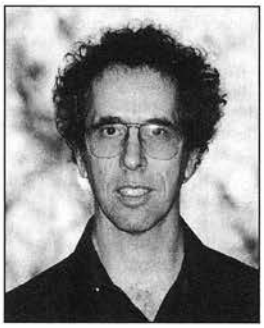
Additional Information: Member, IAS, 1984–1985, 2002–2003; Fellow, Royal Academy of Sweden, Mittag-Leffler Institute, 1986–1987; UK Research Council, fall 1987; Bunting Institute, 1995–1996; MAA/NES Teacher of the Year Award, 2003; Member: AWM, MAA; Reciprocity Member: LMS; AAAS, 1988; Institute of Physics (UK), 2000.

Selected Publications: 1. with G. Wilson, Vector bundles over curves and solutions of the KP equations, *Theta Functions—Bowdoin 1987, Part 1*, Proc. Sympos. Pure Math., vol. 49, Part 1, Amer. Math. Soc., Providence, RI, 1989, pp. 553–569. MR **90i:**14018; 2. Seventy years of spectral curves: 1923–1993, *Integrable Systems and Quantum Groups* (R. Donagi, B. Dubrovin, E. Frenkel, and E. Previato), Lecture Notes in Math., vol. 1620, Springer, Berlin, 1996, pp. 419–481. MR **97e:**58119; 3. with B. van Geemen, On the Hitchin system, *Duke Math. J.* **85** (1996), 659–683. MR **97k:**14010; 4. with W. M. Oxbury and C. Pauly, Subvarieties of $S\mathcal{U}_C(2)$ and 2θ-divisors in the Jacobian, *Trans. Amer. Math. Soc.* **350** (1998), 3587–3614. MR **98m:**14034; 5. *Advances in Algebraic Geometry Motivated by Physics* (E. Previato, ed.), Contemp. Math., vol. 276, Amer. Math. Soc., Providence, RI, 2001. MR **2001m:**14002.

Statement: To the primary committee charge, that of soliciting nominations for editorial committees, I would bring special emphasis in four areas. One, the need and pleasure of rediscovering the classics, republishing early mathematics with expert interpretation in modern language and novel applications. Two, the need to serve members of the Society and the larger community by hearing from them; for example, instituting a prize for school students to produce an essay on what kind of mathematics books they would read. Three, advancing the Mathematics Digital Project hand in hand with publication, especially to bring mathematics literature to those who may be at an economic or physical disadvantage. Four, the need to establish links with other disciplines: the face of mathematics is changing rapidly in view of breakthroughs in the sciences. Mathematics publishing today is one of the most exciting places to be, and I would be most honored to serve the Society in this area.

To the committee's other charge, that of promoting women's participation, I would bring a vast network of personal acquaintances who have excelled in their field.

Daniel Ruberman



Professor of Mathematics, Brandeis University.

Born: May 12, 1955, New York, New York.

Ph.D.: University of California, Berkeley, 1982.

AMS Committees: *Bulletin* Editorial Committee, 1995–2001 (associate editor for research reports).

Additional Information: Chair, Mathematics Department, Brandeis University, 1998–2000.

Selected Addresses: Séminaire Arthur Besse, École Polytechnique, Palaiseau, June 2001; Conference on Holomorphic Curves and Low-Dimensional Topology, Institute for Advanced Studies, March 2002; William J. Spencer Lecture, Kansas State University, May 2002; Ontario Topology Conference, October 2002; AMS Special Session on Geometric Topology, Bloomington, April 2003.

Selected Publications: 1. Mutation and volumes of knots in S^3, *Invent. Math.* **90** (1987), 189–215. MR **89d:**57018; 2. with J. Morgan and T. Mrowka, *The L^2-Moduli Space and a Vanishing Theorem for Donaldson Polynomial Invariants*, Monogr. Geom. Topol., Vol. II, International Press, Cam-

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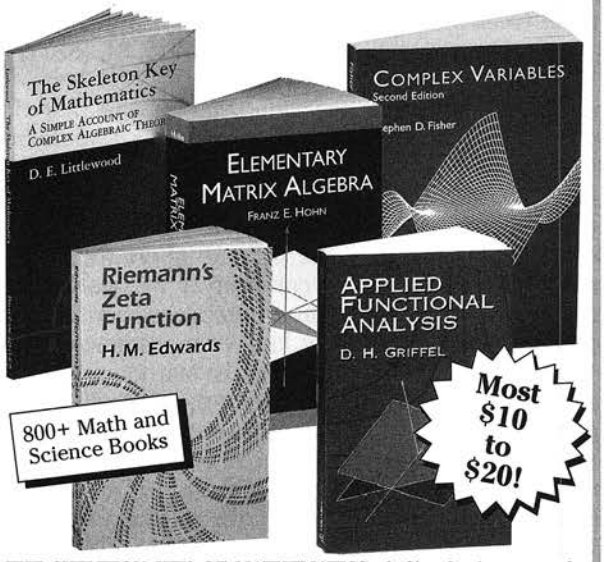

THE SKELETON KEY OF MATHEMATICS: A Simple Account of Complex Algebraic Theories, D. E. Littlewood. Straightforward explanation of abstract principles common to science and math. Euclid's algorithm; congruences; polynomials; complex numbers and algebraic fields; algebraic integers, ideals, and *p*-adic numbers; groups; Galois theory; algebraic geometry; more. "Unreservedly recommended"—*Journal of the Institute of Actuaries Students' Society.* 1960 ed. (1949 pub.) 138pp. 5⅜ x 8½. **42543-6 $9.95**

ELEMENTARY MATRIX ALGEBRA, Franz E. Hohn. Fully rigorous treatment starts with basics and progresses to sweepout process for obtaining complete solution of any given system of linear equations and role of matrix algebra in presentation of useful geometric ideas, techniques, and terminology. Also, commonly used properties of determinants, linear operators and linear transformations of coordinates. 1973 ed. xviii+524pp. 5⅜ x 8½. **42534-7 $24.95**

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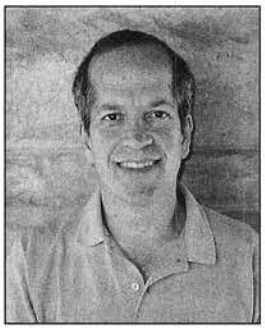
bridge, 1994. MR **95h:**57039; 3. with D. Jaffe, A sextic surface cannot have 66 nodes, *J. Algebraic Geom.* **6** (1997), 151–168. MR **98m:**14035; 4. An obstruction to smooth isotopy in dimension 4, *Math. Res. Lett.* **5** (1998), 743–758. MR **2000c:**57061; 5. Positive scalar curvature, diffeomorphisms and the Seiberg-Witten invariants, *Geom. Topol.* **5** (2001), 895–924. MR **2002k:**57076.

Statement: The AMS plays an important role in producing high-quality journals that give access to important mathematics at a reasonable price. My experience as an associate editor of *Bulletin* showed me that the strength of a journal is determined by the discrimination and breadth of its editors and by their energy in pursuing good papers. As a member of the Editorial Boards Committee, I would work to enhance the Society's journals by appointing knowledgeable mathematicians who will take an active role as editors.

Karl Rubin



Professor of Mathematics, Stanford University.

Born: January 27, 1956, Urbana, Illinois.

Ph.D.: Harvard University, 1981.

AMS Committees: Centennial Fellowships Committee, 1990–1991; Central Section Program Committee, 1993–1994 (chair, 1994); Committee to Select the Winner of the Cole Prize, 1995–1996 (chair); Arnold Ross Lecture Series Committee, 1995–1997.

Selected Addresses: AMS Invited Addresses: East Lansing, March 1988; Worcester, April 1989; AAAS Topical Lecture, San Francisco, January 1994; AMS-MAA-SIAM Invited Address, Washington, DC, January 2000; International Congress of Mathematicians, Beijing, 2002.

Additional Information: AMS Cole Prize in Number Theory, 1992; Editor: *Journal of Number Theory*, 1987–1999; *Compositio Mathematica*, 1993–1998; *Journal für die reine und angewandte Mathematik*, 1994–2001.

Selected Publications: 1. Tate-Shafarevich groups and *L*-functions of elliptic curves with complex multiplication, *Invent. Math.* **89** (1987), 527–559. MR **89a:**11065; 2. The "main conjectures" of Iwasawa theory for imaginary quadratic fields, *Invent. Math.* **103** (1991), 25–68. MR **92f:**11151; 3. with A. Silverberg, A report on Wiles' Cambridge lectures, *Bull. Amer. Math. Soc. (N.S.)* **31** (1994), 15–38. MR **94k:**11062; 4. *Euler Systems*, Ann. of Math. Stud., vol. 147, Princeton University Press, Princeton, 2000. MR **2001g:**11170; 5. with A. Silverberg, Ranks of elliptic curves, *Bull. Amer. Math. Soc. (N.S.)* **39** (2002), 455–474.

Statement: AMS journals are an important service to the mathematical community, and the primary responsibility for maintaining their quality lies with their editorial boards. A good editor should be conscientious, well organized, and fair and must have a broad and deep knowledge of relevant subject areas. In addition, the editorial committees should be representative of the mathematical community.

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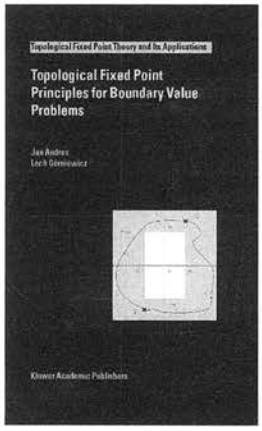

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This monograph will be especially useful for post-graduade students and researchers interested in topological methods in nonlinear analysis, particularly in differential equations, differential inclusions and (multivalued) dynamical systems. The content is also likely to stimulate the interest of mathematical economists, population dynamics experts as well as theoretical physicists exploring the topological dynamics.

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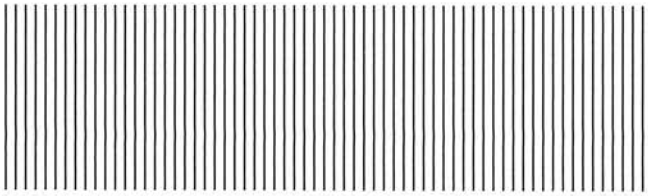

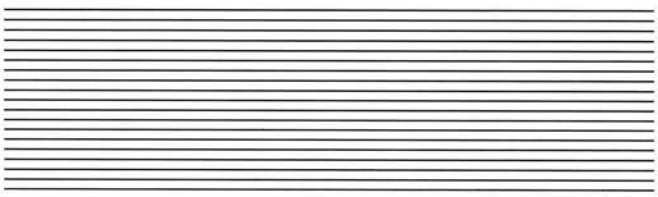

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Most recent, if any, position held *post Ph.D.*

University or Company _____

Position Title _____

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

_____

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

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

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

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

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This form is provided courtesy of the American Mathematical Society.

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

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

2000 Mathematics Subject Classification

00 General
01 History and biography
03 Mathematical logic and foundations
05 Combinatorics
06 Order, lattices, ordered algebraic structures
08 General algebraic systems
11 Number theory
12 Field theory and polynomials
13 Commutative rings and algebras
14 Algebraic geometry
15 Linear and multilinear algebra, matrix theory
16 Associative rings and algebras
17 Nonassociative rings and algebras
18 Category theory, homological algebra
19 *K*-theory
20 Group theory and generalizations
22 Topological groups, Lie groups
26 Real functions
28 Measure and integration
30 Functions of a complex variable
31 Potential theory
32 Several complex variables and analytic spaces
33 Special functions
34 Ordinary differential equations
35 Partial differential equations
37 Dynamical systems and ergodic theory
39 Difference and functional equations
40 Sequences, series, summability
41 Approximations and expansions
42 Fourier analysis
43 Abstract harmonic analysis
44 Integral transforms, operational calculus
45 Integral equations
46 Functional analysis
47 Operator theory
49 Calculus of variations and optimal control, optimization

51 Geometry
52 Convex and discrete geometry
53 Differential geometry
54 General topology
55 Algebraic topology
57 Manifolds and cell complexes
58 Global analysis, analysis on manifolds
60 Probability theory and stochastic processes
62 Statistics
65 Numerical analysis
68 Computer science
70 Mechanics of particles and systems
74 Mechanics of deformable solids
76 Fluid mechanics
78 Optics, electromagnetic theory
80 Classical thermodynamics, heat transfer
81 Quantum theory
82 Statistical mechanics, structure of matter
83 Relativity and gravitational theory
85 Astronomy and astrophysics
86 Geophysics
90 Operations research, mathematical programming
91 Game theory, economics, social and behavioral sciences
92 Biology and other natural sciences
93 Systems theory, control
94 Information and communication, circuits
97 Mathematics education

Mathematics Calendar

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

September 2003

2003-July 2004 **Set Theory**, Centre de Recerca Matemática, Bellaterra, Spain. (Jun./Jul. 2003, p. 721)
Organizers: Local: J. Bagaria (ICREA and Univ. of Barcelona); Visitor: S. Todorcevic (CNRS).
Main Research Topics: Ramsey methods in functional analysis, the continuum problem.
Other Research Topics: Applications of combinatorial set theory and forcing to general topology and Boolean algebras; Inner model theory for large cardinals; Generic absoluteness and its consequences in combinatorics and descriptive set theory; Current topics in descriptive set theory; Current topics in combinatorial set theory.
Seminars: There will be two weekly seminars on Set Theory (coordinated by J. Bagaria) and Combinatorics and Its Applications to Analysis (coordinated by S. Todorcevic).
Conference: Barcelona Conference on Set Theory; Dates: September 16-20, 2003; http://www.crm.es/set-theory/.
Advanced Course: Advanced Course on Ramsey Methods in Analysis; Dates: January 19-28, 2004; http://www.crm.es/RamseyMethods/.
Information: Centre de Recerca Matemática, Apartat 50, 08193 Bellaterra, Spain; tel: +34 935 811 081; fax: +34 935 812 202; http://www.crm.es/.

1-3 **3rd WSEAS International Conference on Instrumentation, Measurement, Control, Circuits and Systems**, Malta, Italy. (Aug. 2003, p. 844)
Information: http://www.wseas.org.

1-3 **3rd WSEAS International Conference on Information Science and Applications**, Malta, Italy. (Aug. 2003, p. 844)
Information: http://www.wseas.org.

1-3 **3rd WSEAS International Conference on Soft Computing, Optimization, Simulation & Manufacturing Systems**, Malta, Italy. (Aug. 2003, p. 844)
Information: http://www.wseas.org.

1-3 **4th WSEAS Multiconference in Applied Mathematics**, Malta, Italy. (Jun./Jul. 2003, p. 721)
Description: The WSEAS multiconference in linear algebra, numerical analysis, differential equations, optimization, probability and statistics, operational research, computers, education, algorithms, discrete mathematics and control is the fourth in the successful history of the conference that was held in Athens, Greece (2000); Cairns, Australia (2001); and Miedyzydroje, Poland (2002). As in 2002 in the conference in Poland, all the accepted papers will be published in WSEAS Transactions on Mathematics.
Information: http://www.wseas.org/.

1-6 **The Sixth International Workshop on Differential Geometry and Its Applications and The Third German-Romanian Seminar on Geometry**, Cluj-Napoca, Romania. (Oct. 2002, p. 1135)
Invited Speakers (confirmed by the end of May 2002): P. Benito (Spain), C.-H. Chu (England), J. Dorfmeister (Germany), A. Elduque (Spain), L. Funar (France), R. Grimaldi (Italy), Th. Hangan (France), E. Macias-Virgos (Spain), S. Marchiafava (Italy), A. Sambusetti (Italy), M. Schlichenmaier (Germany), S. Schmidt (Germany), V. Sergiescu (France), L. Vanhecke (Belgium).
Organizers: D. Andrica, "Babes Boyai" Univ. of Cluj-Napoca, email: dandrica@math.ubbcluj.ro; R. Iordanescu, Inst. of Math. of the

This section contains announcements of meetings and conferences of interest to some segment of the mathematical public, including ad hoc, local, or regional meetings, and meetings and symposia devoted to specialized topics, as well as announcements of regularly scheduled meetings of national or international mathematical organizations. A complete list of meetings of the Society can be found on the last page of each issue.
An announcement will be published in the *Notices* if it contains a call for papers and specifies the place, date, subject (when applicable), and the speakers; a second announcement will be published only if there are changes or necessary additional information. Once an announcement has appeared, the event will be briefly noted in every third issue until it has been held and a reference will be given in parentheses to the month, year, and page of the issue in which the complete information appeared. Asterisks (*) mark those announcements containing new or revised information.
In general, announcements of meetings and conferences held in North America carry only the date, title of meeting, place of meeting, names of speakers (or sometimes a general statement on the program), deadlines for abstracts or contributed papers, and source of further information. Meetings held outside the North American area may carry more detailed information. In any case, if there is any application deadline with respect to participation in the meeting, this fact should be noted. All communications on meetings and conferences in the mathematical sciences should be sent to the Editor of the *Notices* in care of the American Mathematical Society in Providence or electronically to notices@ams.org or mathcal@ams.org.
In order to allow participants to arrange their travel plans, organizers of meetings are urged to submit information for these listings early enough to allow them to appear in more than one issue of the *Notices* prior to the meeting in question. To achieve this, listings should be received in Providence **eight months** prior to the scheduled date of the meeting.
The complete listing of the Mathematics Calendar will be published only in the September issue of the *Notices*. The March, June, and December issues will include, along with new announcements, references to any previously announced meetings and conferences occurring within the twelve-month period following the month of those issues. New information about meetings and conferences that will occur later than the twelve-month period will be announced once in full and will not be repeated until the date of the conference or meeting falls within the twelve-month period.
The Mathematics Calendar, as well as Meetings and Conferences of the AMS, is now available electronically through the AMS website on the World Wide Web. To access the AMS website, use the URL: http://www.ams.org/.

Romanian Acad., Bucharest, email: Radu.Iordanescu@imar.ro; C. Pintea, "Babes Boyai" Univ. of Cluj-Napoca; C. Varga, "Babes Boyai" Univ. of Cluj-Napoca; T. Zamfirescu, Univ. of Dortmund, email: Tudor.Zamfirescu@mathematik.uni-dortmund.de.

1–December 19 **Granular and Particle-Laden Flows**, Isaac Newton Institute for Mathematical Sciences, Cambridge, England. (Mar. 2003, p. 407)
Description: The programme will be concerned with theoretical issues in the burgeoning areas of dry granular and particle laden flows. The flow of such materials is of considerable practical interest, with applications ranging from the geosciences to industry. In recent years it has also become a very active area in the international physics community, as it provides rich structure in the form of novel pattern-forming processes. Much of the progress that is made in these studies relies upon relatively simple mathematical modelling which is often ad hoc in nature. In all cases, a fundamental difficulty which makes essential theoretical input difficult is the availability of suitable continuum models. Indeed, appeal is often made to microscopic descriptions, although these are often limited in scope. Therefore, the time is now ripe for a workshop where mathematicians and physicists can be brought together to discuss these fundamental issues at a detailed level. Three specific topics will be addressed:
1. Localisation and type change: The mathematical issues raised at the interface between appropriate models for different flow regimes.
2. Pattern formation and chaos: The mathematical modelling of patterns and their dynamics in controlled experiments on segregation and vibrated layers.
3. Geophysical and particle-laden flows: Theoretical modelling of problems ranging from the formation of sedimentary rock to avalanching.
Organizers: N. Gray (Manchester), K. Hutter (Darmstadt), J. T. Jenkins (Cornell), T. Mullin (Manchester).
Information: http://www.newton.cam.ac.uk/programmes/CPD/. Isaac Newton Institute for Mathematical Sciences, 20 Clarkson Road, Cambridge, CB3 OEH or CB3 0EH; tel: +44 (0) 1223 335999; fax: +44 (0) 1223 330508; email: info@newton.cam.ac.uk.

2–5 **Symposium for the Developments of the Cantorian Set Theory**, Paris, France. (Jan. 2003, p. 83)
Organizers: F. Collot, R. Saumont, F. Anceau.
Program and Call for Papers: Search of New Axioms for the Set Theory, the Browerian Conceptions Revisited, Continuum Hypothesis, Well-Ordering on the Continuum, Generalized Continuum Hypothesis, Problem of the Countable Ordinal Numbers ε, Exotic Irrational Numbers, Nonstandard Analysis, Conway's Numbers, Applications to Computer Science, Quantic Theory, Biology, Cosmology.
Submission: Extended abstracts (at most 6 pages) of papers to be presented at the conference to: F. Collot, 4 rue Mayet 75006, Paris, before June 1, 2003. Abstracts or papers will be published in the journal *Bio-Math.*
Information: email: editions.europeenne@wanadoo.fr.

2–6 **The Barcelona Conference on Asymptotic Statistics**, Bellaterra, Barcelona, Spain. (Jan. 2003, p. 83)
Aim: The aim of the conference is to open a new line of international events devoted to asymptotic methods in statistics.
Topics: Inference for continuous-time stochastic processes, linear and nonlinear time series, wavelets and theory of extreme values.
Main Speakers: D. Boscq (Univ. Paris 6), R. Cao (Univ. de A Coruña), A. V. Ivanov (Internat. Christian Univ., Kyïv), I. Johnstone (Stanford Univ.), R. Khasminskii (Wayne State Univ.), U. Küchler (Humboldt-Univ. zu Berlin), Y. Kutoyants (Univ. de Maine) A. Le Breton (Univ. Joseph Fourier), T. Mikosch (Univ. of Copenhagen).
Coordinator: V. Zaiats.
Scientific Committee: Y. Kutoyants, U. Küchler, F. Utzet, and V. Zaiats.
Organizing Committee: F. Utzet, P. Puig, W. González, and V. Zaiats.
Deadlines: For applications for financial support, May 23; for registration and payment, June 30.
Information: email: bas2003@crm.es or visit http://www.crm.es/bas2003/.

3–5 **2003 Joint Conference on Declarative Programming: APPIA-GULP-PRODE 2003**, Reggio Calabria, Italy. (Jun./Jul. 2003, p. 722)
Description: The aim of the conference is to foster scientific cooperation between Italian, Portuguese, Spanish, and Latin American, researchers—although submissions are open to the whole declarative programming community—to improve the knowledge of the state of the art of declarative programming (through the invited talks) and to show ongoing research done (through presentations of papers).
Information: http://www.informatica.ing.unirc.it/agp03/ or email: agpo@mat.unical.it.

3–6 **ERATO Conference on Quantum Information Science 2003 (EQIS'03)**, Niijimakaikan, Kyoto, Japan. (Aug. 2003, p. 844)
Description: The EQIS meetings are to focus on quantum information science and technology, a new interdisciplinary field bridging computer science, quantum physics, mathematics, optics- and nano-technologies. EQIS'03 will be the third conference in a series and is to concentrate on theoretical and also experimental aspects of quantum information science. The program of EQIS'03 will consist of invited talks, short communications and posters. EQIS'03 is also expected to be accompanied by satelite pre- and postconference workshops.

Contributions for short communications and posters will be solicited in the research areas related to quantum information science, including but not limited to: design and analysis of quantum algorithms and circuits; quantum games; quantum computational and communication complexity; quantum computing and automata models; quantum cryptography; quantum information theory; quantum entanglement; quantum fault-tolerant and decoherence-free computations; quantum continuous variable computations; quantum geometric and topological computations; nonstandard models of quantum computation; quantum optics; NMR and solid state technologies; fermionic, bosonic, and anyonic computation.
Sponsors: ERATO Quantum Computation and Information Project, Japan Science and Technology Corporation.
Deadlines: Submissions (communications and posters): July 15, 2003. Notification of Acceptance/Rejection: August 1, 2003. Early Registration Deadline: August 9, 2003.
Information: http://www.qci.jst.go.jp/eqis03/.

4–9 **Analytic Methods of Analysis and Differential Equations (AMADE-2003)**, Belarusian State University, Minsk, Belarus. (Jan. 2003, p. 83)
Description: Belarusian State University (BSU) and Institute of Mathematics of Belarusian National Academy of Sciences, together with Moscow State University, organize the 3rd International Conference "Analytic Methods of Analysis and Differential Equations (AMADE-2003)" on September 4–9, 2003, in Minsk, Belarus. The arrival and departure days are September 3 and 10. The conference will be held under the guidance of ISAAC (International Society of Analysis, Applications and Computations).
Topics: Integral Transforms and Special Functions; Differential Equations and Applications; Integral, Difference, Functional Equations and Fractional Calculus; Real and Complex Analysis.
Organizing Committee: I. V. Gaishun (Belarus, cochair), V. A. Il'in (Russia, cochair), A. V. Kozulin (cochair), A. A. Kilbas (Belarus, vice chair), M. V. Dubatovskaya (Belarus, secretary), S. V. Rogosin (Belarus, secretary), H. Begehr (Germany), V. I. Burenkov (Great Britain), V. V. Gorokhovik (Belarus), N. A. Izobov (Belarus), V. I. Korzyuk (Belarus), P. A. Mandrik (Belarus), E. I. Moiseev (Russia), S. G. Samko (Portugal), N. I. Yurchuk (Belarus).

Program Committee: P. Adler (France), M. Dzhenaliev (Kazakhstan), H.-J. Glaeske (Germany), R. Gorenflo (Germany), V.I. Gromak (Belarus), N.K. Karapetyants (Russia), V. S. Kiryakova (Bulgaria), A. I. Kozhanov (Russia), A. Kufner (Czech), Kun Soo Chang (Korea), I. Laine (Finland), O. I. Marichev (USA), V. V. Mityushev (Poland), O. A. Repin (Russia), E. A. Rovba (Belarus), V. N. Rusak (Belarus), M. Saigo (Japan), S. Saitoh (Japan), A. A. Sen'ko (Belarus), A. P. Soldatov (Russia), J. J. Trujillo (Spain), N. A. Virchenko (Ukraine), L. A. Yanovich (Belarus).
Deadline: Let us know by the end of December 2002 about your intention to participate in the conference. Please send the following information: Your name, affiliation and position, mailing address and telephone (fax), email, section title, and title of report to: AMADE-2003, Dept. of Math. and Mech., Belarusian State Univ., Fr. Skaryny Ave. 4, 220050 Minsk 50, Belarus; email: amade@im.bas-net.by and amade@bsu.by; http://amade.virtualave.net/.

5–10 **6th International Conference on Geometry and Applications**, Varna, Bulgaria. (Jun./Jul. 2003, p. 722)
Topics: Foundations of Geometry and Incidence Geometry, Differential Geometry, Applications of Computers in Geometry, Geometry in the School.
Conference Chairs: W. Benz (Hamburg), G. Stanilov (Sofia).
Information: G. Stanilov, email: stanilov@fmi.uni-sofia.bg; Ch. Lozanov, email: lozanov@fmi.uni-sofia.bg.

7–11 **Topological Phases in Condensed Matter Physics**, AIM Research Conference Center, Palo Alto, California. (Aug. 2003, p. 844)
Program: This workshop, sponsored by AIM and the NSF, will explore the interface between topological quantum field theory and solid state physics. We will study which "topological phases" might be physically realized and how they might be detected and finally manipulated.
Organizers: M. Freedman, C. Nayak, and Z. Wang.
Deadline: June 1, 2003.
Information: http://aimath.org/ARCC/workshops/topquantum.html.

8–10 **25th World Conference on Boundary Element Methods: BEM 25: Incorporating Electromagnetic Effects on Human Beings and Equipment Seminar**, Split, Croatia. (Oct. 2002, p. 1135)
Organizer: Wessex Inst. of Tech, UK, in collaboration with the Univ. of Split, FESB Croatia.
Sponsor: The Croatian Ministry of Science and Technology.
Information: http://www.wessex.ac.uk/conferences/2003/bem25/.

8–12 **BSDCon'03**, San Mateo, California.
Information: http://www.usenix.org/events/bsdcon03/.

8–12 **Eurocomb'03–European Conference on Combinatorics, Graph Theory and Applications**, Prague, Czech Republic. (Apr. 2003, p. 498)
Topic: Combinatorics and Graph Theory. The conference concentrates mainly on four areas: algebraic, algorithmic, geometric, and probabilistic combinatorics, including their applications to other areas of mathematics, computer science and engineering. During the symposium the European Prize in Combinatorics will be awarded.
Information: http://kam.mff.cuni.cz/~ecomb03/.

8–December 13 **Inverse Problems: Computational Methods and Emerging Applications**, Institute for Pure and Applied Mathematics, UCLA, Los Angeles, California. (Oct. 2002, p. 1135)
Information: http://www.ipam.ucla.edu/programs/inv2003/.

9–11 **Quantum Analysis in Operator Algebras**, Research Institute for Mathematical Sciences, Kyoto University, Kyoto, Japan. (Aug. 2003, p. 844)
Information: http://www.kurims.kyoto-u.ac.jp/workshop-e.html.

10–12 **Sixth International Conference on Computational Methods for the Solution of Electrical and Electromagnetic Engineering Problems: ELECTROCOMP 2003**, Split, Croatia. (Oct. 2002, p. 1135)
Organizer: Wessex Inst. of Tech, UK, in collaboration with the Univ. of Split, FESB Croatia.
Information: http://www.wessex.ac.uk/conferences/2003/electrocomp03/.

11–14 **Logic, Game Theory and Social Choice 3**, University of Siena, Certosa di Pontignano, Siena, Italy. (Apr. 2003, p. 498)
Description: Following LGS1 (Tilburg 1999) and LGS2 (St. Petersburg 2001), LGS3 will bring into focus the developing theoretical connections between logic and game theory, game theory and social choice, and logic and social choice. The conference program will consist of invited lectures and contributed papers. Submissions of contributed papers are invited. Papers focussing on connections between the relevant disciplines are especially encouraged by the program committee.
Deadline: Submissions should be received before March 31, 2003.
Topics: The topics of LGS3 include, but are not limited to, Logic and Game Theory: game semantics, information flow in games, knowledge representation in games, category-theoretic and recursion-theoretic methods in game theory; Game Theory and Social Choice: implementation, coalition formation, strategy-proofness; Social Choice and Logic: rights-systems modelling, uses of deontic and fuzzy logics in social choice theory, category-theoretic and recursion-theoretic methods in social choice; concerning applications, some relevant examples are: strategic properties of decision processes and procedures, complexity of decision procedures, evolution of collective decision rules, characterization and assessment of influence in strategic networks, coalition formation in political/economic decision making.
Invited Speakers: J. M. Hyland (Univ. of Cambridge, UK), B. Monjardet (Univ. de Paris 1), D. Samet (Univ. of Tel Aviv), J. Van Benthem (Univ. of Amsterdam and Stanford Univ.).
Information: Further information on LGS3, including submissions, participation fees, and accommodations will be made available in due course at the conference website, http://www.econ-pol.unisi.it/lgs3/.

12–14 **EMS Mathematical Weekend**, Gulbenkian Foundation, Lisbon, Portugal. (Apr. 2003, p. 498)
Plenary Speakers: M. Audin (Strasburg), J.-M. Bismut (Orsay), B. Dacorogna (Lausanne), H. Foellmer (Berlin), G. Lebeau (Nice).
Special Sessions: Symplectic and Related Geometries, Analysis and Geometry, Calculus of Variations, Stochastic Analysis and Mathematical Finance, Non-linear Evolution Equations
Organizers: European Mathematical Society and the Portuguese Mathematical Society
Local Organizers: A. Bela Cruzeiro, A. Cannas da Silva, P. Freitas, R. Loja Fernandes and J. Matias (IST-Lisbon).
Information: http://www.math.ist.utl.pt/ems/; phone: 351 218 417 113; fax: 351 218 417 598; email: rfern@math.ist.utl.pt; http://www.math.ist.utl.pt/~rfern/.

12–16 **International Conference of Computational Methods in Sciences and Engineering (ICCMSE 2003)**, Kastoria, Greece. (Feb. 2003, p. 294)
Description: In the past decades many significant insights have been made in several areas of computational methods in sciences and engineering. New problems and methologies have appeared. There is permanently a need in these fields for the advancement of information exchange. The aim of the conference is to bring together computational scientists and engineers from several disciplines in order to share methods, methologies, and ideas.

Topics: The topics to be covered include (but are not limited to): Computational mathematics, computational physics, computational chemistry, computational engineering, computational mechanics, computational finance, computational medicine, computational biology, computational economics, high-performance computing, mathematical methods in sciences and engineering, industrial mathematics, etc.
Organizers: General Chair: Z. Kalogiratou, Tech. Educ. Inst. of W. Macedonia, Kastoria, Greece. Invited Chair: T. E. Simos, Univ. of Peloponnese, Tripolis, Greece.
Contact Information: Secretary ICCMSE, email: iccmse@uop.gr; 26 Menelaou Street, Amfithea Paleon Faliron, GR-175 64, Athens, Greece; fax: +30210 94 20 091.
Information: http://www.uop.gr/~iccmse/, http://kastoria.teikoz.gr/~iccmse/.

12-17 **Combinatorics in Oporto**, University of Porto, Porto, Portugal. (Jun./Jul. 2003, p. 722)
Main Topics: Graph Theory, Matroid Theory (including Coxeter Matroids and Oriented Matroid Theory) and Convex Geometry.
Program: (a) Two minicourses (September 12 and 13), specially designed for students and young researchers, by M. Lemos (Univ. Fed. Pernambuco, Brazil): "Interaction between Graphs and Matroids", and U. Brehm (Tech. Univ. Dresden, Germany): "Polyhedral Maps"; (b) talks (September 15, 16, and 17): a series of eight to nine invited talks of 50 minutes and thirteen to fifteen contributed talks of 25 minutes; (c) poster session.
Invited Speakers: J. Bokowski (Tech. Univ. Darmstadt, Germany), A. Borovik (UMIST, Manchester, UK), U. Brehm (Tech. Univ. Dresden, Germany), J. Dias da Silva (Univ. Lisboa, Portugal), D. Larman (Univ. College of London, UK), M. Las Vergnas (CNRS, Paris, France), M. Lemos (Univ. Fed. Pernambuco, Brazil), M. Noy (Univ. Politecnica Catalunya, Spain), J. Szwarcfiter (Univ. Fed. Rio de Janeiro, Brazil).
Deadline: For sending abstracts, June 10, 2003.
Information: http://www.fc.up.pt/mp/comb03/.

14-17 **2nd WSEAS International Conference on Applications of Electrical Engineering**, New York, New York. (Aug. 2003, p. 844)
Information: http://www.wseas.org.

14-17 **5th WSEAS International Conferences on Algorithms, Scientific Computing, Modelling and Simulation; Telecommunications and Informatics**, New York, New York. (Aug. 2003, p. 844)
Information: http://www.wseas.org.

15-19 **Colloquium on the Occasion of the 200th Anniversary of Charles-François Sturm and Workshop on Sturm-Liouville Theory**, University of Geneva, Geneva, Switzerland. (Oct. 2002, p. 1135)
Information: http://theory.physics.unige.ch/~fiteo/sturm/colloquium.html.

15-19 **IMA Tutorial: Open Week Tutorial**, University of Minnesota, Minneapolis, Minnesota. (Mar. 2003, p. 407)
Organizers: S. Keller-McNulty (Los Alamos National Labs), M. Newton (Wisconsin-Madison), S. Tavaré (USC).
Information: Institute for Mathematics and its Applications, Univ. of Minnesota, 207 Church St. SE, 400 Lind Hall, Minneapolis, MN 55455; phone: 612-624-6066; email: visit@ima.umn.edu; http://www.ima.umn.edu/complex/fall/t1.html.

15-21 **International Conference on Nonlinear Partial Differential Equations**, Alushta, the Crimea, Ukraine. (May 2003, p. 603)
Topics: 1. Qualitative properties of solutions of nonlinear elliptic and parabolic equations. 2. Degenerate nonlinear elliptic and parabolic equations and their applications in mathematical physics. 3. Blow-up and singularities for quasilinear elliptic and parabolic equations. 4. Homogenization problems for nonlinear PDE. 5. Free boundary problems
Visas: All foreign nationals coming to the Ukraine should have a valid passport and most will need a visa. If you need a visa, we advise you to apply for one at a Ukrainian consular office in your country.
Information: A. A. Kovalevsky, Institute of Applied Mathematics & Mechanics of NAS of Ukraine, R. Luxemburg St. 74 83114 Donetsk, Ukraine; Phone: 38(0622)552394; Fax: 38(0622)552265; email: NPDE2003@iamm.ac.donetsk.ua; http://www.iamm.ac.donetsk.ua/mmain.html.

15-21 **Optimization, Approximation, and Multiscale Analysis with Applications to Signal and Image Processing**, Borovez (Rila Mountains), Bulgaria. (Jun./Jul. 2003, p. 722)
Description: The minisymposium will be accompanying the International Congress Massee 2003, a conference organized by the Mathematical Society of SouthEastern Europe (MASSEE).
Organizing and Program Committee: H. Gonska (Chair), Univ. of Duisburg-Essen, Germany; D. Kacso (Secretary), Univ. of Duisburg-Essen, Germany; O. Kounchev (Co-chair), Inst. of Mathematics and Informatics, Bulgarian Academy of Sciences, Sofia; P. Nettaanmaki, Univ. of Jyväskylä, Finland; H. Render, Univ. of Duisburg-Essen, Germany; J. Sprekels, Weierstrass Inst. for Applied Analysis and Stochastics, Berlin, Germany; D. Tiba, Inst. of Mathematics, Romanian Academy of Sciences, Bucharest.
Invited Speakers: A. Bejancu, Univ. of Leeds, UK; B. Bojanov, Sofia Univ. and Bulgarian Academy of Sciences; F.-J. Delvos, Univ. of Siegen, Germany; W. Haußmann, Univ. of Duisburg-Essen, Germany; B. Sendov, Bulgarian Academy of Sciences; D.-X. Zhou, City Univ., Hong Kong.
Information: Information on the minisymposium: http://www.math.bas.bg/~kounchev/Workshop2003.html. Information on the International Congress Massee 2003: http://www.math.bas.bg/massee2003/. Email inquiries should be directed to kounchev@math.bas.bg or tiba@wias-berlin.de.

16-20 **The Barcelona Conference on Set Theory**, Bellaterra, Barcelona, Spain. (Jan. 2003, p. 83)
Aim: To present the latest developments and results in all areas of set theory and their applications to other areas of mathematics.
Topics: Descriptive set theory, inner model theory, forcing, infinite combinatorics, and applications to analysis.
Main Speakers: M. Dzamonja (Univ. of East Anglia), I. Farah (York Univ.), J. Hirschorn (Instit. für Formale Logik, Univ. Wien), R. Schindler (Instit. für Formale Logik, Univ. Wien), O. Spinas (Christian-Albrechts-Univ. zu Kiel), J. Zapletal (Univ. of Florida, Gainesville).
Coordinator: J. Bagaria.
Program Committee: A. Blass, S. Friedman, S. Todorcevic, and W. H. Woodin.
Local Organizing Committee: D. Asperó, J. Bagaria, R. Bosch, J. Llopis, and J. López-Abad.
Deadlines: For applications for financial support, May 23; for registration and payment, June 30.
Information: email: set-theory@crm.es and website: http://www.crm.es/set-theory/.

17-19 **Computational Modelling in Medicine**, Edinburgh, UK. (Aug. 2003, p. 844)
Topics: Mathematical modelling and numerical simulation play a major role in many important medical applications. The meeting will be organised around the two interlinked themes of the vascular and pulmonary systems and soft tissue mechanics. The purpose is to bring together people who work on mathematical modelling, numerical analysis, simulation and direct medical applications related to these areas, and to act as a focus to stimulate further research and the development of even more realistic medical simulations.
Information: http://www.ma.hw.ac.uk/icms/meetings/2003/cmm/.

*17-20 **Workshop on Computational Aspects of Graphical Models**, Aalborg University, Denmark.
Information: http://www.math.auc.dk/gr/gr2003.html.

*20-21 **First East Coast Operator Algebras Symposium**, Vanderbilt University, Nashville, Tennessee.
Description: The East Coast Operator Algebras Symposium (ECOAS) is a new yearly conference series in operator algebras and applications which will be held during the fall semester at various venues along the generalized East Coast. The first meeting in this series will take place at Vanderbilt University on Saturday, September 20, and Sunday, September 21, 2003. Vaughan Jones (UC Berkeley), Dirk Kreimer (IHES and Boston University), and Henri Moscovici (Ohio State University) have agreed to give invited talks. Further invited speakers will be announced in July. Students and postdocs are strongly encouraged to attend the symposium. The deadline to apply for financial aid is August 25, 2003.
Organizers: D. Bisch (Vanderbilt Univ.), G. Kasparov (Vanderbilt Univ.), and G. Yu (Vanderbilt Univ.).
Information: For additional information, please consult the conference web page at http://www.math.vanderbilt.edu/~ecoas03.

20-21 **Innovative Teaching of Mathematics "New Concepts & Cutting Edge Technology Applied to Mathematical Education"**, Research Institute for Mathematical Sciences (RIMS), Kyoto University, Kyoto, Japan. (Aug. 2003, p. 844)
Description: Until now many conferences have been devoted to Clifford geometric algebra and its applications. In the 1990s Clifford geometric algebra started to be used for undergraduate and graduate teaching at some universities. In the view of the conceptual merits of geometric algebra there are increasingly strong efforts (e.g., summer courses for school teachers) under way to introduce Clifford geometric algebra also into school curricula. In order to further investigate and communicate the conceptual advantages of geometric algebra for the teaching of mathematics, the time seems ripe for an international symposium with an explicit focus on Clifford geometric algebra for teaching.

The second major focus of this symposium is to present new ways of innovative cooperation between the industrial and scientific communities for the use of modern communication technology in mathematical teaching. A kind of forum for the two communities is intended to exchange new ideas and steer the future development in the most meaningful direction.
Organizers: R. Nagaoka (Univ. of the Air, Tokyo), H. Ishi (Yokohama City Univ.), E. Hitzer (Fukui Univ.).
Speakers: Speakers both from abroad and domestic Japanese experts are invited. Confirmed are: D. Hestenes (Arizona), R. Gonzalez Calvet (Barcelona), U. Kortenkamp (Berlin), H. Uno (SHARP, Japan).
Information: http://sinai.mech.fukui-u.ac.jp/ITM2003/.

21-24 **Inference and Prediction in Neocortical Circuits**, AIM Research Conference Center, Palo Alto, California. (Aug. 2003, p. 844)
Program: This workshop, sponsored by AIM, NSF, and RNI, will be devoted to working toward an understanding of inference and prediction in neocortical circuits.

The cerebral cortex is responsible for most of our conscious experience, yet we remain largely ignorant of the principles underlying its function despite progress on many fronts of neuroscience. The principal reason for this is not a lack of data, but rather the absence of a solid theoretical framework for motivating experiments and interpreting findings. The purpose of this workshop is to bring together mathematicians, statisticians, computer scientists, neuroscientists, and psychologists in order to work towards a theoretical framework for neocortical function.
Organizers: J. Hawkins and B. Olshausen.
Application Deadline: June 7, 2003.
Information: http://aimath.org/ARCC/workshops/brain.html.

22-26 **Analytic Dynamical Systems, Summability of Divergent Series and Galois Theories**, Université Paul Sabatier, Toulouse, France. (Mar. 2003, p. 407)
Description: International Conference on the occasion of the 60th Anniversary of Jean-Pierre Ramis.
Topics: Complex analysis, analytic dynamical systems (Painvelé equations, d-modules, differences and q-differences equations, foliations, p-adic differential equations), Summability of divergent series and applications, Galois theories.
Speakers: Y. André (Paris); J.-B. Bost (Orsay); B. Braaksma (Groningen); A. Connes (Collège de France); O. Costin (Rutgers); B. Dubrovin (Sissa); Y. Il'Yashenko (Moscou and Cornell); V. Kaloshin (Princeton); T. Kawai (RIMS-Kyoto); Y. Laurent (Grenoble); A. Lins Neto (IMPA-Rio); J. Morales (Barcelona); R. Moussu (Dijon); K. Okamoto (Tokyo); J. Sauloy (Toulouse); D. Sauzin (Paris); M. Singer (MSRI - Berkeley); H. Umemura (Nagoya); M. Van der Put (Groningen); A. Verjovski (Cuernavaca).
Organizers: A. Duval (Lille), F. Fauvet (Strasbourg), M. Loday-Richaud (Angers), M. Klughertz (Toulouse), J.-F. Mattei (Toulouse), L. Stolovitch (Toulouse).
Information: email: ramisconf@picard.ups-tlse.fr; http://picard.ups-tlse.fr/.

24-26 **International Conference on Differential Equations Devoted to the 100th Anniversary of K. P. Persidskii**, Institute of Mathematics of the ME&S of the RK, Almaty, Kazakhstan (CIS). (Sept. 2002, p. 1001)
Background: The conference honors K. P. Persidskii, the academician of the Academy of Sciences of Kazakh Republic (1946), well known to mathematicians all over the world for his significant contribution to the theory of differential equations.
Workshop Topics: (1) Differential equations, (2) Dynamic systems, (3) Theory of stability, (4) Mathematical physics, (5) Related problems of mathematical analysis, (6) Applied and numerical mathematics.
Speakers: M. I. Imanaliev (Kyrgyzstan), V. M. Millionshchikov (Russia), M. I. Rakhimberdiev (Kazakhstan), R. Kh. Rozov (Russia), V. V. Rumyantsev (Russia), A. M. Samoilenko (Ukraine).
Deadlines: April 1, 2003: deadline for submission of applications; June 1, 2003: conformation of acceptance; July 1, 2003: fee payments for accepted participants.
Information: G. K. Zakiryanova; tel.: +7(3272) 91-37-64; fax: +7(3272) 91-37-40; email: zakir@math.kz, Institute of Mathematics of the ME&S of the RK, 125, Pushkin street, 480100 Almaty, Kazakhstan (CIS). Visit http://www.math.kz/.

24-28 **Workshop on Cauchy Problem for the Einstein Equations**, Centre de Recherches Mathématiques, Montréal, Québec, Canada. (Aug. 2003, p. 844)
Description: A number of major advances have been achieved over the past few years in the analysis of the Cauchy problem in general relativity. These include the proof of the nonlinear stability of Minkowski space, the proof of the Riemannian Penrose conjecture, and the rigorous description of the asymptotic behavior at infinity of the admissible Cauchy data. This workshop will bring together some of the key players who have been involved in these developments and will provide an opportunity for exploring some of the remaining open problems.

The workshop will be preceded by two short courses given by G. Huisken (MPI Golm) and A. Ashtekhar (Penn State).
Organizers: F. Finster (Regensburg), N. Kamran (McGill).
Invited Participants: M. Anderson (Stony Brook) (*), R. Bartnik (Canberra) (*), H. Bray (MIT) (*), M. Choptuik (UBC), Y. Choquet-Bruhat (Paris 6), D. Christodoulou (ETH) (*), J. Corvino (Brown) (*), P. Chruschiel (Tours), H. Friedrich, G. Galloway (Miami), C. Gerhardt (Heidelberg) (*), C. Gundlach (Southampton) (*), T. Ilmanen (ETH) (*), J. Isenberg (Oregon), J. Kijowski, S. Klainerman (Princeton) (*), J. Lewandowski, E. T. Newman, F. Nicolo (Rome) (*), D. Pollack (Washington) (*), A. Rendall (AEI Golm) (*), C. Rovelli (CPT Luminy) (*), C. Sogge (Johns Hopkins) (*), R. Schoen (Stanford) (*), E. Seidel

(AEI Golm) (*), T. Thiemann (AEI Golm) (*), S. Zelditch (Johns Hopkins) (*), N. Zipser (MIT) (*). (*) to be confirmed.

29-30 **Workshop "High-Resolution Schemes for Convection-Dominated Flows: 30 Years of FCT"**, University of Dortmund, Germany. (Jun./Jul. 2003, p. 722)

Scope: Convection-dominated flows are notoriously difficult to treat numerically. Solutions produced by standard discretization techniques are corrupted by nonphysical oscillations and/or excessive numerical diffusion. The first high-resolution scheme to overcome these shortcomings was the now classical Flux-Corrected-Transport (FCT) algorithm introduced 30 years ago by Boris and Book. Their pioneering idea of blending high- and low-order discretizations has paved the way for the development of a whole range of high-resolution schemes which use flux/slope limiters to prevent the formation of wiggles in the vicinity of shocks and discontinuities while retaining the high accuracy of approximation in regions where the solution is sufficiently smooth. The aim of this 2-day workshop is to provide a forum for discussion of the progress made in the numerical simulation of convection-dominated flows during the three decades elapsed since the birth of FCT. Scientists from around the globe are encouraged to present their results regarding recent trends and developments in this challenging research field.

Organizing Committee: D. Kuzmin, Univ. of Dortmund, Germany; R. Loehner, George Mason Univ., USA; S. Turek, Univ. of Dortmund, Germany.

Speakers: The tentative list of speakers includes leading experts (D. L. Book, R. Loehner, S. Zalesak) who have laid the foundations of the FCT methodology and demonstrated its potential in a variety of spectacular CFD simulations.

Information: An online registration form will be available shortly at the homepage of the workshop: `http://www.mathematik.uni-dortmund.de/lsiii/conf/fct30.html`.

29-October 3 **IMA Workshop 1: Statistical Methods for Gene Expression: Microarrays and Proteomics**, University of Minnesota, Minneapolis, Minnesota. (Mar. 2003, p. 407)

Organizers: M. A. Newton (Wisconsin-Madison), G. Parmigiani (Johns Hopkins).

Information: Institute for Mathematics and its Applications, University of Minnesota, 207 Church St. SE, 400 Lind Hall, Minneapolis, MN 55455; phone: 612-624-6066; email: `visit@ima.umn.edu`; `http://www.ima.umn.edu/complex/fall/c1.html`.

30-October 3 **International Silk Road Conference: Quantum Theory, Partial Differential Equations of Mathematical Physics and Their Applications**, Tashkent, Uzbekistan. (May 2003, p. 604)

Organizers: Inst. of Nuclear Physics, Uzbekistan Acad. of Sciences, Tashkent; The INTAS-Network Project Nr.15,2000, entitled "Partial Differential Equations Modelling Semiconductors"; The Wolfgang Pauli Institute, Vienna, `http://www.wpi.ac.at/`; The Abdus Salam International Centre for Theoretical Physics, Trieste, Italy.

Topics: (1) Nonlinear Differential Equations of Mathematical Physics, (2) Inverse problems, (3) Kinetic equations and Problems of Statistical Physics, (4) Mathematical Modelling of Semiconductors, (5) Fluid Dynamics, (6) Spectral properties of Hamiltonians, (7) Quantum Semiconductor Device Models and Nanotechnology.

Language: English at plenary sessions and both English and Russian at parallel sessions.

Deadlines: Applications for financial support: April 15, 2003. Registration form: May 1, 2003. Abstract: June 1, 2003. The second information bulletin: May 1, 2003. The conference fee: September 1, 2003.

Information: Further information about the conference may be obtained from: M. Yu. Rasulova, Institute of Nuclear Physics, Ulugbek, Tashkent, 702132, Uzbekistan; tel.: +998712/(3712) 60 67 53; fax: +998712/(3712) 64 25 90; email: `qtpm2003@suninp.tashkent.su` or `wittgenstein.mathematik@univie.ac.at`.

30-October 7 **Mathematics in Armenia—Advances and Perspectives**, Institute of Mathematics of National Academy of Sciences of Armenia, Yerevan, Armenia. (Feb. 2003, p. 295)

Main Topics: Real and complex analysis, Probability and mathematical statistics, Differential and integral equations, Algebra and geometry.

Organizing Committee: G. Gevorkian, M. Ginovian, A. Hakobyan, B. Nahapetian, A. Sahakia.

Speakers: S. Adian (Russia), D. Drasin (USA), N. Nikolskii (France), S. Aivazian (Russia), P. Gauthier (Canada), S. Nikolskii (Russia), R. Ambartzumyan (Armenia), L. Gogoladze (Georgia), A. Olevskii (Israel), N. Arakelian (Armenia), A. Gonchar (Russia), K. Oskolkov (USA), O. Besov (Russia), I. Ibragimov (Russia), H. Shahgholian (Sweden), J. Brennan (USA), B. Kashin (Russia), V. Temlyakov (USA), X. Cabre (USA), W. Luh (Germany), P. Ul'yanov (Russia), L. Caffarelli (USA), V. Mikhailov (Russia), N. Uraltseva (Russia), Z. Ciesielski (Poland), R. Minlos (Russia).

Deadline: For application: April 1, 2003.

Information: email: `conf@instmath.sci.am`; `http://math.sci.am/conf.html`.

October 2003

1-5 **Workshop on the Interaction of Gravity with Classical Fields**, Centre de Recherches Mathématiques, Montréal, Québec, Canada. (Aug. 2003, p. 845)

Description: The interaction of gravity with external fields is governed by highly coupled systems of partial differential equations on manifolds. The analysis of these systems leads to rigorous analytical results on fundamental questions such as the scattering of waves by black holes and the role of external fields in the dynamics of gravitational collapse and black hole formation.

The workshop will be preceded by two short courses given by J. Smoller (Michigan). It will be simultaneous with the first series of Aisenstadt lectures for the year, to be delivered by S. T. Yau.

Organizers: F. Finster (Regensburg), N. Kamran (McGill).

Invited Participants: S. Anco, H. Andreasson (Chalmers Goteborg), A. Bachelot (Bordeaux) (*), R. Beig (Vienna) (*), H. Beyer (AEI Golm), B. Carter (Meudon), M. Dafermos, S. De Bievre (Lille) (*), P. Forgacs (Missouri), P. Hislop (Kentucky) (*), W. Israel (Victoria), B. Koyama (Nagoya), H. Kunzle (Alberta), J. Kunz (Oldenburg), A. Linden (Bloomington), D. Maison (Munchen), R. McLenaghan (Waterloo), R. Melrose (MIT) (*), J. P. Nicolas (Bordeaux), E. Poisson (Guelph), I. Racz (*), A. Sa-Barreto (Purdue), I. Sigal (Toronto) (*), W. Simon (Vienna) (*), A. Soffer (Rutgers), C. Sogge (Johns Hopkins) (*), J. Stalker (Princeton) (*), N. Straumann (Zurich) (*), S. Tahvildar-Zadeh (Rutgers), A. Tomimatsu (Nagoya) (*), C. Uggla (Karlstad) (*), J. Ventrella (UBC and Austin, TX) (*), B. Whiting (Florida), S. T. Yau (Harvard), M. Zworski (Berkeley) (*). (*) to be confirmed.

2-4 **AMS Joint Central and Western Section Meeting**, University of Colorado, Boulder, Colorado (May 2003, p. 604)

Information: `http://www.ams.org/amsmtgs/sectional.html`.

11-12 **AMS Eastern Section Meeting**, SUNY-Binghamton, Binghamton, New York. (Sept. 2002, p. 1001)

Information: `http://www.ams.org/amsmtgs/sectional.html`.

13-15 **3rd WSEAS International Conferences on Simulation, Modelling and Optimization; Signal, Speech and Image Processing; Multimedia, Internet and Video Technologies; Robotics, Distance Learning and Intelligent Communication Systems; Nanoelectronics, Nanoengineering and Electromagnetic Compatibility**, Rethymno, Crete, Greece. (Aug. 2003, p. 845)

Information: `http://www.wseas.org`.

13-15 **5th WSEAS International Conference on Mathematics and Computers in Physics; Mechanical Engineering Multiconference**, Rethymno, Crete, Greece. (Aug. 2003, p. 845)

Information: `http://www.wseas.org`.

13–17 **2003 IEEE/WIC International Conference on Web Intelligence (WI 2003)**, Tianlun Dynasty Hotel, Beijing, China. (Feb. 2003, p. 295)
Description: Web Intelligence (WI) is a new direction for scientific research and development that explores the fundamental roles as well as practical impacts of Artificial Intelligence (AI) and advanced Information Technology (IT) on the next generation of Web-empowered products, systems, services, and activities. The 2003 IEEE/WIC International Conference on Web Intelligence (WI 2003) is held jointly with the 2003 IEEE/WIC International Conference on Intelligent Agent Technology (IAT 2003, http://www.comp.hkbu.edu.hk/IAT03/). The IEEE/WIC 2003 joint conferences are sponsored and organized by IEEE Computer Society Technical Committee on Computational Intelligence (TCCI) (http://www.cs.uvm.edu/%7Exwu/tfvi/index.shtml) and by Web Intelligence Consortium (WIC) (http://wi-consortium.org/).
Topics: Intelligent Web-Based Business and Grid Computing, Knowledge Networks and Management, Ubiquitous Computing and Social Intelligence, Intelligent Human-Web Interaction, Web Information Management, Web Information Retrieval, Web Agents, Web Mining and Farming, Emerging Web Technology.
Information: http://www.comp.hkbu.edu.hk/WI03/.

15–20 **Von Neumann Centennial Conference: Linear Operators and Foundations of Quantum Mechanics**, Budapest, Hungary. (Sept. 2002, p. 1001)
Description: The conference will cover many topics in linear operator theory and the mathematical foundations of quantum mechanics, including recent developments showing the broad and long-standing impact of von Neumann's work. In addition to a session devoted to historical and personal perspectives on von Neumann, the main subjects are: linear operators, especially Schrödinger and other unbounded operators, their role in mathematical physics; stochastics aspects of quantum mechanics, for example, probability and statistics in the Hilbert space formalism; quantum information theory and quantum entropy; algebras of operators, von Neumann algebras and their applications in quantum statistical mechanics and in field theory; formal approaches to quantum theory, such as quantum logics and quantum structures.
Advisory Board: H. Araki, A. Jaffe, P. D. Lax, J. Palis, W. Thirring.
Main Organizer: D. Petz.
Information: http://www.math.bme.hu/~vonneumann/.

17–18 **Twenty-Third Southeast-Atlantic Regional Conference on Differential Equations**, Kennesaw State University, Kennesaw, Georgia. (Aug. 2003, p. 845)
Information: http://math.kennesaw.edu/searcde/.

20–24 **IMA Workshop 2: Comparative Genomics**, University of Minnesota, Minneapolis, Minnesota. (Mar. 2003, p. 408)
Organizers: J. Lagergren (Royal Inst. of Tech., Stockholm), B. Moret (UNM), D. Sankoff (Ottawa).
Information: Institute for Mathematics and its Applications, University of Minnesota, 207 Church St. SE, 400 Lind Hall, Minneapolis, MN 55455; phone: 612-624-6066; email: visit@ima.umn.edu; http://www.ima.umn.edu/complex/fall/c2.html.

20–25 **International Symposium of Mathematics, Analysis and Probability**, Hammamet, Tunisia. (Apr. 2003, p. 498)
Scientific Program: Analysis on Variety, Harmonic Analysis, Infinite Dimensional Analysis, Stochastic Analysis and Applications, Noncommutative and Quantum Probability, Random Walk, Brownian Motion.
Organizers: The symposium is organized in association with the French Mathematical Society (SMF) and the Tunisia Mathematical Society (SMT).
Scientific Committee: J.-P. Anker, D. Bakry, J. Bertoin, Ph. Biane, Ph. Bougerol, H. Chebli, J.-L. Clerk, J. Faraut, K. Harzallah, H. Ouerdiane, J.-J. Risler, K. Trimeche.
Organizing Committee: Ph. Biane, R. Boukhris, R. Hachaichi, R. Gannoun, H. Ouerdiane, H. Sadraoui, L. Silva, F. Ballalouna.
Invited Speakers: L. Accardi, S. Albeverio, A. Ancona, M. Babillot, D. Békollé, B. Farah, H. B. Massoud, P. Carmona, L. Gallardo, A. Guionnet, Y. Guivarc'h, T. Hida, Y. Hu, N. Kammoun, V. Kaimanovich, M. S. Khalgui, P. Krée, Y. J. Lee, P. Malliavin, K. Mokni, S. Mustapha, D. Nualart, N. Obata, N. O'Connel, Y. Ouknine, M. Roeckner, B. Roynette, C. Sabot, Z. Shi, A. S. Sznitman, A. Touati, C. Vilani, D. Voiculescu, W. Werner, J. A. Yan, M. Yor, A. Zuk.
Information: P. Biane, DMA-Superior Normal School 45, ulm street, 75230 Paris Cedex 05, France; tel: + 33 (0)1 44 32 20 39; fax: + 33 (0)1 44 32 20 80; email: Philippe.Biane@ens.fr; or H. Ouerdiane, Dept. of Math., Faculty of the Sciences of Tunis, Campus universitaire, 1060 Tunis, Tunisia; fax: + 216 1 885 350; email: habib.ouerdiane@fst.rnu.tn.

23–26 **Amoebas and Tropical Geometry**, AIM Research Conference Center, Palo Alto, California. (Aug. 2003, p. 845)
Program: This workshop will be devoted to a brand new subject called tropical geometry. Tropical varieties are piecewise-linear objects in Euclidean space. The link between the classical complex geometry and the tropical geometry is provided by amoebas or logarithmic images of complex varieties. The tropical varieties appear as certain degenerations of amoebas.
Organizers: G. Mikhalkin, B. Sturmfels, and O. Viro.
Application Deadline: June 15, 2003.
Information: http://aimath.org/ARCC/workshops/amoebas.html.

24–25 **AMS Southeastern Section Meeting**, University of North Carolina, Chapel Hill, North Carolina. (Sept. 2002, p. 1001)
Information: G. Alsfeld; email: gma@ams.org; http://www.ams.org/amsmtgs/sectional.html.

26–31 **LISA'03—17th Systems Administration Conference**, San Diego, California. (Jun./Jul. 2003, p. 723)
Information: http://www.usenix.org/events/lisa03/.

27–29 **International Network Optimization Conference**, Institut National des Télécommunications, Evry/Paris, France. (Jun./Jul. 2003, p. 723)
Scope: Information sciences and communication technologies are increasingly both a main focus and a major application of well-established as well as emerging theories and techniques. Examples are operations research, graph theory and queueing theory, in addition to stochastic search, to state just a few. The aim of this conference is to bring together people from those disciplines with a main focus on network optimization. Special attention will be given to the latest technologies and to the challenges encountered therein.
Deadlines: Short paper submission deadline: April 25, 2003. Notification of acceptance: July 14, 2003. Long paper submission (optional): August 16, 2003. Submission of camera-ready short papers: August 16, 2003. Deadline for early conference registration: September 19, 2003.
Information: http://www.int-evry.fr/INOC2003/; email: inoc2003-oc@int-evry.fr.

28–31 **Fourteenth International Symposium on Methodologies for Intelligent Systems**, Maebashi TERRSA, Maebashi City, Japan. (Feb. 2003, p. 295)
Description: This symposium is intended to attract individuals who are actively engaged both in theoretical and practical aspects of intelligent systems. The goal is to provide a platform for a useful exchange between theoreticians and practitioners, and to foster the cross-fertilization of ideas in the following areas: active media human-computer interaction, autonomic and evolutionary computation, intelligent agent technology, intelligent information retrieval, intelligent information systems, knowledge representation and integration, knowledge discovery and data mining, logic for

artificial intelligence, soft computing, web intelligence. In addition, we solicit papers dealing with applications of intelligent systems in complex/novel domains, e.g. human genome, global change, manufacturing, health care, etc. Authors are invited to submit their manuscript in the LNCS/LNAI style (maximum 10 pages). All paper submissions will be handled electronically. Detailed instructions are provided on the conference homepage at http://www.wi-lab.com/ismis03/.

Deadlines: Submission of Papers: March 10, 2003. Acceptance Notification: May 15, 2003. Final Paper: June 30, 2003.

Call for Papers: ISMIS 2003.

Information: For additional information contact: Z. W. Ras (ISMIS 2003), Univ. of North Carolina, Dept. of Computer Science, Charlotte, NC 28226; Fax: 704-547-3516; email: ras@uncc.edu. N. Zhong (ISMIS 2003), Department of Information Engineering, Maebashi Institute of Technology, 460-1, Kamisadori-Cho, Maebashi-City, 371-0816, Japan; telephone & fax: +81-27-265-7366; email: zhong@maebashi-it.ac.jp.

November 2003

3–5 **Second International Conference on Computational Methods in Multiphase Flow**, Santa Fe, New Mexico. (Oct. 2002, p. 1135)

Organizer: Wessex Inst. of Tech, UK, in collaboration with the Univ. of Mexico.

Information: http://www.wessex.ac.uk/conferences/2003/multiphase03/.

3–7 **DIMACS Workshop on Data Quality, Data Cleaning and Treatment of Noisy Data**, DIMACS Center, Rutgers University, Piscataway, New Jersey. (Aug. 2003, p. 845)

Short Description: Many disciplines have taken piecemeal approaches to data quality. The areas of process management statistics, data mining database research, and metadata coding have all developed their own ad hoc approaches to solve different pieces of the data quality puzzle. These include statistical techniques for process monitoring, treatment of incomplete data and outliers, techniques for monitoring and auditing data delivery processes, database research for integration, discovery of functional dependencies and join paths, and languages for data exchange and metadata representation. We need an integrated end-to-end approach within a common framework, where the various disciplines can complement and leverage each other's strengths. In this workshop our broad objective is to bring together experts from different research disciplines to initiate a comprehensive technical discussion on data quality, data cleaning, and treatment of noisy data; specifically: to provide an overview of the existing research in data quality; to present data quality as a continuous, end-to-end concept; to discuss and update the definition of data quality; to develop metrics for measuring data quality; to emphasize data exploration, data browsing, and data profiling for validating schema specific constraints and identifying aberrations; to focus on disciplines such as knowledge representation and rule-based programming for capturing and validating domain specific constraints; to highlight applications and case studies; to present research tools and techniques; and to identify research problems in data quality and data cleaning.

Organizer: P. Dasu, AT&T Labs, tamr@research.att.com.

Local Arrangements: M. Mercado, DIMACS Center, mercado@dimacs.rutgers.edu, 732-445-5928.

Deadline: Abstracts for contributed papers and posters: September 6, 2003.

Information: Visit http://dimacs.rutgers.edu/Workshops/DataCleaning/.

3–8 **IV International Colloquium on Differential Equations and Applications**, Maracaibo, Venezuela. (Apr. 2003, p. 498)

Topics: This meeting will include topics in Discrete Dynamical Systems, Control Theory, Stochastic Differential Equations, Nonlinear Optimization Methods, Fluid Mechanics, and Numerical Analysis. In addition to contributed talks, the program also includes a course on Semilinear Evolution Equations by Prof. Anibal Rodriguez Bernal from the Complutense University of Madrid.

Deadline: The deadline for receipt of paper proposals in LaTeXis April 30, 2003. Notification of acceptance will be given before May 30, 2003. Full manuscripts from the selected abstracts are expected by no later than August 1, 2003. Each paper submitted will be peer-reviewed by the Technical and Program Committee.

Information: For additional information contact A. D. Rueda or J. G. Matamala, email: ivceda@luz.ve.

4–6 **Seventh International Conference on Computational Modelling of Free and Moving Boundary Problems**, Santa Fe, New Mexico. (Oct. 2002, p. 1135)

Organizer: Wessex Inst. of Tech, UK, in collaboration with the Univ. of Mexico.

Information: http://www.wessex.ac.uk/conferences/2003/movingboundaries03/.

* 6–7 **Digital Biology: The Emerging Paradigm**, National Institutes of Health, Bethesda, Maryland.

Description: This symposium will offer a broad look at the convergence of biomedical and computational research. Key issues to be addressed include: (1) the mounting scientific imperative to study biological systems at multiple levels of organization, (2) the growing need to use quantitative approaches to analyze biomedical data on a large scale, and (3) the potential impact of extensive computer networks on the nature and conduct of biomedical research.

Keynote Speakers and Program Highlights: S. Brenner, a recipient of the 2002 Nobel Prize in Physiology or Medicine, will present the biology keynote address. N. Myhrvold, a co-founder and managing director of the private entrepreneurial firm Intellectual Ventures and formerly chief technology officer at Microsoft Corporation, will present the technology keynote address. Other program features include scientific poster presentations; demonstrations; a grant-writing information session; and concurrent sessions addressing scientific data integration, networked science, and quantitative biology.

Call for Posters: Those wishing to present a poster at the meeting should submit an abstract of the research by August 20, 2003. Authors will be notified of acceptance by September 30, 2003.

Registration and Additional Information: Guidelines for abstract preparation and submission, poster presentation, selection criteria, a preliminary agenda, and registration information are all available at http://www.bisti.nih.gov/2003meeting/. If you have questions, please email: bistic@nih.gov.

7–9 **Weekend Algebra Meeting**, Florida Atlantic University, Boca Raton, Florida. (Jun./Jul. 2003, p. 723)

Format: The format is simple, there is no registration fee, and, conversely, we cannot offer honoraria or travel reimbursement (except for graduate students and young Ph.D.'s; see below). We are planning to have 20-minute presentations on Friday afternoon, Saturday morning, and Sunday morning. On Saturday afternoon there will be a special session on current directions and emerging opportunities in our areas of research. The department plans to host a banquet on Friday evening and a party on Saturday evening.

Organizers: L. Klingler (klingler@fau.edu) and M. Schmidmeier (mschmidm@fau.edu).

Sponsor: The Charles E. Schmidt College of Science of Florida Atlantic University.

Support: We have applied for NSF support for graduate students and young Ph.D.'s (travel and local expenses).

Information and Registration: We are going to send out the second email announcement in May. If you haven't received the first announcement but want us to keep you informed, please preregister at http://www.math.fau.edu/weekend-algebra/; send

an email to one of the organizers; or send a fax to Weekend Algebra Meeting 2003 (561-297-2436).

10–13 **SIAM Conference on Geometric Design & Computing**, Elliott Grand Hyatt, Seattle, Washington. (Nov. 2002, p. 1287)
Information: email: meetings@siam.org.

14–18 **Workshop on Patterns in Physics**, The Fields Institute, Toronto, Ontario. (Jun./Jul. 2003, p. 723)
Organizing Committee: R. Almgren, N. Ercolani (Chair), D. Henderson, J. Lega, M. Pugh.
Information: http://www.fields.utoronto.ca/programs/scientific/03-04/pde/physics/index.html.

17–21 **IMA Workshop 3: Networks and the Population Dynamics of Disease Transmission**, University of Minnesota, Minneapolis, Minnesota. (Mar. 2003, p. 408)
Organizers: M. Morris (Washington), C. Neuhauser (UMN).
Information: Institute for Mathematics and its Applications, University of Minnesota, 207 Church St. SE, 400 Lind Hall, Minneapolis, MN 55455; phone: 612-624-6066; email: visit@ima.umn.edu; http://www.ima.umn.edu/complex/fall/c3.html.

19–22 **ICDM '03: The Third IEEE International Conference on Data Mining**, Melbourne, Florida. (Jun./Jul. 2003, p. 723)
Call for Papers: Papers due: June 10, 2003.
Invited Speakers: T. G. Dietterich, Oregon State Univ.; U. M. Fayyad, digiMine.com; H. Mannila, Univ. of Helsinki, Finland; G. W. Myers, Univ. of California, Berkeley; P. S. Yu, IBM T. J. Watson Research Center.
Scope: Areas of interest are machine learning, automated scientific discovery, statistics, pattern recognition, knowledge acquisition, soft computing, databases and data warehousing, data visualization, and knowledge-based systems. As an important part of the conference, the workshops program will focus on new research challenges and initiatives, and the tutorial program will cover emerging data mining technologies and the state-of-the-art of data mining developments.
Information: http://www.cs.uvm.edu/~xwu/icdm-03.html.
Further Information: Xindong Wu (ICDM 2003), Department of Computer Science, University of Vermont, 351 Votey Building, Burlington, VT 05405; phone: 802-656-7839; fax: 802-656-0696; email: xwu@cs.uvm.edu.

26–29 **Modern Problems of Mathematical Physics and Informational Technologies**, National University of Uzbekistan, Tashkent, Uzbekistan. (Jun./Jul. 2003, p. 724)
Description: The conference is devoted to modern problems in the area of differential equations and IT science. Scientists of any scientific background are welcome to participate (students, Ph.D. students, and professional researchers).
Topics: (1) Degenerating equations and mixed type equations, (2) Spectral theory of differential operators, (3) Boundary value problems of differential equations and their applications, (4) Calculus and information technologies.
Deadline: Deadline for submitting papers (LaTeX file, no more than 5 papers) is June 1, 2003.
Information: (in Russian): http://www.nuu.uz/conf/.

27–28 **II International Workshop on Information Technologies and Computing Techniques for the Agro-Food Sector**, CIMNE, Barcelona, Spain. (Aug. 2003, p. 845)
Description: Mathematical models combined with appropriate numerical simulations have become indispensable to make accurate predictions in industry applications, but also to optimize and control processes. Moreover, current trends are moving towards the combination of information technologies with computational techniques.

The main objective of this second edition of the AFoT workshop is to provide a thorough introduction to the most important issues regarding the use of information technologies, and mathematical and computing techniques in the context of the food sector. Topics of interest include novel IT-related methods and tools (e.g., Web-based simulation and decision support systems) plus all the traditional computer simulation techniques (especially regarding distributed process systems), as well as signal processing techniques for advanced sensors.

Agro-Food Technology (AFoT) is a thematic area within MACSI-Net, a European network supported by the Information Society Technologies Programme (IST) of the Fifth Framework Programme of the European Commission. MACSI-Net is an initiative to form an open network for the advancement of mathematics, computing, and simulation for industry.

The workshop is one of the activities of the MACSI-Net network to urge unified mathematical and computing techniques involving food scientists, engineers, and industrial people, as well as to encourage new cooperation at an international level between companies and research institutions.
Information: email: ebalsa@cimne.upc.es.

December 2003

5–8 **Numerical Probabilistic Methods for High-Dimensional Problems in Finance**, AIM Research Conference Center, Palo Alto, California. (Aug. 2003, p. 846)
Program: This workshop, sponsored by AIM and the NSF, will be devoted to developing and studying efficient numerical algorithms, based on probabilistic methods, for solving high-dimensional optimization/nonlinear problems in finance and exploring the connection with the theory of Forward Backward Stochastic Differential Equations while at the same time extending that theory. The workshop will bring together researchers in numerical methods, PDEs, Monte Carlo simulation, quantitative finance, Malliavin calculus, Forward Backward Stochastic Differential Equations, nonparametric regression kernel techniques, and similar. We hope especially to facilitate communication on this topic between mathematicians, researchers from finance departments, and those from the finance industry.
Organizers: J. Cvitanic and N. Touzi.
Application Deadline: June 21, 2003.
Information: Visit http://aimath.org/ARCC/workshops/highdimfinance.html.

8–12 **Stochastic Methods in Coagulation and Fragmentation**, Isaac Newton Institute for Mathematical Sciences, Cambridge, UK. (Jun./Jul. 2003, p. 724)
Information: Isaac Newton Institute for Mathematical Sciences, 20 Clarkson Road, Cambridge, CB3 OEH UK; tel: +44 (0) 1223 335999; fax: +44 (0) 1223 330508; email: info@newton.cam.ac.uk. Further information and application forms are available from the WWW at: http://www.newton.cam.ac.uk/programs/IGS/igsw04.html.

14–16 **International Conference on Matrix Analysis and Applications**, Nova Southeastern University, Fort Lauderdale, Florida. (Mar. 2003, p. 408)
Description: The aim of this meeting is to stimulate research and interaction of researchers interested in all aspects of linear algebra and matrix analysis and applications, and to provide an opportunity for researchers to exchange ideas and recent developments on the subjects.
Keynote Speaker: R. Horn, Univ. of Utah.
Organizing Committee: T. Ando (Hokkaido Univ., Japan), C.-K. Li (College of William and Mary, USA), G. P. H. Styan (McGill Univ., Canada), H. Woerdeman (College of William and Mary, USA, and Catholic Univ., Belgium), F. Zhang (Nova Southeastern Univ., USA).
Contact: ckli@math.wm.edu or zhang@nova.edu.
Information:http://www.resnet.wm.edu/~cklixx/nova03.html.

14–18 **Computational Algebraic Statistics**, AIM Research Conference Center, Palo Alto, California. (Aug. 2003, p. 846)

Program: This workshop, sponsored by AIM and the NSF, will bring together researchers in the emerging field of computational algebraic statistics. This new field applies methods of computational algebra and discrete geometry to problems in multivariate analysis, experimental design, probability theory, and disclosure limitation. The interaction of these areas has led, for instance, to the algebraic geometry of hierarchical models and Bayesian networks. The workshop will be a springboard for new ideas to expand the frontiers in computing Gröbner bases in the context of algebraic statistics, counting lattice points in polytopes, and optimally disseminating massive data while preserving confidentiality.
Organizers: J. A. De Loera, S. Fienberg, S. Hosten, A. Karr, and B. Sturmfels.
Application Deadline: July 1, 2003.
Information: http://aimath.org/ARCC/workshops/compalgstat.html.

15–19 **Numerical Methods in Imaging Science and Information Processing**, Institute for Mathematical Sciences, National University of Singapore, Singapore. (Dec. 2002, p. 1422)
Organizers: R. Chan (Chinese Univ. of Hong Kong, China), S. S. Goh (National Univ. of Singapore), Z. Shen (National Univ. of Singapore), C.-W. Shu (Brown Univ.).
Plenary Speakers: J. Benedetto (Univ. of Maryland), N. Bose (Pennsylvania State Univ.), R. Chan (Chinese Univ. of Hong Kong, China), T. Chan (Univ. of California, Los Angeles), C. Chui (Stanford Univ./Univ. of Missouri - St. Louis), M. Hanke-Bourgeois (Johannes-Gutenberg-Universität, Germany), M. Hegland (Australian National Univ., Australia), A. Katsaggelos (Northwestern Univ.), S. Osher (Univ. of California, Los Angeles), R. Plemmons (Wake Forest Univ.), C.-W. Shu (Brown Univ.).
Registration: Registration forms are available at http://www.ims.nus.edu.sg/Programs/imgsci/numerical.htm and should be received at least one month before the conference. For general enquiries, send email to ims@nus.edu.sg, while for enquiries on academic matters, send email to S. S. Goh at matgohss@nus.edu.sg.
Contributed Talks: Abstracts for 15-minute contributed talks are welcomed and should be received by November 14, 2003. Please submit abstracts to S. S. Goh at matgohss@nus.edu.sg. Authors will be notified within one month of submission of the abstracts.

15–19 **The 8th Asian Technology Conference in Mathematics**, Chung Hua University, Hsin-Chu, Taiwan. (Apr. 2003, p. 499)
Aim: The aim of this conference is to provide an interdisciplinary forum for teachers, researchers, educators and decision makers around the world in the fields of mathematics and mathematical sciences. It will also provide a venue for researchers and developers of computer technology to present their results in using technology in both basic research and pedagogical research and to exchange ideas and information on their latest developments. The conference will cover a broad range of topics on the relevancy of technology in mathematical research and teaching.
Topics: Mathematics for information technology; Geometry using technology; Computer algebra; Internet technology for mathematics; Machine learning, theorem proving and games; Multimedia distance learning; Graphics calculators; Mathematical research and teaching using technology; Physics research and teaching using technology; Applications in mathematical sciences using technology; Mathematical software and tools on the WWW; Assessment of implementation of technology in education; Integrating technology into mathematics education; Mathematics learning and cognition; Childhood mathematics learning.
Information: Please visit http://www.atcminc.com/.

*15–19 **The 28'th Australasian Conference on Combinatorial Mathematics and Combinatorial Computing**, Melbourne, Australia.
Topics: The conference covers all areas of combinatorics, including theoretical and computational.
Invited Speakers: P. Adams, Queensland, Australia, Using graph theory to sequence problematic regions of genomes; L. Bader, Naples, Italy, Flocks of cones and related structures; A. Gulliver, Victoria, Canada, Self-reciprocal polynomials; S. Inamdar, ISI Bangalore, India, On the rigidity of finite projective planes; J. Siran, Slovak University of Technology, Slovak Republic, Highly symmetrical maps on nonorientable surfaces; H. Van Maldeghem, Gent, Belgium, Buildings: More than just bricks and apartments; I. Wanless, Australian National University, Canberra, Atomic latin squares and perfect factorizations.
Information: Additional information is available from the organizer, L. Batten, Deakin Univ., lmbatten@deakin.edu.au, or at http://www.cm.deakin.edu.au/comb03melbourne. The registration form and call for abstracts will be available on the website by the end of July, and an early registration discount applies to all those who register by November 14, 2003.

17–20 **First Joint International Meeting between the American Mathematical Society and Various Indian Mathematical Societies**, Bangalore, India. (Sept. 2002, p. 1001)
Information: http://www.ams.org/amsmtgs/internmtgs.html.

18–20 **1st Indian International Conference on Artificial Intelligence (IICAI-03)**, Hyderabad, India. (Aug. 2003, p. 846)
Focus: This conference focuses on all areas of AI and its applications to many areas. We are inviting paper submissions and sessions proposals.
Information: http://www.iiconference.org.

19–21 **WSEAS Multiconferences**, Tenerife, Canary Islands, Spain. (Jun./Jul. 2003, p. 724)
Description: The multiconference is the 4th in the successfull history of the conference that was held in Athens, Greece (2000), Cairns, Australia (2001), Miedyzydroje, Poland (2002). As in 2002 in the conference in Poland, all the accepted papers will be published in WSEAS *Transactions on Mathematics*.
Topics: 4th WSEAS International Conference on Mathematics and Computers in Biology and Chemistry (MCBC'03) with special emphasis on: Bioengineering, molecular biology, mathematical biology, biochemistry, biophysics, computer biology, biological dynamical systems. 4th WSEAS International Conference on mathematics and computers in business and economics (MCBC'04) (theoretical, mathematical, computational, statistical, experimental methods for economics, business and management science and applications). 7th WSEAS Internat.Conf. on 4th WSEAS International Conference on Automation & Information (ICAI'03). 4th WSEAS International Conference on acoustics, music, speech and language processing (ICAMSL 2003) (former acoustics and music: theory and applications).
Information: http://www.wseas.org/.

20–22 **International Symposium on Recent Advances in Mathematics & Its Applications (ISRAMA 2003)**, Kolkata (Calcutta), India. (Jun./Jul. 2003, p. 724)
Topics: Algebra, Discrete Mathematics & Theoretical Computer Science; Analysis & Topology and Their Applications; Geometry and Its Applications; Dynamical Systems, Chaos and Fractals; Continuum Mechanics; Plasma Physics; Control Theory and Optimization Theory; Bio-mechanics; Applications of Mathematics to Environmental Problems; History and Philosophy of Physical Science; Quantum Information Theory. All deliberations in the symposium shall take place in English.
Registration Fee: US $200 for each participant from other countries (local hospitality will be provided).
Contact: All correspondence regarding the symposium should be addressed to: M. R. Adhikari, Secretary, Calcutta Mathematical Society, Physics & Applied Mathematics Unit, AE-374, Sector-1, Salt Lake City, Calcutta-700064, India; email: cms@cal2.vsnl.net.in; H. P. Mazumdar, Convenor; Indian Statistical Institute, 203 B. T. Road, Calcutta-700035, India; hpm@isical.ac.in.

22–25 **International Conference on Analysis and Applications**, Department of Mathematics, Banaras Hindu University, Varanasi 221 005, India. (Jun./Jul. 2003, p. 724)

Conference Themes: Recent trends of researches in classical and modern analysis including functional analysis, operator theory, distribution theory, harmonic analysis and wavelets, optimization theory, approximation theory, computational analysis and differential equations.

Invited Speakers: R. D. Charmichael (USA), J. Schmeelk (USA), S. Pilipovic' (Yugoslavia), K. Fujita (Japan), S. Watanabe (Japan), H. P. Dikshit (India), P. K. Jain (India), S. Kesavan (India), G. Mishra (India), U. B. Tewari (India), J. N. Pandey (Canada), S. P. Singh (Canada), H. M. Srivastava (Canada), M. W. Wong (Canada).

Call for Papers: Abstract of contributed papers should be sent by July 31, 2003. Proceedings of the conference will be published.

Information: N. Lal, R. S. Pathak, Dept. of Math., Banaras Hindu Univ., Varanasi 221 005, India; tel: 091-542-2575262/2275662; fax: 091-542-2368174; email: rspathak@banaras.ernet.in; http://ramshankarpathak@yahoo.co.in/.

January 2004

5–9 **Workshop on Large N Limits of $U(N)$ Gauge Theory in Physics and Mathematics**, Centre de Recherches Mathématiques, Montréal, Québec, Canada. (Aug. 2003, p. 846)

Description: This workshop is devoted to the large N expansion in quantum Yang Mills theory, particularly in the explicitly solvable 2D setting. During the '90s a series of articles by such physicists as D. J. Gross, W. Taylor, G. Matytsin, M. Douglas, V. Kazakov, and G. Moore produced a series of conjectured expansions for objects of 2D Yang-Mills with gauge group $U(N)$, such as the partition function of a closed surface of genus g, the partition function of a cylinder, the expected value of the Wilson loop functional, as well as certain characters $\chi_R(U)$. These quantities are related to traces and other invariants of heat kernels, as well as to volumes and traces over moduli spaces of flat connections. The asymptotics of the partition functions are governed by statistics of branched covers of surfaces.

Topics: The Matytsin asymptotics for the characters $\chi_R(U)$, recently proven by A. Guionnet and O. Zeitouni; the Kazakov-Douglas phase transition in $g = 0$, recently proven by A. Boutet de Monvel and M. Shcherbina; Zelditch's limit formula for the partition function on the cylinder; statistics of branched covers (integrals over Hurwitz spaces); volumes and trace integrals over moduli spaces of flat bundles; the large N limit of objects of S_N; relations between large N theory of YM_2 and random matrix models; relations with free probability; the new, very fast developing work of Dijkgraaf-Vafa.

Organizers: P. Bleher (IUPUI), V. Kazakov (École Normale), and S. Zelditch (Johns Hopkins).

Invited Participants: Physics: R. Dijkgraaf (Amsterdam) (*), M. Douglas (Rutgers), B. Eynard (Saclay), I. Kostov (Saclay), M. Marino (Harvard), G. Moore (Rutgers) (*), M. Staudacher (Max Planck) (*), W. Taylor (MIT) (*), C. Vafa (Harvard) (*).

Mathematics: P. Biane (ENS) (*), A. M. Boutet de Monvel (Paris 7), D. Diderot, C. Frohman (SUNY) (*), W. Goldman (Maryland), A. Guionnet (UMPA-Lyon), K. Johannson (KTU) (*), A. Okounkov (Berkeley), R. Pandharipande (Princeton) (*), N. Reshetikhin (UC Berkeley) (*), M. Shcherbina (Kharkov), R. Wentworth (Johns Hopkins) (*), C. Woodward (Rutgers), O. Zeitouni (Technion). (*) to be confirmed.

7–9 **IMA Short Course: The Internet for Mathematicians**, University of Minnesota, Minneapolis, Minnesota. (Mar. 2003, p. 408)

Organizers: W. Willinger (AT&T Research), B. Hajek (Illinois).

Information: Institute for Mathematics and its Applications, University of Minnesota, 207 Church St. SE, 400 Lind Hall, Minneapolis, MN 55455; phone: 612-624-6066; email: visit@ima.umn.edu; http://www.ima.umn.edu/complex/winter/sc1.html.

7–10 **Joint Mathematics Meetings**, Phoenix Civic Plaza, Phoenix, Arizona. (Sept. 2002, p. 1001)

Information: http://www.ams.org/amsmtgs/2004_phioeintro.html.

9–10 **2003-04 ASL Winter Meeting (with Joint Mathematics Meetings)**, Phoenix, Arizona. (Apr. 2003, p. 499)

Program Committee: T. McNicholl, I. Neeman, and C. Wood (chair).

Information: Email: asl@vassar.edu.

11 **IMA Tutorial: Measurement, Modeling and Analysis of the Internet**, University of Minnesota, Minneapolis, Minnesota.

Organizers: B. Hajek (Illinois), D. Towsley (Massachusetts). (Mar. 2003, p. 408)

Information: Institute for Mathematics and its Applications, University of Minnesota, 207 Church St. SE, 400 Lind Hall, Minneapolis, MN 55455; phone: 612-624-6066; email: visit@ima.umn.edu; http://www.ima.umn.edu/complex/winter/t2.html.

11–14 **Thompson's Group at 40 Years**, AIM Research Conference Center, Palo Alto, California. (Aug. 2003, p. 846)

Program: This workshop, sponsored by AIM and the NSF, will be devoted to understanding Thompson's group from many different viewpoints and approaching some open questions about the group.

This workshop will bring together researchers in group theory, category theory, and dynamics for a joint approach towards Thompson's group. We hope especially to facilitate communication between researchers in these differing fields who may view Thomspson's group in quite different ways. Exploring the connections between these viewpoints will lead to new and innovative approaches to some open problems concerning this group.

Organizers: S. Cleary, S. Gersten, J. Stallings, and J. Taback.

Application Deadline: September 1, 2003.

Information: Visit http://aimath.org/ARCC/workshops/thompsonsgroup.html.

12–16 **IMA Workshop 4: Measurement, Modeling and Analysis of the Internet**, University of Minnesota, Minneapolis, Minnesota. (Mar. 2003, p. 408)

Organizers: B. Hajek (Illinois), D. Towsley (Massachusetts).

Information: Institute for Mathematics and its Applications, University of Minnesota, 207 Church St. SE, 400 Lind Hall, Minneapolis, MN 55455; phone: 612-624-6066; email: visit@ima.umn.edu; http://www.ima.umn.edu/complex/winter/c4.html.

18–22 **Computing: The Australasian Theory Symposium**, University of Otago, Dunedin, New Zealand. (Aug. 2003, p. 846)

Topics: Papers are invited on all aspects of theoretical computer science. Some representative but not exclusive topics include the following: logic, reasoning and verification; formal specification techniques and program semantics; formal development methods, program refinement, synthesis and transformation; concurrent, parallel and distributed system theory; algorithm design and data structures; streaming data computation; computational biology, geometry, and number theory; complexity and computability; automata, types and category theory; tools for automated reasoning, and program analysis and development.

Important Dates: August 29, 2003: Deadline for submissions of full papers. October 11, 2003: Notification of acceptance for formal submissions. November 29, 2003: Deadline for informal submissions. November 14, 2003: Final versions of accepted formal papers due, deadline for author registrations, notification of acceptance for informal submissions. January 18–22, 2004: Australasian Computer Science Week, incorporating CATS 2004.

Information: http://www.cs.otago.ac.nz/staffpriv/mike/CATS04/CATS04.html.

19–July 9 **Statistical Mechanics of Molecular and Cellular Biological Systems**, Isaac Newton Institute for Mathematical Sciences, Cambridge, England. (Mar. 2003, p. 408)

Description: The programme will be structured along four linked themes:
1. Single molecule biophysics (including protein dynamics, mechanical force spectroscopy).
2. Membrane/cortical dynamics and self-assembly (including lipid phase separation, motility and interaction with the extracellular matrix).
3. Molecular motors (including modelling of single-molecule motors in the presence of noise, cooperative behaviour, etc.).
4. Molecular and cellular aspects of gene expression (including DNA binding proteins and complexes, cell division, transmembrane signalling, networks or polymerisation and depolymerisation).
While all four will be worked on throughout the 6-month period, there will be periods of more focus on each when the theoretically based scientists and mathematicians of the long-term programme will be visited on a shorter-term basis by key experimentalists working in these areas and their boundaries.
Organizers: T. McLeish (Leeds), J. Trinick (Leeds), P. Stockley (Leeds), J. Molloy (York), W. Poon (Edinburgh), T. Duke (Cambridge).
Information: Isaac Newton Institute for Mathematical Sciences, 20 Clarkson Road, Cambridge, CB3 OEH UK; tel: +44 (0) 1223 335999; fax: +44 (0) 1223 330508; email: info@newton.com.ac.uk; http://www.newton.cam.ac.uk/.

*20–25 **International Educational Conference & Exhibition**, Knowledge Village, Dubai, UAE.
Description: This is the first international conference on educational and knowledge development centers and institutions in the world. The event will include all universities and research centers and academies in the world. The main objective of this event is to facilitate the direct contact and exchange of knowledge between the educational centers in the world and their direct contact with the public that has a high demand. The conference will be held in the first and largest knowledge village and education center in the world.
Information: Tel: 0097142695539; fax: 0097142695311/2650043; email: blexpo@emirates.net.ae; trctcs@uohyd.

21–30 **Advanced Course on Ramsey Methods in Analysis**, Bellaterra (Barcelona), Spain. (Apr. 2003, p. 499)
Coordinator: J. Bagaria.
Information: http://www.crm.es/RamseyMethods/.

26–July 16 **Random Matrix Approaches in Number Theory**, Isaac Newton Institute for Mathematical Sciences, Cambridge, England. (Mar. 2003, p. 408)
Description: The programme will mainly focus on how random matrix theory can further contribute to unanswered questions in number theory and on how to put the connection between random matrices and number theory on a rigorous footing. However, both random matrix theory and number theory individually play significant roles in theoretical physics, and probability random matrix statistics appear in the spectra of quantum systems whose classical limit is chaotic; the problem of quantum unique ergodicity has connections with the theory of modular surfaces and algebraic number theory; many of the main results on the statistics of ensembles of random matrices have been the work of probabilists; the Riemann zeta function even shows up in the theory of Brownian motion—and this is just to name a few. These themes will also be developed through focused workshops.
Organizers: B. Conrey (Palo Alto), P. Diaconis (Stanford), F. Mezzadri (Bristol), P. Sarnak (Princeton).
Information: Isaac Newton Institute for Mathematical Sciences, 20 Clarkson Road, Cambridge, CB3 OEH UK; tel: +44 (0) 1223 335999; fax: +44 (0) 1223 330508; email: info@newton.com.ac.uk; http://www.newton.cam.ac.uk/.

February 2004

2–13 **Advanced Course on Contemporary Cryptology**, Bellaterra (Barcelona), Spain. (Apr. 2003, p. 499)
Coordinator: P. Morillo.
Information: http://www.crm.es/ContemporaryCryptology/.

8 **IMA Tutorial: Robustness and the Internet: Design, Evolution, and Theoretical Foundations**, University of Minnesota, Minneapolis, Minnesota. (Apr. 2003, p. 499)
Organizers: W. Willinger (AT&T), J. Doyle (Caltech).
Information: Institute for Mathematics and its Applications, University of Minnesota, 207 Church St. SE, 400 Lind Hall, Minneapolis, MN 55455; phone: 612-624-6066; email: visit@ima.umn.edu; http://www.ima.umn.edu/complex/winter/t3.html.

9–13 **IMA Workshop 5: Robustness in Complex Systems**, University of Minnesota, Minneapolis, Minnesota. (Apr. 2003, p. 499)
Organizers: W. Willinger (AT&T), J. Doyle (Caltech).
Information: Institute for Mathematics and its Applications, University of Minnesota, 207 Church St. SE, 400 Lind Hall, Minneapolis, MN 55455; phone: 612-624-6066; email: visit@ima.umn.edu; http://www.ima.umn.edu/complex/winter/c5.html.

17–20 **Announcement and Call for Papers: IV International Symposium on Mathematical Methods Applied to the Sciences**, San José, Costa Rica. (Aug. 2003, p. 847)
Topics: Data Analysis, Multivariate Statistics, Clustering and Classification Probability, Stochastic Processes, Financial Mathematics Optimization, Operations Research, Approximation, Numerical Analysis, Applications of the above topics. To submit a short course or a paper, please visit our website for instructions. Send the abstract to: email: jtrejos@cariari.ucr.ac.cr.
Deadline: October 15, 2003.
Languages: English and Spanish.
Registration: Please visit our website for prices and deadlines. We offer special discounts for Central Americans and students. The preliminary program will be available at the beginning of January 2004.
Organizers: J. Trejos (chairman), email: jtrejos@cariari.ucr.ac.cr; W. Mora (webmaster), email: wmora@itcr.ac.cr.
Information: http://www.itcr.ac.cr/simmac/, http://www.emate.ucr.ac.cr.
Further Information: On the website you can find further details about the Scientific and the Organizing Committees, as well as travel, hotel, tourism, and other information.

March 2004

1–26 **Markov Chain Monte Carlo: Innovations and Applications in Statistics, Physics, and Bioinformatics**, Institute for Mathematical Sciences, National University of Singapore, Singapore. (Jun./Jul. 2003, p. 725)
Description: The purpose of this program is to bring together people who work on innovative developments and applications in statistics, physics, and bioinformatics. The program aims to encourage cross-fertilization between workers in rather different developments and also to challenge the theoretical capacity of these methods by exposing them to statistical and bioinformatical applications.
Organizing Committee: W. Kendall, chair (Univ. of Warwick, UK); F. Liang, co-chair (National Univ. of Singapore and Texas A&M Univ., USA) and J.-S. Wang, co-chair (National Univ. of Singapore).
Format: The program will be comprised of a tutorial (March 8–12, 2004) on background material and a workshop (March 22–26, 2004) at the research level, in addition to seminars and informal discussions.
Registration: Registration forms for the tutorial/workshop are available at http://www.ims.nus.edu.sg/Programs/mcmc/index.htm and should be received at least one month before commencement of each activity. Registration is free. Membership is not required for participation.

Membership: Membership application for visiting the institute under the program is also available from the above website. Members do not need to register for specific activities.
Contacts: For general enquiries, please email: ims@nus.edu.sg; for enquiries on scientific aspects of the program, please email W. Kendall, w.s.kendall@warwick.ac.uk; F. Liang, email: fliang@stat.tamu.edu; and J.-S. Wang, email: cscwjs@nus.edu.sg.
Information: For more information please visit: http://www.ims.nus.edu.sg/Programs/mcmc/index.htm.

4–6 **Workshop on Spectral Geometry**, Centre de Recherches Mathématiques, Montréal, Québec, Canada. (Aug. 2003, p. 847)
Description: Relations between the geometric properties of manifolds and the spectrum of the Laplacian have been actively studied for decades. It is well known that many important geometric invariants are determined by the spectrum, and, vice-versa, the behavior of eigenvalues is strongly dependent on the underlying geometry and topology. Still, our understanding of the interplay between geometry and the spectrum is very far from being complete. In recent years some major developments have occurred in various areas of spectral geometry, such as spectral asymptotics, eigenvalue estimates, isospectrality, and others. These problems and their applications will be the focus of the workshop.
Organizer: I. Polterovich (Montréal).
Invited Participants: M. Ashbaugh (Missouri), C. Gordon (Dartmouth), P. Gilkey (Oregon), D. Gioev (UPenn), V. Guillemin (MIT), M. Hitrik (UCLA), V. Ivrii (Toronto), P. Li (UC Irvine), J. Lott (Michigan), R. Mazzeo (Stanford), P. Perry (Kentucky).

7 **IMA Tutorial: Control and Pricing in Communication and Power Networks**, University of Minnesota, Minneapolis, Minnesota. (Apr. 2003, p. 499)
Organizers: C. L. DeMarco (Wisconsin-Madison), F. P. Kelly (Cambridge), T. G. Kurtz (Wisconsin-Madison), R. J. Williams (San Diego).
Information: Institute for Mathematics and its Applications, University of Minnesota, 207 Church St. SE, 400 Lind Hall, Minneapolis, MN 55455; phone: 612-624-6066; email: visit@ima.umn.edu; http://www.ima.umn.edu/complex/winter/t4.html.

8–13 **IMA Workshop 6: Control and Pricing in Communication and Power Networks**, University of Minnesota, Minneapolis, Minnesota. (Apr. 2003, p. 499)
Organizers: C. L. DeMarco (Wisconsin-Madison), F. P. Kelly (Cambridge), T. G. Kurtz (Wisconsin-Madison), R. J. Williams (San Diego).
Information: Institute for Mathematics and its Applications, University of Minnesota, 207 Church St. SE, 400 Lind Hall, Minneapolis, MN 55455; phone: 612-624-6066; email: visit@ima.umn.edu; http://www.ima.umn.edu/complex/winter/c6.html.

8–June 11 **Proteomics**, Institute for Pure and Applied Mathematics, UCLA, Los Angeles, California.
Information: http://www.ipam.ucla.edu/programs/prot2004/.

12–13 **AMS Southeastern Section Meeting**, Florida State Univ., Tallahassee, Florida. (Dec. 2002, p. 1001)
Information: G. Alsfeld, gma@ams.org, http://www.ams.org/amsmtgs/sectional.html.

26–27 **AMS Central Section Meeting**, Ohio Univ., Athens, Ohio. (Dec. 2002, p. 1001)
Information: http://www.ams.org/amsmtgs/sectional.html.

29–April 2 **IMA Short Course: Tools for Modeling and Data Analysis in Finance/Asset Pricing**, University of Minnesota, Minneapolis, Minnesota. (Apr. 2003, p. 499)
Organizers: M. Avellaneda (NYU), P. P. Carr (NYC).
Information: Institute for Mathematics and its Applications, University of Minnesota, 207 Church St. SE, 400 Lind Hall, Minneapolis, MN 55455; phone: 612-624-6066; email: visit@ima.umn.edu; http://www.ima.umn.edu/complex/spring/sc2.html.

April 2004

1–May 15 **Econometric Forecasting and High-Frequency Data Analysis**, Institute for Mathematical Sciences, National University of Singapore, Singapore. (Aug. 2003, p. 847)
Program Organization: This is a program jointly organized by the Institute for Mathematical Sciences; National Univ. of Singapore; and School of Economics and Social Sciences, Singapore Management Univ. Co-chairs: R. S. Mariano (Singapore Management Univ.), S. Ouliaris (National Univ. of Singapore), and Y. K. Tse (Singapore Management Univ.); Members: O. E. Barndorff-Nielsen (Univ. of Aarhus, Denmark), A. Pagan (Australian National Univ., Australia), A. Tay (National Univ. of Singapore), and G. Tiao (Univ. of Chicago, USA).
Description: Econometric forecasting has seen new dimensions recently due to developments in nonstationary time series, systems of equations and nonlinear dynamics modeling, while the advances in high-frequency data (HFD) analysis have recently accelerated with the availability of financial intra-day trade data.
Format: The program will focus on two major topics in econometrics: the first three weeks on forecasting, with the other three weeks on HFD analysis. The program will commence with a plenary session providing an overview of the themes and coverage. It will be followed by a series of formal meetings comprised of open forums, tutorials, research seminars/workshops, and a conference for the presentation of research papers on forecasting and high-frequency analysis.
Registration: Registration forms for the tutorial/workshop are available at http://www.ims.nus.edu.sg/Programs/econometrics/index.htm and should be received at least one month before commencement of each activity. Registration is free. Membership is not required for participation.
Membership: Membership application for visiting the institute under the program is also available from the above website. Members do not need to register for specific activities.
Contacts: For general enquiries please email ims@nus.edu.sg, while for enquiries on scientific aspects of the program, please email R. S. Mariano at rsmariano@smu.edu.sg. More information is available at the program website: http://www.ims.nus.edu.sg/Programs/econometrics/index.htm.

3–4 **AMS Western Section Meeting**, University of Southern California, Los Angeles, California. (May 2003, p. 604)
Information: http://www.ams.org/amsmtgs/sectional.html.

4–7 **Fractal 2004**, Vancouver, Canada. (Jun./Jul. 2003, p. 725)
Topics: "Complexity and Fractals in Nature", 8th International Multidisciplinary Conference.
Information: http://www.kingston.ac.uk/fractal/.

12–16 **IMA Workshop 7: Risk Management and Model Specifications Issues in Finance**, University of Minnesota, Minneapolis, Minnesota. (Apr. 2003, p. 499)
Organizers: M. Avellaneda (NYU), R. Cont (École Polytechnique).
Information: Institute for Mathematics and its Applications, University of Minnesota, 207 Church St. SE, 400 Lind Hall, Minneapolis, MN 55455; phone: 612-624-6066; email: visit@ima.umn.edu; http://www.ima.umn.edu/complex/spring/c7.html.

17–18 **AMS Eastern Section Meeting**, Rider Univ., Lawrenceville, New Jersey. (Sept. 2002, p. 1001)
Information: G. Alsfeld, email: gma@ams.org, http://www.ams.org/amsmtgs/sectional.html.

19–24 **CHT-04: Advances in Computational Heat Transfer**, Cruise ship between Kirkenes and Bergen, Norway. (Jun./Jul. 2003, p. 725)
Objective: To provide a forum for the exposure and exchange of ideas, methods, and results in computational heat transfer. Papers on all aspects of computational heat transfer, both fundamental and applied, will be welcome.

Program: The program will comprise contributed papers, all of which will be poster presentations; nine invited keynote lectures, all presented as stand-up lectures; a panel discussion on "Validation and Verification of Computational Solutions" (with invited participants plus open discussion from the floor); and a minisymposium on "Computational Combustion" (with invited speakers).
Deadline: For extended (3–4 page) abstracts: September 1, 2003.
Information: http://cht04.mech.unsw.edu.au/.

22–25 **2004 ASL Spring Meeting (with APA)**, Chicago, Illinois. (Jun./Jul. 2003, p. 725)
Description: This meeting will be held jointly with the Annual Meeting of the Central Division of the American Philosophical Association.
Program Committee: S. Awodey, T. Bays, and M. Kremer (chair).
Information: Visit http://www.aslonline.org/.

May 2004

3–7 **IMA Workshop 8: Model Implementation, Algorithms and Software Issues**, University of Minnesota, Minneapolis, Minnesota. (Apr. 2003, p. 499)
Organizers: J. Langsam (Morgan Stanley), G. Papanicolaou (Stanford).
Information: Institute for Mathematics and its Applications, University of Minnesota, 207 Church St. SE, 400 Lind Hall, Minneapolis, MN 55455; phone: 612-624-6066; email: visit@ima.umn.edu; http://www.ima.umn.edu/complex/spring/c8.html.

3–8 **AARMS-CRM—Workshop on Singular Integrals and Analysis on CR Manifolds**, Halifax, Nova Scotia, Canada. (Aug. 2003, p. 847)
Description: The theory of singular integral operators in the context of analysis on CR submanifolds of Cn, in particular the Heisenberg group, has been studied and proven fruitful over the last thirty years. In recent years the emphasis has shifted to singular integral operators which do not fall under the standard Calderon-Zygmund theory. These include operators arising from product kernels on nilpotent Lie groups, which in turn lead to the study of flag kernels. The workshop combines the areas of harmonic analysis, several complex variables, symmetric spaces, and Lie groups. It will include two series of lectures, to be delivered by Alexander Nagel (Wisconsin) and Elias M. Stein (Princeton). The workshop will be held in Halifax, Nova Scotia.
Organizers: G. Dafni (Concordia), A. Fraser (Dalhousie).
Speakers: A. Boggess (Texas A&M) (*), A. Bonami (Orleans), D.-C. Chang (Georgetown), P. Ciatti (Padova) (*), M. Cowling (UNSW-Sydney), A. Dooley (UNSW-Sydney), J. Faraut (Paris VI) (*), G. Folland (Seattle), G. Gaudry (UNSW-Sydney) (*), P. Greiner (Toronto), P. Guan (McMaster) (*), K. Hare (Waterloo) (*), A. Koranyi (CUNY), G. Mockenhaupt (Georgia Tech) (*), L. Rothschild (UCSD) (*), E. Sawyer (McMaster) (*), M.-C. Shaw (Notre Dame) (*), P. Sjögren (Göteborg) (*), N. Stanton (Notre Dame) (*), S. Thangavelu (Bangalore), S. Wainger (Wisconsin) (*), J. Wright (Edinburgh) (*). (*) to be confirmed.

3–June 26 **2004 Geometric Partial Differential Equations**, Institute for Mathematical Sciences, National University of Singapore, Singapore. (Aug. 2003, p. 847)
Description: Combining geometric insights and analytic techniques together has generated many fruitful ideas and surprising results. The advances of the analytical results on nonlinear partial differential equations have helped to accelerate research on differential geometry for the last forty years. On the other hand, geometry has provided subtle and elegant equations for investigation. The objective of the program is to initiate and conduct investigations into nonlinear partial differential equations arising from geometric problems, especially those related to the scalar curvature, Q-curvature, and Sigma curvature.
Organizing Committee: Co-chairs: X. Xu (Nat. Univ. of Singapore) and P. Yang (Princeton Univ.); W. Ding (Beijing Univ., China), M. C. Leung (Nat. Univ. of Singapore), C. S. Lin (Nat. Chung Cheng Univ., Taiwan), P. Pang (Nat. Univ. of Singapore), G. Tian (MIT), and N. S. Trudinger (Australian Nat. Univ.).
Format: The program will consist of tutorials on background material and a workshop (May 28–June 2, 2004) at research level, in addition to seminars and informal discussions. The program will focus on the following topics: (i) scalar curvature problem, especially prescribed scalar curvature problem on n-sphere; (ii) conformally invariant operators; (iii) geometric flow problem; and (iv) fully nonlinear partial differential equations.
Registration: Registration forms for the tutorial/workshop are available at http://www.ims.nus.edu.sg/Programs/pdes/index.htm and should be received at least one month before commencement of each activity. Registration is free. Membership is not required for participation.
Membership: Membership application for visiting the institute under the program is also available from the above website. Members do not need to register for specific activities.
Information: For general enquiries please email ims@nus.edu.sg, while for enquiries on scientific aspects of the program, please email X. Xu at matxuxw@nus.edu.sg. More information is available at the program website: http://www.ims.nus.edu.sg/Programs/pdes/index.htm.

4–7 **Workshop on Spectral Theory and Automorphic Forms**, Centre de Recherches Mathématiques, Montréal, Québec, Canada. (Aug. 2003, p. 848)
Organizers: D. Jakobson (McGill), Y. Petridis (CUNY).
Description: In the last forty years it has been understood that there is a close connection between the spectral theory of hyperbolic manifolds and the theory of L-functions attached to automorphic forms. Trace formulas of Selberg and Kuznetsov-Bruggeman are extremely useful in studying the spectrum and eigenfunctions of the hyperbolic Laplacian. Surprising connections have also been discovered between subconvexity estimates for L-functions and the equidistribution results for Eisenstein series and cusp forms.

Analytical questions about families of L-functions include questions about the distributions of zeros and GRH, value-distribution, special values and applications, as well as connections with arithmetical questions (such as distribution of primes, size of class groups, analytic ranks of elliptic curves). One of the most fruitful approaches to the study of statistical properties of zeros of L-functions involves establishing connections with random matrix theory.

The goal of this workshop is to bring together leading researchers in those fields, to introduce young researchers and graduate students to the state of the art results, and to give an account of applications of techniques from analytic number theory to problems in analysis.

The workshop will coincide with the second series of Aisenstadt lectures for the year, to be given by P. Sarnak.
Invited Participants: J. Bolte (Bristol) (*), B. Conrey (AIM) (*), D. Goldfeld (Columbia) (*), W. Duke (UCLA), J. Friedlander (Toronto) (*), D. Hejhal (Minnesota), J. Hoffstein (Brown), L. Ji (Michigan), C. Judge (Indiana), J. Keating (Bristol) (*), E. Kowalski (Bordeaux) (*), S. Koyama (Keio) (*), E. Lindenstrauss (Stanford) (*), W. Luo (Ohio), P. Michel (Montpellier) (*), S. Miller (Rutgers), W. Mueller (Bonn), R. Murty (Queen's) (*), C. O'Sullivan (CUNY) (*), P. Perry (Kentucky) (*), B. Randol (CUNY) (*), Z. Rudnick (Tel Aviv), P. Sarnak (Princeton), K. Soundararajan (Michigan) (*), N. Vatsal (UBC), A. Venkov (Aarhus), M. Wakayama (Kyushu) (*), A. Zaharescu (Illinois) (*), S. Zelditch (Johns Hopkins) (*). (*) to be confirmed.

19–24 **2004 ASL Annual Meeting**, Carnegie Mellon Univ., Pittsburgh, Pennsylvania. (Dec. 2002, p. 1422)
Local Organizing Committee: J. Avigad (Chair), S. Awodey, L. Blum, J. Cummings, E. Schimmerling, and W. Sieg.
Program Committee: S. Artemov (chair), T. Bartoszynski, D. Hirschfeldt, M. C. Laskowski, and W. Sieg.
Information: The 2004 Mathematical Foundations of Programming

Semantics (MFPS) Meeting, to begin on May 23, 2004, will co-locate with the ASL Annual Meeting. For more information about MFPS, visit http://www.math.tulane.edu/MFPS.html.

24–28 **IMA Workshop 9: Financial Data Analysis and Applications**, University of Minnesota, Minneapolis, Minnesota. (Apr. 2003, p. 499)
Organizers: J. Heaton (Chicago), A. Lo (MIT).
Information: Institute for Mathematics and its Applications, University of Minnesota, 207 Church St. SE, 400 Lind Hall, Minneapolis, MN 55455; phone: 612-624-6066; email: visit@ima.umn.edu; http://www.ima.umn.edu/complex/spring/c9.html.

24–28 **Workshop on Hamiltonian Dynamical Systems (jointly with The Fields Institute)**, Centre de Recherches Mathématiques, Montréal, Québec, Canada. (Aug. 2003, p. 848)
Description: A conference on analytic techniques of dynamical systems, including perturbation theory, variational methods, and stability theory. The workshop will cover both finite-dimensional Hamiltonian systems such as in celestial mechanics, and infinite-dimensional Hamiltonian systems, such as those arising from PDE or from other dynamical systems with infinitely many degrees of freedom. Part of The Fields Institute thematic program, it follows a workshop on integrable and near-integrable Hamiltonian PDE, held the previous week in Toronto.
Organizing Committee: D. Bambusi (Milano); W. Craig (McMaster); S. Kuksin (Edinburgh); C. E. Wayne (Boston), chair; E. Zehnder (ETH-Zentrum).

*28–31 **International Conference on Mathematics and Its Applications**, City University of Hong Kong.
Description: The aim of the conference is to share the most recent development in mathematical research, and to enhance international academic exchanges and collaboration. In addition, the conference will be dedicated to Professor R. Wong, Fellow of Royal Society of Canada, Dean of the Faculty of Science and Engineering and Director of the Liu Bie Ju Centre for Mathematical Sciences of City University of Hong Kong, on the occassion of his 60th birthday.
Plenary Speakers: S. S. Antman (Univ. Maryland, USA), R. A. Askey (Univ. Wisconsin, USA), J. M. Ball (Univ. Oxford, UK), D. J. Benney (MIT, USA), M. Berry (Bristol Univ, UK), J. P. Bourguignon, (IHES, France), A. Bressan (Intl. School for Advanced Studies, Italy), P.G. Ciarlet (City Univ., Hong Kong), D. S. Jones (Univ. Dundee, UK), T. T. Li (Fudan Univ., China), P. L. Lions (Collége de France, France), T. P. Liu (Stanford Univ., USA), Z. M. Ma (Peking Univ., China), R. M. Miura (New Jersey Inst. Techn., USA), L. Nirenberg (New York Univ, USA), R. E. O'Malley (Univ. Washington, USA), F.WJ. Olver (Univ. Maryland, USA), J. M. Roquejoffre (Univ. Paul Sabatier, France), S. Smale (Toyota Techn. Inst., USA), A. C. C. Yao (Princeton Univ., USA)
Organizing Committee: P. G. Ciarlet (co-chair), Q. Zhang (co-chair), F. Cucker, H. H. Dai, T. Yang (City University of Hong Kong).
Information: email: mclbj@cityu.edu.hk; tel:+852 2788-9816; fax:+852 2788-7446; http://www.cityu.edu.hk/rcms/icma2004.

June 2004

2004 **Mathematical Foundations of Learning Theory**, Barcelona, Spain. (Apr. 2003, p. 499)
Coordinator: G. Lugosi.
Information: http://www.crm.es/MathematicalFoundations/.

2004 **WSEAS Conferences**, Corfu Island, Greece. (Apr. 2003, p. 500)
Topics: 7th WSEAS Internat. Conf. on Circuits, 7th WSEAS Internat. Conf. on Systems, 7th WSEAS Internat. Conf. on Communications, 7th WSEAS Internat. Conf. on Computers.
Topics for Conferences at Rhodes Island, Greece: 3rd WSEAS Internat. Conf. on Applied Informatics and Communications (AIC'03); 3rd WSEAS Internat. Conf. on Signal Processing, Computational Geometry & Artificial Vision (ISCGAV'03); 3rd WSEAS Internat. Conf. on Systems Theory and Scientific Computation (ISTASC'03) (formerly: Scientific Computation and Soft Computing).
Information: For more details and to contact us, see the website http://www.wseas.org/.

1–11 **Workshop on Semi-classical Theory of Eigenfunctions and PDEs**, Centre de Recherches Mathématiques, Montréal, Québec, Canada. (Aug. 2003, p. 848)
Description: Many questions in quantum chaos are motivated by the correspondence principle in quantum mechanics. It asserts that certain features of the classical system manifest themselves in the semiclassical (as Planck's constant $h^2 0$) limit of a quantization of the classical system. The exact relationship between classical dynamics and asymptotic properties of high energy eigenstates of a quantized system is still not completely understood, despite exciting developments in the last twenty years. Important issues related to the correspondence principle include asymptotic L^∞ (L^p) bounds for the eigenfunctions, integrated (and pointwise) Weyl errors and scarring. Another fundamental question concerns the local and global statistical properties of eigenfunctions (e.g., the random wave model), their nodal sets and critical points. These problems draw extensively on the theory of partial differential equations, and so we propose to bring together experts in these areas.

The workshop will include several short courses. H. Donnelly (Purdue) (*), N. Nadirashvili (Chicago), and D. Jerison (MIT) (*) have been invited.
Organizers: D. Jakobson (McGill), J. Toth (McGill).
Invited Participants: P. Bleher (IUPUI) (*), E. Bogomolny, D. Borthwick (Emory) (*), N. Burq (Paris-Sud) (*), Y. Colin de Verdiere (Grenoble) (*), W. Craig (McMaster) (*), C. Fefferman (Princeton) (*), L. Friedlander (Arizona), P. Gerard (Paris-Sud), P. Guan (McMaster) (*), V. Guillemin (MIT) (*), B. Helffer (Paris-Sud) (*), E. Heller (Harvard) (*), V. Ivrii (Toronto) (*), E. Martinez (UCLA) (*), Min-Oo (McMaster) (*), D. J. Nonnenmacher (Ulm) (*), K. Okikiolu (San Diego) (*), G. Popov (Nantes) (*), T. Paul (École Normale) (*), Z. Rudnick (Tel-Aviv), Y. Safarov (London), P. Sarnak (Princeton) (*), B. Shiffman (Johns Hopkins) (*), M. Shubin (Northeastern) (*), J. Sjöstrand (Polytechnique) (*), U. Smilansky (Weizmann), A. Sobolev (Sussex), C. Sogge (Johns Hopkins), T. Tate (Keio) (*), A. Uribe (Michigan) (*), A. Voros (Saclay) (*), S. T. Yau (Harvard) (*), S. Zelditch (Johns Hopkins) (*), M. Zworski (Berkeley) (*). (*) to be confirmed.

2–4 **ICNPAA 2004: Mathematical Problems in Engineering and Aerospace Sciences**, The West University of Timisoara, Romania. (May 2003, p. 604)
Scope: Includes mathematical problems in all areas of engineering and aerospace sciences.
Organizers: S. Sivasundaram (general chair); S. Balint (local organizing chair).
Sponsors: IFNA, IFIP, IEEE, AIAA.
Deadlines: (1) Organizing Special Session (the title of the session, name of the organizers): June 30, 2003; to send the title of the talks and speakers: November 30, 2003. (2) For abstracts of the talks: January 30, 2004; full papers for the proceedings: July 15, 2004.
Contact: ICNPAA 2004, 104, Snow Goose Ct., Daytona Beach, FL 32119; email: SeenithI@aol.com.
Information: http://www.icnpaa.com/.

16–19 **AIMS' Fifth International Conference on Dynamical Systems and Differential Equations**, California State Polytechnic University, Pomona, California. (Aug. 2003, p. 848)
Topics: The conference will cover all major research areas in analysis and dynamics. Equally emphasized will be real world applications in terms of modeling and computations.
Description: The conference will provide a unique international forum for the international community of mathematicians and scientists working in analysis, differential equations, dynamical systems, and their applications to real world problems in the forms

of modeling and computation. The aim of this conference is to bring the worldwide senior experts as well as young researchers together to report recent achievements, exchange ideas, and address future trends of research in a relaxing but stimulating environment.
Format: There will be one-hour plenary talks, 30-minute special session talks, and 20-minute contributed talks.
Organizing Committee: I. Mihaila, M. Nakashima, C. Pinter-Lucke, S. Wirkus, W. Xie (chair, wxie@csupomona.edu).
Scientific Committee: J. Bona, S. Hu (chair, shh209f@smsu.edu), X. Lu (coordinator: lux@uncwil.edu); W.-M. Ni, M. Otani, R. Temam, K. L. Teo.
Deadline: Early registration and abstract submission: March 1, 2004.
Proceedings: The conference proceedings will be published by AIMS-Press.
Funding: Limited funding from the NSF is expected to support graduate students and young researchers.
Information: Abstract submission, registration, housing, plenary speakers, special sessions, and more details will be posted at http://AiMSciences.org/. For local information, please contact W. Xie at wxie@csupomona.edu. To organize a special session, please contact S. Hu.

*28–July 3 **International Association for Statistical Education (IASE) 2004 Roundtable**, Lund University, Lund, Sweden.
Description: The goal of the Round Table Conferences is to bring together a small number of experts, representing as many different countries as possible, to discuss one another's views and approaches on a given topic area. The Round Table Conferences provide opportunities for developing better mutual understanding of common problems and for making recommendations concerning the topic area under discussion. A main outcome is a monograph containing a set of papers which have been prepared for, and discussed during, the conference. The monograph will present a global overview of the conference subject, to serve as a starting point for further research on the selected theme.
Topic: The topic for the IASE Round Table Conference in 2004 will be Curricular Development in Statistics Education. The need for processing the increasing amount of data people receive in the course of their work and lives has made it imperative that students leave elementary and secondary schools prepared to make reasoned decisions based on sound statistical thinking. Countries and communities have approached this problem in different ways. The Round Table will provide the opportunity for sharing what works and to highlight the challenges and potential solutions researchers have faced as they design and implement curricula to produce statistically literate citizens. The Round Table will be held on 28 June to 3 July in Lund, Sweden, which is in close proximity to Copenhagen, Denmark, where the Tenth International Congress on Mathematical Education will be held on 4-11 July 2004.
Contact Information: Gail Burrill, Scientific Program Committee Chair, 116 N. Kedzie, Division of Science and Mathematics Education, Michigan State University, East Lansing, MI 48824; email: burrill@msu.edu; phone: 517-432-2152, ext. 133.
Information: Our website is http://hobbes.lite.msu.edu/~IASE_2004_Roundtable. Details are also posted on the IASE website, http://www.cbs.nl/isi/iase.htm.

30–July 7 **Fourth World Congress of Nonlinear Analysts (WCNA2004)**, Hyatt Orlando, Orlando, Florida. (Aug. 2003, p. 849)
Short Description: The fourth World Congress (WCNA-2004) of Nonlinear Analysts will be held at the Hyatt Regency Orlando (Near Walt Disney World Resort) under the auspices of the International Federation of Nonlinear Analysts (IFNA). The vision of IFNA and WCNA is to promote, encourage, and influence more cooperation, understanding, and collaboration in the world community of nonlinear analysts from various diverse disciplines; to bring together various disciplines that attempt to understand nonlinear phenomena and solve nonlinear problems; and to help minimize the ever-widening gap between the developed and developing countries by providing scientific and technical research assistance in various forms. It is with this spirit that the International Federation of Nonlinear Analysts was established in 1992 as a transdisciplinary world society. IFNA sponsors the World Congress of Nonlinear Analysts periodically once every four years.
Scientific Program: There will be several invited lectures, organized sessions, minisymposia and workshops (by academic, industrial, and government experts) covering recent trends in nonlinear problems arising in such diverse disciplines as: aerospace sciences, atmospheric sciences, biological sciences, chemical sciences, cosmological sciences, economics, engineering & technological sciences, environmental sciences, geophysical sciences, medical & health sciences, numerical & computational sciences, oceanographic sciences, physical sciences, social sciences, and mathematical sciences. There will be opportunities to present short communications (30 minutes), organize informal seminars, and propose special sessions. More details concerning travel facilities, social events, preregistration, accommodations, submission of abstracts, scientific program, and invited lectures will be provided in the second announcement, which will be posted shortly.
Information: http://kermani.math.fit.edu/; email: wcna2004@yahoo.com.

July 2004

1–December 31 **Wall Bounded and Free-Surface Turbulence and Its Computation**, Institute for Mathematical Sciences, National University of Singapore, Singapore. (Aug. 2003, p. 849)
Description: Turbulence in fluid flow has remained one of the challenging problems of science and engineering today. Although important advances have been made in our knowledge and understanding of the processes of turbulence since the experiments of Osborne Reynolds more than a hundred years ago, our current ability to accurately predict turbulent events and their properties is still very limited for all but simple flows. The present program seeks to create a forum for the exchange of ideas and knowledge on recent developments in the theory of turbulence, turbulence modeling and computation, and turbulence control. The emphasis will be on turbulence at surfaces, since this is commonly encountered in applications, but related works in boundary layer transition and turbulence are also welcome.
Organizing Committee: Co-chairs: B. E. Launder (Univ. of Manchester Inst. of Sci. and Tech.), C. C. Mei (MIT), and K. S. Yeo (Nat. Univ. of Singapore).
Registration: Registration forms for participation in tutorials/workshops are available at http://www.ims.nus.edu.sg/Programs/wbfst/index.htm and should be received at least one month before commencement of each activity. Registration is free of charge. Membership is not required for participation.
Information: For general enquiries please email ims@nus.edu.sg, while for enquiries on scientific aspects of the program, please email K. S. Yeo at mpeyeoks@nus.edu.sg. More information about the program is available at the website: http://www.ims.nus.edu.sg/Programs/wbfst/index.htm.

5–9 **Graphes et Combinatoire, un Colloque a la Memoire de Claude Berge**, Université Paris 6, Paris, France. (Mar. 2003, p. 409)
Program: Graph theory and combinatorics.
Organizers: A. Bondy, J.-C. Fournier, and M. Las Vergnas.

5–9 **19th "Summer" Conference on Topology and Its Applications**, Department of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch, South Africa.
Keynote Lecturers: O. Alas (Univ. of Sao Paulo, Brazil); A. Edalat (Imperial College London, UK); M. Erne (Univ. of Hannover, Germany); M. I. Garrido (Univ. of Extremadura, Badajoz, Spain); V. Gutev (Univ. of Natal, Durban, South Africa); P. Johnstone (Univ. of Cambridge, UK); V. Pestov (Univ. of Ottawa, Canada); D. Repovs (Univ. of Ljubljana, Slovenia).

Workshops: Topological Methods in Algebra: M. D. Neusel (Texas Tech Univ. at Lubbock, USA); Duality as a Unifying Framework: I. Rewitzky (Univ. of Cape Town, South Africa).
Special Sessions: Session 1: Topology and Set Theory (e.g. Foundations, Continuum Theory). Session 2: Topology in Algebra (e.g. Topological Groups, Topological Semigroups). Session 3: Topology in Analysis and Geometry (e.g. Function Spaces, Dynamical Systems, Uniformity, Asymmetric Topology). Session 4: Topology and Computer Science (e.g. Domain Theory, Computational Topology). Session 5: Topology and Category Theory (e.g. Pointfree Topology, Topological Categories, Closure Operators). Participants are invited to present 20-minute talks.
Organizers: H. Kunzi, C. Gilmour, G. Brummer, J. Frith, S. Mabizela, I. Rewitzky, A. Schauerte (Univ. of Cape Town); D. Holgate, P. Matutu (Univ. of Stellenbosch); N. Marcus (Univ. of the Western Cape).
Information: Summer Conference on Topology and Its Applications, Department of Mathematics and Applied Mathematics, University of Cape Town, Private Bag, Rondebosch 7701, South Africa; email: topsum04@maths.uct.ac.za; fax:+27-21-6502334; http://vishnu.mth.uct.ac.za/Conferences/Topology/.

5-16 **Advanced Course on Automata Groups**, Bellaterra (Barcelona), Spain. (Apr. 2003, p. 500)
Coordinator: W. Dicks.
Information: http://www.crm.es/AutomataGroups/.

24-28 **European Congress on Computational Methods in Applied Sciences and Engineering**, Jyväskylä, Finland. (Feb. 2003, p. 295)
Scientific Programme: The scientific programme of the Congress consists of invited keynote lectures by leading experts, minisymposiums, special technological sessions, contributed papers, and poster presentations. Further details will be given in the Third Announcement (May 2003).
Congress Topics: Computational fluid mechanics, Computational solid and structural mechanics, Computational acoustics, Computational electromagnetics, Computational chemistry, Computational mathematics and numerical methods, Inverse problems, Optimization and control, Computational methods in life sciences, Industrial applications.
Call for Papers: Prospective authors are kindly invited to visit the congress website in order to submit their two-page abstracts on topics related to the themes of the Congress by November 15, 2003.
Further Information: The congress website http://www.mit.jyu.fi/eccomas2004/ or ECCOMAS Chairman, Prof. Pekka Neittaanmäki, Univ. of Jyväskylä, Dept. of Math. Inform. Tech., P.O. Box 35 FIN-40014, Univ. of JyvJyväskyl, Finland; fax: +358 14 260 2771; email: pn@mit.jyu.fi; ECCOMAS 2004 Congress Secretariat, Ms. Pirjo-Leena Pitkänen, Jyväskylä Congresses, P.O. Box 212 FIN-40101, Jyväskylä, Finland; fax +358 14 339 8159; email: pirjo-leena.pitkanen@jyvaskylaan.com.

25-31 **2004 ASL European Summer Meeting (Logic Colloquium '04)**, Torino, Italy. (Jun./Jul. 2003, p. 725)
Program Committee: T. Arai, D. DeJohgh, W. Goldfarb, G. Hjorth, S. Lempp, G. Lolli, D. Marker, D. Martin, R. McKenzie, W. Pohlers (Chair), W. Sieg, A. Sorbi, and A. Wilkie.
Local Organizing Committee: A. Andretta (Chair), S. Berardi, R. Camerlo, U. De Liguoro, M. Dezani, A. Marcone, N. Olivetti, and D. Zambella.
Information: http://lc2004.unito.it/.

26-30 **IMS Annual Meeting/6th Bernoulli World Congress**, Barcelona, Spain. (Aug. 2003, p. 849)
Topics: The program covers a wide range of topics in statistics and probability, presenting recent developments and the state of the art in a variety of modern research topics and in applications such as mathematical finance and statistical bioinformatics. The program include up to twelve Special Invited Lectures given by leading specialists, thirty-five Invited Paper Sessions and a large number of contributed talks.
Organizers: D. Nualart, Chairman of the Organizing Committee; W. Kendall, Chairman of the Scientific Committee.
Information: http://www.imub.ub.es/events/wc2004/.

26-30 **Workshop on Spectral Theory of Schrödinger Operators**, Centre de Recherches Mathématiques, Montréal, Québec, Canada. (Aug. 2003, p. 849)
Description: This workshop will focus on the spectral theory of random and quasiperiodic Schrödinger operators. In solid state physics random and almost periodic Schrödinger operators serve as models of disordered systems such as alloys, glasses and amorphous materials. The disorder of the system is reflected by the dependence of the potential on some random parameters.

From a mathematical point of view, random Schrödinger operators show quite "unusual" spectral behavior. If the disorder is large enough, then these operators have dense point spectrum with exponentially decaying eigenfunctions (Anderson localization). The appearance of dense point spectra is a reflection of the physical fact that the strongly disordered systems are bad conductors. It is believed that in the weak disorder regime and for dimensions larger then 2 these operators have some absolutely continuous spectrum which corresponds to nonzero conductivity of the weakly disordered systems. The mathematical proof of this expected spectral phase transition (Anderson delocalization) is a fundamental open problem in mathematical physics.

This workshop will bring together the world leaders in spectral theory of random and quasiperiodic Schrödinger operators. Its goal is to review the state of the art of the field and to map new directions of the research.

The program includes short courses to be given by M. Aizenman (Princeton), B. Simon (Caltech) (*), and S. Jitomirskaya (Irvine).

Organizers: V. Jaksic (McGill), Y. Last (Hebrew).
Invited Participants: J. Avron (Technion), J.M. Barbaroux (Toulon), J. M. Combes (Marseille) (*), D. Damanik (Caltech), E. B. Davies (London), R. Del-Rio (UNAM), A. Elgart (Princeton), A. Fedotov (St. Petersburg), A. Figotin (Irvine), R. Froese (UBC) (*), F. Germinet (Lille), F. Gesztesy (Missouri), M. Goldstein (Toronto), A. Gordon, I. Herbst (Virginia) (*), P. Hislop (Kentucky), D. Hundertmark (Caltech), A. Joye (Grenoble), Y. Karpeshina (Alabama), R. Killip (Caltech), W. Kirsch (Bochum), A. Kiselev (Wisconsin), A. Klein (Irvine), F. Klopp (Paris), A. Laptev (Stockholm), D. Lenz (Chemnitz), S. Molchanov (UNCC), L. Pastur (Paris), C. Remling (Osnabruck), W. Schlag (Caltech), A. Sobolev (Sussex), P. Stollmann (Chemnitz), G. Stolz (Alabama), S. Tcheremchantsev (Orleans), B. Vainberg (UNCC). (*) to be confirmed.

*26-30 **XIV Brazilian Topology Meeting**, Campinas, São Paulo, Brazil.
Host: Instituto de Matemática, Universidade Estadual de Campinas (UNICAMP)–Campinas, São Paulo, Brazil.
Description: Characteristic Classes, Cobordism, Fixed Point Theory, Foliations, Group Actions, Homotopy Theory, Immersions, Low-Dimensional Topology, and related topics.
Organizers: D. L. Gonçalves, S. Firmo, N. A. Goussevskii, J. Guaschi, S. Fenley, P. Zvengrowski.
Information: email: top2004@ime.unicamp.br; http://www.ime.unicamp.br/top2004.

26-31 **2004 ASL European Summer Meeting (Logic Colloquium '04)**, Torino, Italy. (Apr. 2003, p. 500)
Program Committee: T. Arai, D. DeJongh, W. Goldfarb, G. Hjorth, S. Lempp, G. Lolli, D. Marker, D. Martin, R. McKenzie, W. Pohlers (chair), W. Sieg, A. Sorbi, and A. Wilkie.
Local Organizing Committee: A. Andretta (chair), S. Berardi, R. Camerlo, U. De Liguoro, M. Dezani, A. Marcone, N. Olivetti, and D. Zambella.
Information: F. Whitney; email: asl@vassar.edu.

August 2004

2–6 **Workshop on Dynamics in Statistical Mechanics**, Centre de Recherches Mathématiques, Montréal, Québec, Canada. (Aug. 2003, p. 850)
Description: During the last years significant efforts have been devoted to the study of dynamical properties of (classical and quantum) open systems. In particular, through the study of noisy or forced dissipative systems, or Hamiltonian systems with a large number of degrees of freedom, our understanding of the mathematical structure of nonequilibrium statistical mechanics has greatly improved. The aim of this meeting is to present the latest results and discuss the possible future directions of research in this area. The following topics will be discussed:

Axiomatic approaches: Under appropriate hypotheses on the ergodic properties of the underlying dynamical system (chaotic hypothesis, asymptotic abelianness, etc.), it is possible to prove various predictions of nonequilibrium thermodynamics (linear response, Kubo formula, Onsager's relations, etc.). This approach also leads to unexpected results, like the Gallavotti-Cohen fluctuation theorem.

Specific models: Modern techniques (quantum field theory, algebraic quantum dynamical systems, spectral analysis, renormalization group, etc.) have been successfully applied to the study of various models (spin-boson, spin-fermion, Pauli-Fierz, Lorentz-gas, etc.). Elementary physical properties like return to equilibrium or existence and structural properties of nonequilibrium steady states have been obtained in this way. More difficult questions, like the emergence of the Fourier law, are currently under investigation.

Markovian dynamics: It gives a natural mathematical framework to study the dynamics of various nonequilibrium processes: Hamiltonian systems coupled to reservoirs, exclusion processes on the lattice, noisy extended systems.

The program includes short courses to be given by H. Araki (Kyoto), B. Derrida (École Normale), J. Froehlich (ETH), J.-P. Eckmann (Geneva) (*).
Organizers: V. Jaksic (McGill), C.-A. Pillet (Toulon).
Invited Participants: V. Bach (Mainz) (*), J. Bellissard (Georgia Tech), S. De Bievre (Lille), D. Dawson (McGill), J. Derezinski (Warsaw), L. Erdos (Georgia Tech), B. Hellfer (Paris-Sud), G. Gallavotti (Rutgers) (*), C. Gerard (Polytechnique), M. Griesemer (Alabama), A. Knauf (Erlangen) (*), S. Kuksin (Heriot-Watt), A. Kupiainen (Helsinki) (*), J. Lebowitz (Rutgers), C. Liverani (Roma) (*), C. Maes (Leuven), T. Matsui (Kyushu), M. Merkli (ETH), F. Nier (Rennes), L. Rey-Bellet (UMass), M. Sigal (Toronto), D. Spehner (Essen), H. Spohn (Munchen) (*), L. E. Thomas (Virginia), A. Verbeure (Leuven) (*), H. T. Yau (NYU) (*). (*) to be confirmed.

2–27 **Magnetic Reconnection Theory**, Isaac Newton Institute for Mathematical Sciences, Cambridge, England. (Apr. 2003, p. 500)
Description: The basic theory of MHD reconnection in two dimensions is now well developed, and the time is ripe for two new developments, which are the main aims of the programme, namely, to develop: (i) the theory for the way the process can operate in three dimensions; (ii) models for the various aspects of collisionless reconnection. We would envisage having two short workshops, an introductory one at the beginning to set the scene and one at the end to present the results and stimulate further work. There would be a series of brainstorming sessions on various key topics throughout the 4 weeks, with the emphasis on the sharing of ideas and genuine cross-fertilization. for the whole 4 weeks. In addition, the groups would have been prepared by a series of email debates amongst the participants in the months leading up to the programme, so that the members will be well prepared and ready to hit the ground running when they arrive.
Organizers: E. R. Priest (St. Andrews), J. Birn (Los Alamos), T. G. Forbes (New Hampshire).
Information: Isaac Newton Institute for Mathematical Sciences, 20 Clarkson Road, Cambridge, CB3 OEH UK; tel: +44 (0) 1223 335999; fax: +44 (0) 1223 330508; email: info@newton.com.ac.uk; http://www.newton.cam.ac.uk/.

6–7 **New Directions in Probability Theory**, Fields Institute, Toronto, Canada. (Aug. 2003, p. 850)
Description: The meeting consists of five sessions and four one-hour lectures, of which two are IMS Medallion Lectures. It is intended for a general probability audience interested in recent developments in probability theory. The topics of the session are Random Walks with Self-Repulsion, Random Matrices, Random Media, Superprocesses, and Markov Chains with Algorithms.
CoSponsor: The Institute of Mathematical Statistics (IMS) and The Fields Institute for Research in Mathematical Sciences. The meeting immediately precedes the Joint Statistical Meetings of August 8–12 (co-sponsored by ASA, IMS, ENAR, WNAR, SSC). It will take place on Friday/Saturday and will be held at The Fields Institute.
Information & Registration: There will be no registration fee for the meeting. However, space at The Fields Institute is limited, and so early registration is recommended; http://www.imstat.org/meetings/NDPT/default.htm.

16–December 17 **Quantum Information Science**, Isaac Newton Institute for Mathematical Sciences, Cambridge, England. (Apr. 2003, p. 500)
Organizers: C. H. Bennett (IBM Yorktown), D. P. DiVincenzo (IBM Yorktown), N. Linden (Bristol), S. Popescu (Bristol).
Information: Isaac Newton Institute for Mathematical Sciences, 20 Clarkson Road, Cambridge, CB3 OEH UK; tel: +44 (0) 1223 335999; fax: +44 (0) 1223 330508; email: info@newton.com.ac.uk; http://www.newton.cam.ac.uk/.

* 24–27 **International Conference on Nonlinear Operators, Differential Equations and Applications (ICNODEA-2004)**, Babes-Bolyai University, Cluj-Napoca, Romania.
Purpose: To bring together experts in nonlinear analysis and promote contacts between Romanian mathematicians and mathematicians from all over the world in order to discuss recent advances in the field.
Organizers: I. A. Rus, Gh. Micula, A. Petrusel, R. Precup.
Program: Plenary lectures, invited section lectures, short communications, poster session.
Call for Papers: Papers related to the following topics are appropriate for submission to the conference: Fixed Point Theory, Ordinary Differential Equations, Nonlinear Integral Equations, Partial Differential Equations, Analysis of Multivalued Mappings, Optimal Control, Biomathematics, Mathematical Economics, Approximation and Numerical Methods.
Language: English.
Registration Deadline: April 30, 2004.
Information: All correspondence related to the conference should be addressed to: I. A. Rus, G. Micula, A. Petrusel, or R. Precup, Babes-Bolyai University, Department of Applied Mathematics, Str. M. Kogalniceanu 1, 3400 Cluj-Napoca, Romania; email: nodeacj@math.ubbcluj.ro;http://www.math.ubbcluj.ro/~mserban/confan.htm; phone: ++40-64-405327; fax: ++40-64-191906.

30–September 3 **9th Conference on Differential Geometry and Its Applications**, Prague, Czech Republic. (Apr. 2003, p. 500)
Organizer: Faculty of Mathematics and Physics of Charles University in collaboration with other Czech universities.
Information: email: jbures@karlin.mff.cuni.cz.

September 2004

1–6 (REVISED) **Sixth Pan-African Congress of Mathematicians**, Institute National des Sciences Appliquees et del la Technologie (INSAT), Université 7 Novembre à Carthage, Tunis, Tunisia. (May 2003, p. 604)
Theme: Mathematical Sciences and the Development of Africa—Challenges for Building a Knowledge Society in Africa. The scientific

program will include plenary lectures, invited lectures, contributed research papers, a symposium, and exhibitions.
Contact: Those interested in speaking at or participating in the congress are invited to contact: A. Boukricha, local organizing committee, Université de Tunis EL Manar Departement de Mathématiques, Faculté des Sciences De Tunis, 1060 Tunis, Tunisia; email: aboukricha@fst.rnu.tn.
Information: Please submit curriculum vitae and abstract to: J. Persens, Pres., African Mathematical Union, Univ. of the Western Cape, Private Bag X17, Belville 7535, South Africa; jpersens@uwc.ac.za; and copies to: J.-P. Ezin, Sec. General, African Mathematical Union, Institut de Mathematiques et de Sciences Physiques, BP613, Porto Novo, Benin; jpezin@syfed.bj.refer.org.

14–18 **Third International Conference on Boundary Integral Methods: Theory and Applications**, Brunel Univ., West London, United Kingdom. (Nov. 2002, p. 1287)
Description: As well as discussing recent developments in the theory and numerical analysis of boundary integral equations, the conference will strive to encompass applications of contemporary relevance such as direct and inverse (medium and high) frequency scattering, electromagnetics and moving boundary problems in hydrodynamics. Continuing progress in key computational techniques such as multipole, wavelets and panel clustering, together with innovative algorithm design will be an additional theme.
Conference Organizing and Scientific Committee: S. Amini (Univ. of Salford), S. Chandler-Wilde (Brunel Univ., Chair), K. Chen (Univ. of Liverpool), P. Davies (Univ. of Strathclyde), I. Graham (Univ. of Bath), P. Martin (Colorado School of Mines).
Information:http://www.brunel.ac.uk/~mastsnc/bimta3.html.

October 2004

16–17 **AMS Southeastern Section Meeting**, Vanderbilt University, Nashville, Tennessee. (May 2003, p. 604)
Information: http://www.ams.org/amsmtgs/sectional.html.

16–17 **AMS Western Section Meeting**, University of New Mexico, Albuquerque, New Mexico. (May 2003, p. 604)
Information: http://www.ams.org/amsmtgs/sectional.html.

November 2004

6–7 **AMS Eastern Section Meeting**, University of Pittsburgh, Pittsburgh, Pennsylvania.
Information: G. Alsfeld; email: gma@ams.org; http://www.ams.org/amsmtgs/sectional.html.

December 2004

5–16 **International Workshop on Nonlinear Partial Differential Equations**, IPM, Tehran, Iran. (Aug. 2003, p. 850)
Scope: New trends and activities in the theory and applications of nonlinear partial differential equations. Topics include free boundary problems, applications of nonlinear pde's in fluids and geometry, inverse problems in pde's, stochastic and kinetic pde's, fully nonlinear pde's.
Sponsors: Institute for Studies in Theoretical Physics and Mathematics (IPM) (http://www.ipm.ir), Tehran, Iran; Wolfgang Pauli Institute (WPI) (http://www.wpi.ac.at), Vienna, Austria.
Organizers: P. A. Markowich (WPI), M. Shahshahani (IPM).
Scientific Committee: H. W. Engl (Linz, Austria), P. A. Markowich (WPI, Vienna), H. Shahgholian (KTH, Sweden), M. M. Shahshahani (IPM, Tehran), S. Tahvildarzadeh (Rutgers, USA), N. Uraltseva (St. Petersburg, Russia).
Call for Papers: Papers will be accepted for presentation at the workshop subject to approval by the Scientific Committee. Please send submissions (extended abstract) electronically (preferably in PDF format) to one of the organizers at an email address listed below.
Contact: M. M. Shahshahani (mehrdads@ipm.ir); P. A. Markowich (wittgenstein.mathematik@univie.ac.at).

17–19 **International Conference on Smarandache Algebraic Structures**, Indian Institute of Technology, IIT Madras, Chennai-600 036 Tamil Nadu, India. (Aug. 2003, p. 850)
Description: A Smarandache n-structure on a set S means a weak structure w_0 on S such that there exists a chain of proper subsets $P_{n-1} \subset P_{n-2} \subset \ldots \subset P_2 \subset P_1 \subset S$ whose corresponding structures verify the inverse chain $w_{n-1} \succ w_{n-2} \succ \ldots \succ w_2 \succ w_1 \succ w_0$, where $\succ$ signifies "strictly stronger" (i.e., structure satisfying more axioms).
Program: (1) Smarandache-type groupoids, semigroups, rings, fields; (2) Smarandache-type k-modules, vector spaces, linear algebra, fuzzy algebra.
Organizer: W. B. Vasantha Kandasamy.
Speakers: R. Padilla, M. Khoshnevisan, M. Popescu.
Deadline: November 30, 2004.
Information: http://www.gallup.unm.edu/~smarandache/eBooks-otherformats.htm.

January 2005

5–8 **Joint Mathematics Meetings**, Hyatt Regency Atlanta & Atlanta Marriott Marquis, Atlanta, Georgia. (Sept. 2002, p. 1001)
Information: http://www.ams.org/amsmtgs/national.html.

17–July 15 **Model Theory and Applications to Algebra and Analysis**, Isaac Newton Institute for Mathematical Sciences, Cambridge, England. (Apr. 2003, p. 500)
Description: Pure model theory. We expect further developments in the use of stability theory techniques in unstable contexts (simple theories, algebraically closed valued fields) and in nonelementary classes.
Model theory of fields with operators, and connections with arithmetic geometry. The model theory of differentially closed fields and of other fields with operators has been at the centre of model-theoretic proofs of results in arithmetic geometry. The Zil'ber programme of pseudo-analytic functions is also expected to have some interesting consequences.
O-minimality and related topics. O-minimality is a property of ordered structures, yielding results akin to traditional real analytic results, such as the classical finiteness theorems for subanalytic sets (cell decompositions, Whitney stratifications, etc.). Mathematically central, new examples of o-minimal structures have emerged, and the logical theory has had applications to Lie theory, to asymptotics, and to neural networks.
Henselian fields. Model theory of Henselian fields, and in particular of p-adic fields and Arc spaces. Connections with algebraic and analytic geometry. Study of cohomology theories and motives, aiming at uniformity results. Study of compact complex manifolds and uses of stability.
Model theory of groups. We plan to have a workshop on groups of finite Morley rank, a topic connected to the classification of finite simple groups via its techniques and its aims. The recent (and very exciting) developments in the model theory of nonabelian free groups should also be studied, depending on its degree of maturity.
Organizers: Z. Chatzidakis (Paris), A. Pillay (Illinois), A. Wilkie (Oxford).
Information: Isaac Newton Institute for Mathematical Sciences, 20 Clarkson Road, Cambridge, CB3 OEH UK; tel: +44 (0) 1223 335999; fax: +44 (0) 1223 330508; email: info@newton.com.ac.uk; http://www.newton.cam.ac.uk/.

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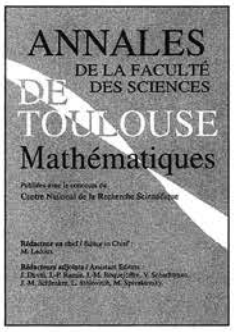

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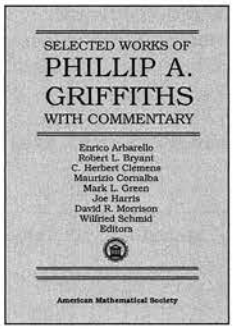
Algebra and Algebraic Geometry



Selected Works of Phillip A. Griffiths with Commentary

Enrico Arbarello, *Università "La Sapienza", Rome*, **Robert L. Bryant**, *Duke University, Durham, NC*, **C. Herbert Clemens**, *University of Utah, Salt Lake City*, **Maurizio Cornalba**, *Università di Pavia, Italy*, **Mark L. Green**, *University of California, Los Angeles*, **Joe Harris**, *Harvard University, Cambridge, MA*, **David R. Morrison**, *Duke University, Durham, NC*, and **Wilfried Schmid**, *Harvard University, Cambridge, MA*, Editors

Over the last four decades, Phillip Griffiths has been a central figure in mathematics. During this time, he made crucial contributions in several fields, including complex analysis, algebraic geometry, and differential systems. His books and papers are distinguished by a remarkably lucid style that invites the reader to understand not only the subject at hand, but also the connections among seemingly unrelated areas of mathematics. Even today, many of Griffiths' papers are used as a standard source on a subject. Another important feature of Griffiths' writings is that they often bring together classical and modern mathematics.

The four parts of *Selected Works—Analytic Geometry, Algebraic Geometry, Variations of Hodge Structures*, and *Differential Systems*—are organized according to the subject matter and are supplemented by Griffiths' brief, but extremely illuminating, personal reflections on the mathematical content and the times in which they were produced.

Griffiths' *Selected Works* provide the reader with a panoramic view of important and exciting mathematics during the second half of the 20th century.

Contents: ***Part I. Analytic Geometry:*** **P. Griffiths**, Commentary on Vector bundles; *Vector Bundles:* **Ph. A. Griffiths**, The extension problem for compact submanifolds of complex manifolds I; **P. A. Griffiths**, The extension problem in complex analysis II; embeddings with positive normal bundle; **P. A. Griffiths**, Hermitian differential geometry, Chern classes, and positive vector bundles; **P. A. Griffiths**, Period spaces and Hodge theory; **P. A. Griffiths** and **W. Schmid**, Locally homogeneous complex manifolds; **P. Griffiths** and **W. Schmid**, Recent developments in Hodge theory: A discussion of techniques and results; **P. R. Deligne**, **P. Griffiths**, **J. Morgan**, and **D. Sullivan**, Real homotopy theory of Kähler manifolds; *Analytic geometry:* **P. A. Griffiths**, Holomorphic mapping into canonical algebraic varieties; **J. Carlson** and **P. Griffiths**, A defect relation for equidimensional holomorphic mappings between algebraic varieties; **P. Griffiths**, Complex differentiable and integral geometry and curvature integrals associated to singularities of complex analytic varieties; **M. Cornalba** and **P. Griffiths**, Analytic cycles and vector bundles on non-compact algebraic varieties; **M. Green** and **P. Griffiths**, Two applications of algebraic geometry to entire holomorphic mappings; Acknowledgments; Selected titles; ***Part 2. Algebric Geometry:*** **P. A. Griffiths**, Introductory comments to Part 2; *Cycles and deformation theory:* **P. A. Griffiths**, Some results on algebraic cycles on algebraic manifolds; **P. A. Griffiths**, Complex-analytic properties of certain Zariski open sets on algebraic varieties; **C. H. Clemens** and **P. A. Griffiths**, The intermediate Jacobian of the cubic threefold; *Abel's theorem:* **P. A. Griffiths**, Variations on a theorem of Abel; **P. Griffiths** and **J. Harris**, A Poncelet theorem in space; **P. Griffiths** and **J. Harris**, Residues and zero-cycles on algebraic varieties; **S. S. Chern** and **P. Griffiths**, Abel's theorem and webs; *Algebraic and differential geometry:* **P. A. Griffiths**, Complex analysis and algebraic geometry; **P. Griffiths** and **J. Harris**, Algebraic geometry and local differential geometry; *Loci of divisors:* **P. Griffiths** and **J. Harris**, The variety of special linear systems on a general algebraic curve; **P. Griffiths** and **J. Harris**, On the Noether-Lefschetz theorem and some remarks on codimension-two cycles; **E. Arbarello**, **M. Cornalba**, **P. Griffiths**, and **J. Harris**, Special divisors on algebraic curves; Acknowledgments; Selected Titles; ***Part 3. Variations of Hodge Structures:*** **P. A. Griffiths**, Introductory comments to part 3; *Periods of integrals:* **P. A. Griffiths**, Periods of integrals on algebraic naifolds, I (Construction and properties of the modular varieties); **P. A. Griffiths**, Periods of integrals on algebraic manifolds, II (Local study of the period mapping); **Ph. A. Griffiths**, Periods of integrals on algebraic manifolds III (some global differential-geometric properties of the period mapping); **P. A. Griffiths**, On the periods of certain rational integrals I; **P. A. Griffiths**, On the periods of certain rational integrals: II; **P. A. Griffiths**, Periods of integrals on algebraic manifolds: Summary of main results and discussion of open problems; *Variations of Hodge structures:* **J. Carlson**, **M. Green**, **P. Griffiths**, and **J. Harris**, Infinitesimal variations of Hodge structure (I); **P. Griffiths** and **J. Harris**, Infinitesimal variations of Hodge structure (II): An infinitesimal invariant of Hodge classes; **P. A. Griffiths**, Infinitesimal variations of Hodge structure (III): Determinantal varieties and the infinitesimal invariant of normal functions; Acknowledgments; Selected Titles; ***Part 4. Differential Systems:*** **P. A. Griffiths**, Introductory comments to part 4; *Moving frames and differential geometry:* **P. Griffiths**, On Cartan's method of Lie groups and moving frames as applied to uniqueness and existence questions in differential geometry; *Differential systems and Hodge structure:* **P. A. Griffiths**, Poincaré and algebraic geometry; **R. L. Bryant** and **P. A. Griffiths**, Some observations on the infinitesimal period relations for regular threefolds with trivial canonical bundle; **R. L. Bryant** and **P. Griffiths**, Reduction for constrained variational problems and $\int \frac{1}{2}\kappa^2 ds$; *Integrability:* **P. A. Griffiths**, Linearizing flows and a cohomological interpretation of Lax equations; *The characteristic variety and its geometry:* **P. A. Griffiths**, Some aspects of exterior differential systems; **R. L. Bryant** and **P. A. Griffiths**, Characteristic cohomology of differential systems (I): General theory; **R. L. Bryant** and **P. A. Griffiths**, Characteristic cohomology of differential systems II: conservation laws for a class of parabolic equations; **R. Bryant**, **P. Griffiths**, and **L. Hsu**, Hyperbolic exterior differential systems and their conservation laws, Part I; **R. Bryant**, **P. Griffiths**, and **L. Hsu**, Hyperbolic exterior differential systems and their conservation laws, Part II; Acknowledgments; Selected Titles.

Collected Works, Volume 18

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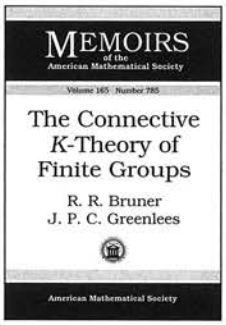
Set: October 2003, 2598 pages, Hardcover, ISBN 0-8218-1066-9, LC 2003050345, 2000 *Mathematics Subject Classification*: 32G20, 32L10, 14C25, 14C34, 14H51, 14C30, 14D07, 32J25, 58A14, 58A15, **All AMS members $239**, List $299, Order code CWORKS/18N



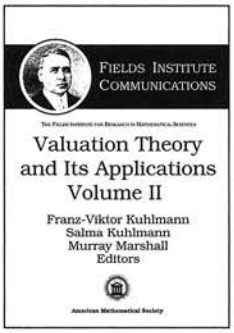
The Connective K-Theory of Finite Groups

R. R. Bruner, *Wayne State University, Detroit, MI*, and **J. P. C. Greenlees**, *University of Sheffield, UK*

Contents: Introduction; General properties of the ku-cohomology of finite groups; Examples of ku-cohomology of finite groups; The ku-homology of finite groups; The ku-homology and ku-cohomology of elementary abelian groups; Appendix A. Conventions; Appendix B. Indices; Appendix. Bibliography.

Memoirs of the American Mathematical Society, Volume 165, Number 785

September 2003, 127 pages, Softcover, ISBN 0-8218-3366-9, LC 2003051902, 2000 *Mathematics Subject Classification*: 19L41, 19L47, 19L64, 55N15; 20J06, 55N22, 55N91, 55T15, 55U20, 55U30, **Individual member $32**, List $53, Institutional member $42, Order code MEMO/165/785N



Valuation Theory and Its Applications, Volume II

Franz-Viktor Kuhlmann, **Salma Kuhlmann**, and **Murray Marshall**, *University of Saskatchewan, Saskatoon, Canada*, Editors

This book is the second of two proceedings volumes stemming from the International Conference and Workshop on Valuation Theory held at the University of Saskatchewan (Saskatoon, SK, Canada). It contains the most recent applications of valuation theory to a broad range of mathematical ideas. Valuation theory arose in the early part of the twentieth century in connection with number theory and continues to have many important applications to algebra, geometry, and analysis.

The research and survey papers in this volume cover a variety of topics, including Galois theory, the Grunwald-Wang Theorem, algebraic geometry, resolution of singularities, curves over Prüfer domains, model theory of valued fields and the Frobenius, Hardy fields, Hensel's Lemma, fixed point theorems, and computations in valued fields.

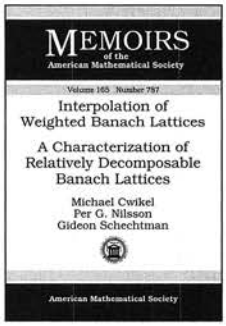
It is suitable for graduate students and research mathematicians interested in algebra, algebraic geometry, number theory, and mathematical logic.

Contents: **K. Aghigh** and **S. K. Khanduja**, A note on tame fields; **M. Aschenbrenner**, Some remarks about asymptotic couples; **H. H. Brungs**, **H. Marubayashi**, and **E. Osmanagic**, Prime segments for cones and rings; **V. Cossart** and **G. Moreno-Socías**, Irreducibility criterion: A geometric point of view; **J. Denef** and **H. Schoutens**, On the decidability of the existential theory of $\mathbb{F}_p[[t]]$; **W. Gao**, **D. B. Leep**, **J. Mináč**, and **T. L. Smith**, Galois groups over nonrigid fields; **B. Green**, Automorphisms of formal power series rings over a valuation ring; **H. Knaf**, Regular curves over Prüfer domains; **J. Koenigsmann**, Encoding valuations in absolute Galois groups; **F.-V. Kuhlmann**, **H. Lombardi**, and **H. Perdry**, Dynamic computations inside the algebraic closure of a valued field; **G. Leloup**, Preorders, rings, lattice-ordered groups and formal power series; **F. Lorenz** and **P. Roquette**, The theorem of Grunwald-Wang in the setting of valuation theory; **R. I. Michler**, Invariants of singular plane curves; **J. Ohm**, $\mathcal{V}$-rational fields; **H. Perdry**, A generalization of Hensel's lemma; **F. Pop**, Classically projective groups and pseudo classically closed fields; **P. Popescu-Pampu**, Approximate roots; **T. Scanlon**, Quantifier elimination for the relative Frobenius; **E. Schörner**, Ultrametric fixed point theorems and applications; **B. Teissier**, Valuations, deformations, and toric geometry.

Fields Institute Communications, Volume 33

September 2003, 459 pages, Hardcover, ISBN 0-8218-3206-9, LC 2002021581, 2000 *Mathematics Subject Classification*: 12-XX; 03-XX, 11-XX, 13-XX, 14-XX, 16-XX, 20-XX, **All AMS members $95**, List $119, Order code FIC/33N

Analysis



Interpolation of Weighted Banach Lattices/A Characterization of Relatively Decomposable Banach Lattices

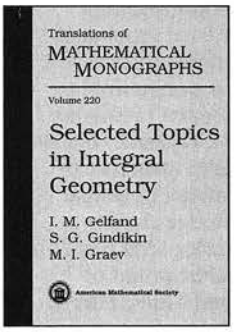
Michael Cwikel, *Technion-Israel Institute of Technology, Haifa*, **Per G. Nilsson**, *Lund, Sweden*, and **Gideon Schechtman**, *Weizmann Institute of Science, Rehovot, Israel*

Contents: *Interpolation of weighted Banach lattices, by Michael Cwikel and Per G. Nilsson:* Introduction; Definitions, terminology and preliminary results; The main results; A uniqueness theorem; Two properties of the K-functional for a couple of Banach lattices; Characterizations of couples which are uniformly Calderón-Mityagin for all weights; Some uniform boundedness principles for interpolation of Banach lattices; Appendix: Lozanovskii's formula for general Banach lattices of measurable functions; References; *A characterization of relatively decomposable Banach lattices, by Michael Cwikel, Per G. Nilsson and Gideon Schechtman:* Introduction; Equal norm upper and lower p-estimates and some other preliminary results; Completion of the proof of the main theorem; Application to the problem of characterizing interpolation spaces; References.

Memoirs of the American Mathematical Society, Volume 165, Number 787

September 2003, 127 pages, Softcover, ISBN 0-8218-3382-0, LC 2003051900, 2000 *Mathematics Subject Classification*: 46B70, 46E30, **Individual member $32**, List $53, Institutional member $42, Order code MEMO/165/787N

Independent Study



Selected Topics in Integral Geometry

I. M. Gelfand and **S. G. Gindikin**, *Rutgers University, New Brunswick, NJ*, and **M. I. Graev**, *Institute of System Studies, RAS, Moscow*

The miracle of integral geometry is that it is often possible to recover a function on a manifold just from the knowledge of its integrals over certain submanifolds. The founding example is the Radon transform, introduced at the beginning of the 20th century. Since then, many other transforms were found, and the general theory was developed. Moreover, many important practical applications were discov-

ered. The best known, but by no means the only one, being to medical tomography.

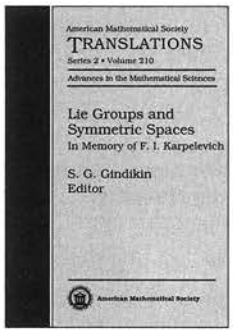
This book is a general introduction to integral geometry, the first from this point of view for almost four decades. The authors, all leading experts in the field, represent one of the most influential schools in integral geometry. The book presents in detail basic examples of integral geometry problems, such as the Radon transform on the plane and in space, the John transform, the Minkowski–Funk transform, integral geometry on the hyperbolic plane and in the hyperbolic space, the horospherical transform and its relation to representations of $SL(2,\mathbb{C})$, integral geometry on quadrics, etc. The study of these examples allows the authors to explain important general topics of integral geometry, such as the Cavalieri conditions, local and nonlocal inversion formulas, and overdetermined problems in integral geometry. Many of the results in the book were obtained by the authors in the course of their career-long work in integral geometry.

This book is suitable for graduate students and researchers working in integral geometry and its applications.

Contents: Radon transform; John transform; Integral geometry and harmonic analysis on the hyperbolic plane and in the hyperbolic space; Integral geometry and harmonic analysis on the group $G = SL(2,\mathbb{C})$; Integral geometry on quadrics; Bibliography; Index.

Translations of Mathematical Monographs, Volume 220

September 2003, 170 pages, Hardcover, ISBN 0-8218-2932-7, LC 2003052222, 2000 *Mathematics Subject Classification*: 53C65; 42A38, 42B10, 43A32, 44A12, 46F12, 60D05, 60E05, 60E10, 65R10, 92C55, **All AMS members $47**, List $59, Order code MMONO/220N



Lie Groups and Symmetric Spaces

In Memory of F. I. Karpelevich

S. G. Gindikin, *Rutgers University, New Brunswick, NJ*, Editor

The book contains survey and research articles devoted mainly to geometry and harmonic analysis of symmetric spaces and to corresponding aspects of group representation theory. The volume is dedicated to the memory of Russian mathematician, F. I. Karpelevich (1927–2000).

Of particular interest are the survey articles by Sawyer on the Abel transform on noncompact Riemannian symmetric spaces, and by Anker and Ostellari on estimates for heat kernels on such spaces, as well as the article by Bernstein and Gindikin on integral geometry for families of curves. There are also many research papers on topics of current interest.

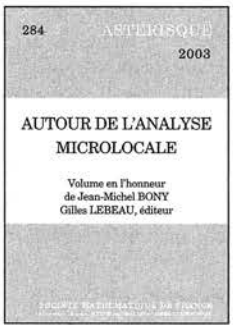
The book is suitable for graduate students and research mathematicians interested in harmonic analysis and representation theory.

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

Contents: D. N. Akhiezer, Asymptotic distribution of eigenvalues for certain elements of the group ring of a compact Lie group; **D. V. Alekseevsky** and **A. J. Di Scala**, Minimal homogeneous submanifolds of symmetric spaces; **J.-P. Anker** and **P. Ostellari**, The heat kernel on noncompact symmetric spaces; **E. M. Baruch, I. Piatetski-Shapiro**, and **S. Rallis**, On the uniqueness of Fourier Jacobi models for representations of $U(2,1)$; **J. Bernstein** and **S. Gindikin**, Notes on integral geometry for manifolds of curves; **B. Enriquez** and **P. Etingof**, Quantization of Alekseev-Meinrenken dynamical r-matrices; **J. Faraut**, Analysis on the crown of a Riemannian symmetric space; **I. Gelfand, V. Retakh**, and **R. L. Wilson**, Quaternionic quasideterminants and determinants; **S. Gindikin**, Product-formula for c-function and inverse horospherical transform; **J. Hilgert, A. Pasquale**, and **E. B. Vinberg**, The dual horospherical Radon transform as a limit of spherical Radon transforms; **A. W. Knapp**, The Gindikin-Karpelevič formula and intertwining operators; **T. Kobayashi** and **S. Nasrin**, Multiplicity one theorem in the orbit method; **B. Krötz** and **G. Ólafsson**, The c-function for non-compactly causal symmetric spaces and its relations to harmonic analysis and representation theory; **I. G. Macdonald**, A formal identity for affine root systems; **V. F. Molchanov**, Canonical representations and overgroups; **Y. A. Neretin**, Pencils of geodesics in symmetric spaces, Karpelevich boundary, and associahedron-like polyhedra; **M. A. Olshanetsky** and **V.-B. K. Rogov**, Poisson formula for a family of non-commutative Lobachevsky spaces; **A. L. Onishchik**, Real semisimple Lie algebras and their representations; **T. Oshima**, A calculation of c-functions for semisimple symmetric spaces; **P. Sawyer**, The Abel transform on symmetric spaces of noncompact type.

American Mathematical Society Translations—Series 2 (*Advances in the Mathematical Sciences*), Volume 210

September 2003, 355 pages, Hardcover, ISBN 0-8218-3472-X, LC 91-640741, 2000 *Mathematics Subject Classification*: 22Exx, 53C35, **All AMS members $95**, List $119, Order code TRANS2/210N



Autour de l'analyse microlocale

Volume en l'honneur de Jean-Michel Bony

Gilles Lebeau, *Université de Nice, France*, Editor

This volume is dedicated to Jean-Michel Bony by his former students, collaborators, and friends on the occasion of his sixtieth birthday. It contains research articles by leading mathematicians on linear, nonlinear, and algebraic microlocal analysis, illustrating the vividness of the field to which he contributed so much.

The volume is suitable for graduate students and research mathematicians interested in microlocal analysis.

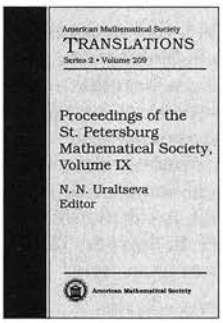
A publication of the Société Mathématique de France (SMF). Distributed by the AMS in North America. Orders from other countries should be sent to the SMF. Members of the SMF receive a 30% discount from list.

Contents: S. Alinhac, An example of blowup at infinity for a quasilinear wave equation; **H. Bahouri** and **J.-Y. Chemin**, Microlocal analysis, bilinear estimates and cubic quasilinear wave equation; **M. Kashiwara** and **P. Schapira**, Microlocal

study of ind-sheaves I: micro-support and regularity; **Y. Laurent**, Regularity of $\mathcal{D}$-modules associated to a symmetric pair; **A. Melin** and **J. Sjöstrand**, Bohr-Sommerfeld quantization condition for non-selfadjoint operators in dimension 2; **Y. Morimoto** and **C.-J. Xu**, Logarithmic Sobolev inequality and semi-linear Dirichlet problems for infinitely degenerate elliptic operators; **Jeffrey Rauch**, Group velocity at smooth points of hyperbolic characteristic varieties; **J.-M. Trépreau**, Discrimination analytique des difféomorphismes résonnants de $(\mathbb{C}, 0)$ et réflexion de Schwarz.

Astérisque, Number 284

May 2003, 320 pages, Softcover, ISBN 2-85629-132-5, 2000 *Mathematics Subject Classification*: 17B15, 30C35, 30D05, 31C10, 35Axx, 35A07, 35A27, 32C38, 35D10, 35Hxx, 35L25, 35L40, 35L55, 35L70, 35Nxx, 35P05, 37F99, 37J40, 37K05, 47J20, 58J52, **Individual member $50**, List $55, Order code AST/284N



Proceedings of the St. Petersburg Mathematical Society, Volume IX

N. N. Uraltseva, *Saint Petersburg State University, St Petersburg, Russia*, Editor

The articles in this collection present new results in analysis, combinatorics, probability, theory of functions, and partial differential equations. The material presented in the book will be of interest to a broad range of specialists.

In several papers, the authors study the classical solvability of the Cauchy-Dirichlet problem for a class of parabolic systems, the solvability of the Dirichlet problem for the quasilinear second order parabolic systems, estimates for solutions of uniformly elliptic systems, and generalizations of the embedding theorems. In other papers, the authors describe a new method for the computation of correlation dimension, present generalizations of the fast Fourier transform method for wavelet expansions, and study the spectrum of two-dimensional periodic magnetic Schrödinger operator.

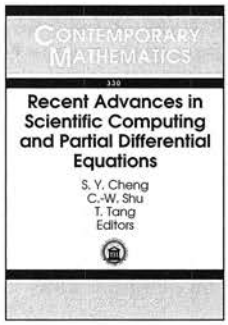
This item will also be of interest to those working in discrete mathematics and combinatorics, probability, and differential equations.

Contents: **A. A. Arkhipova**, On classical solvability of the Cauchy-Dirichlet problem for nondiagonal parabolic systems in the case of two spatial variables; **A. D. Baranov**, The Bernstein inequality in the de Branges spaces and embedding theorems; **V. O. Kal'vin**, The oblique derivative problem in spaces with asymptotics on edges; **V. N. Malozemov** and **S. M. Masharsky**, Glassman's formula, fast Fourier transform, and wavelet expansions; **A. I. Nazarov**, Dirichlet problem for quasilinear parabolic equations in domains with smooth closed edges; **S. I. Repin**, Two-sided estimates of deviation from exact solutions of uniformly elliptic equations; **J. V. Romanovsky** and **L. A. Evdokimov**, Calculation of correlation dimension of a time series based on enumeration of suboptimal solutions; **N. A. Shirokov**, Approximation by entire functions of an infinite system of closed intervals; **R. G. Shterenberg**, Absolute continuity of the spectrum of the two-dimensional magnetic periodic Schrödinger operator with positive electric potential.

American Mathematical Society Translations—Series 2, Volume 209

October 2003, approximately 232 pages, Hardcover, ISBN 0-8218-3405-3, 2000 *Mathematics Subject Classification*: 00B15; 00B55, **All AMS members $78**, List $97, Order code TRANS2/209N

Applications



Recent Advances in Scientific Computing and Partial Differential Equations

S. Y. Cheng, *Hong Kong University of Science & Technology, Kowloon*, **C.-W. Shu**, *Brown University, Providence, RI*, and **T. Tang**, *Hong Kong Baptist University, Kowloon*, Editors

The volume is from the proceedings of the international conference held in celebration of Stanley Osher's sixtieth birthday. It presents recent developments and exciting new directions in scientific computing and partial differential equations for time dependent problems and its interplay with other fields, such as image processing, computer vision and graphics. Over the past decade, there have been very rapid developments in the field. This volume emphasizes the strong interaction of advanced mathematics with real-world applications and algorithms.

The book is suitable for graduate students and research mathematicians interested in scientific computing and partial differential equations.

This item will also be of interest to those working in differential equations.

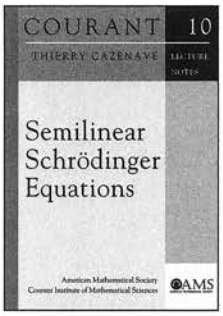
Contents: **Y. Brenier**, Systems of particles involving permutations and their continuous limits; **R. E. Caflisch** and **D. G. Meyer**, A reduced order model for epitaxial growth; **T. F. Chan** and **J. Shen**, On the role of the BV image model in image restoration; **L.-T. Cheng** and **W. E**, The heterogeneous multi-scale method for interface dynamics; **A. Ditkowski** and **D. Gottlieb**, On the Engquist Majda absorbing boundary conditions for hyperbolic systems; **M.-H. Giga** and **Y. Giga**, Minimal vertical singular diffusion preventing diffusion preventing overturning for the Burgers equation; **K. Harriman**, **P. Houston**, **B. Senior**, and **E. Süli**, hp-version discontinuous Galerkin methods with interior penalty for partial differential equations with nonnegative characteristic form; **D. Li** and **F. J. Hickernell**, Trigonometric spectral collocation methods on lattices; **L. Ju**, **M. D. Gunzburger**, and **L. S. Hou**, Approximation of exact boundary controllability problems for the 1-D wave equation by optimization-based methods; **P. Ming** and **Z.-c. Shi**, Some low order quadrilateral Reissner-Mindlin plate elements; **H. Tang** and **T. Tang**, Multi-dimensional moving

mesh methods for shock computations; **D. D. Vvedensky**, **C. Baggio**, **A. Chua**, **C. Haselwandter**, and **R. Vardavas**, Stochastic differential equations for driven lattice systems; **T. Yabe**, **K. Takizawa**, **F. Xiao**, and **A. Ikehata**, Universal solver CIP for all phases of matter.

Contemporary Mathematics, Volume 330

August 2003, 222 pages, Softcover, ISBN 0-8218-3155-0, LC 2003050344, 2000 *Mathematics Subject Classification*: 35-02, 35-06, 65-02, 65-06, 68U10, **All AMS members $47**, List $59, Order code CONM/330N

Differential Equations



Semilinear Schrödinger Equations

Thierry Cazenave, *Université de Paris VI, Pierre et Marie Curie*

The nonlinear Schrödinger equation has received a great deal of attention from mathematicians, particularly because of its applications to nonlinear optics. It is also a good model dispersive equation, since it is often technically simpler than other dispersive equations, such as the wave or the Korteweg-de Vries equation. From the mathematical point of view, Schrödinger's equation is a delicate problem, possessing a mixture of the properties of parabolic and elliptic equations. Useful tools in studying the nonlinear Schrödinger equation are energy and Strichartz's estimates.

This book presents various mathematical aspects of the nonlinear Schrödinger equation. It studies both problems of local nature (local existence of solutions, uniqueness, regularity, smoothing effect) and problems of global nature (finite-time blowup, global existence, asymptotic behavior of solutions). In principle, the methods presented apply to a large class of dispersive semilinear equations. The first chapter recalls basic notions of functional analysis (Fourier transform, Sobolev spaces, etc.). Otherwise, the book is mostly self-contained.

It is suitable for graduate students and research mathematicians interested in nonlinear partial differential equations and applications to mathematical physics.

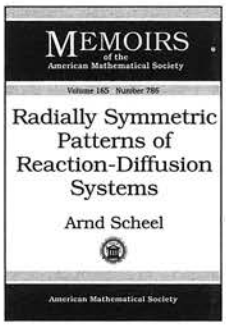
This item will also be of interest to those working in mathematical physics.

Titles in this series are copublished with the Courant Institute of Mathematical Sciences at New York University.

Contents: Preliminaries; The linear Schrödinger equation; The Cauchy problem in a general domain; The local Cauchy problem; Regularity and the smoothing effect; Global existence and finite-time blowup; Asymptotic behavior in the repulsive case; Stability of bound states in the attractive case; Further results; Bibliography.

Courant Lecture Notes, Volume 10

October 2003, 323 pages, Softcover, ISBN 0-8218-3399-5, 2000 *Mathematics Subject Classification*: 35Q55; 35A05, 35B30, 35B33, 35B35, 35B40, 35B45, 35B65, **All AMS members $34**, List $42, Order code CLN/10N



Radially Symmetric Patterns of Reaction-Diffusion Systems

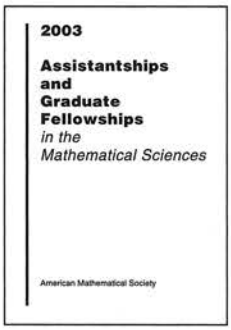
Arnd Scheel, *University of Minnesota, Minneapolis*

Contents: Introduction; Instabilities in one space dimension; Stationary radially symmetric patterns; Time-periodic radially symmetric patterns; Discussion; Bibliography.

Memoirs of the American Mathematical Society, Volume 165, Number 786

September 2003, 86 pages, Softcover, ISBN 0-8218-3373-1, LC 2003051901, 2000 *Mathematics Subject Classification*: 35K57, 35B32, 37L10, 37L15, 34C37; 35J60, 35B40, 37G40, **Individual member $31**, List $51, Institutional member $41, Order code MEMO/165/786N

General and Interdisciplinary



Assistantships and Graduate Fellowships 2003

Review of a previous edition:

This directory is a tool for undergraduate mathematics majors seeking information about graduate programs in mathematics. Although most of the information can be gleaned from the Internet, the usefulness of this directory for the prospective graduate student is the consistent format for comparing different mathematics graduate programs without the hype. Published annually, the information is up-to-date, which is more than can be said of some Websites. Support for graduate students in mathematics is a high priority of the American Mathematical Society, which also provides information for fellowships and grants they offer as well as support from other societies and foundations. The book is highly recommended for academic and public libraries.

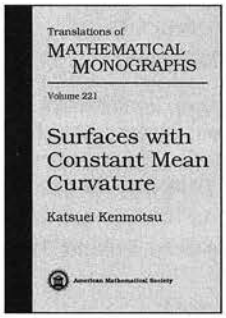
—American Reference Books Annual

This valuable reference source brings together a wealth of information about resources available for graduate study in mathematical sciences departments in the U.S. and Canada.

November 2003, approximately 128 pages, Softcover, ISBN 0-8218-3470-3, **Individual member $14**, List $23, Order code ASST/2003N

Geometry and Topology

Supplemental Reading



Surfaces with Constant Mean Curvature

Katsuei Kenmotsu, *Tohoku University, Sendai, Japan*

The mean curvature of a surface is an extrinsic parameter measuring how the surface is curved in the three-dimensional space. A surface whose mean curvature is zero at each point is a minimal surface, and it is known that such surfaces are models for soap film. There is a rich and well-known theory of minimal surfaces. A surface whose mean curvature is constant but nonzero is obtained when we try to minimize the area of a closed surface without changing the volume it encloses. An easy example of a surface of constant mean curvature is the sphere. A nontrivial example is provided by the constant curvature torus, whose discovery in 1984 gave a powerful incentive for studying such surfaces. Later, many examples of constant mean curvature surfaces were discovered using various methods of analysis, differential geometry, and differential equations. It is now becoming clear that there is a rich theory of surfaces of constant mean curvature.

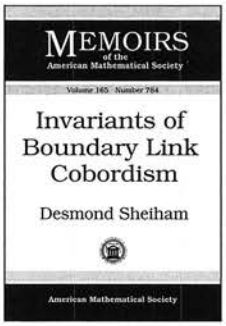
In this book, the author presents numerous examples of constant mean curvature surfaces and techniques for studying them. Many finely rendered figures illustrate the results and allow the reader to visualize and better understand these beautiful objects.

The book is suitable for advanced undergraduates, graduate students and research mathematicians interested in analysis and differential geometry.

Contents: Preliminaries from the theory of surfaces; Mean curvature; Rotational surfaces; Helicoidal surfaces; Stability; Tori; The balancing formula; The Gauss map; Intricate constant mean curvature surfaces; Supplement; Programs for the figures; Postscript; Bibliography; List of sources for the figures; Index; Other titles in this series.

Translations of Mathematical Monographs, Volume 221

October 2003, approximately 160 pages, Softcover, ISBN 0-8218-3479-7, 2000 *Mathematics Subject Classification*: 53-01, 53A10, **All AMS members $28**, List $35, Order code MMONO/221N



Invariants of Boundary Link Cobordism

Desmond Sheiham, *University of California, Riverside*

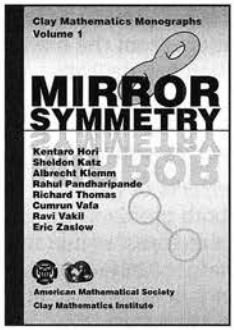
Contents: Introduction; Main results; Preliminaries; Morita Equivalence; Devissage; Varieties of representations; Generalizing Pfister's theorem; Characters; Detecting rationality and integrality; Representation varieties: Two examples; Number theory invariants; All division algebras occur; Appendix I. Primitive element theorems; Appendix II. Hermitian categories; Bibliography; Index.

Memoirs of the American Mathematical Society, Volume 165, Number 784

September 2003, 110 pages, Softcover, ISBN 0-8218-3340-5, LC 2003051903, 2000 *Mathematics Subject Classification*: 18F25, 57Q45, 57Q60, 16G20, **Individual member $31**, List $52, Institutional member $42, Order code MEMO/165/784N

Mathematical Physics

Independent Study



Mirror Symmetry

Kentaro Hori, *University of Toronto, ON, Canada*, **Sheldon Katz**, *University of Illinois at Urbana-Champaign*, **Albrecht Klemm**, *Humboldt-University, Berlin, Germany*, **Rahul Pandharipande**, *Princeton University, NJ*, **Richard Thomas**, *Imperial College, London*, **Cumrun Vafa**, *Harvard University, Cambridge, MA*, **Ravi Vakil**, *Stanford University, CA*, and **Eric Zaslow**, *Northwestern University, Evanston, IL*

This thorough and detailed exposition is the result of an intensive month-long course on mirror symmetry sponsored by the Clay Mathematics Institute. It develops mirror symmetry from both mathematical and physical perspectives with the aim of furthering interaction between the two fields. The material will be particularly useful for mathematicians and physicists who wish to advance their understanding across both disciplines.

Mirror symmetry is a phenomenon arising in string theory in which two very different manifolds give rise to equivalent physics. Such a correspondence has significant mathematical consequences, the most familiar of which involves the enumeration of holomorphic curves inside complex manifolds by solving differential equations obtained from a "mirror" geometry. The inclusion of D-brane states in the equivalence has led to further conjectures involving calibrated submanifolds of the mirror pairs and new (conjectural) invariants of complex manifolds: the Gopakumar-Vafa invariants.

This book gives a single, cohesive treatment of mirror symmetry. Parts 1 and 2 develop the necessary mathematical and physical background from "scratch". The treatment is focused, developing only the material most necessary for the task. In Parts 3 and 4 the physical and mathematical proofs of mirror symmetry are given. From the physics side, this means demonstrating that two different physical theories give isomorphic physics. Each physical theory can be described geometrically, and thus mirror symmetry gives rise to a "pairing" of geometries. The proof involves applying $R \leftrightarrow 1/R$ circle duality to the phases of the fields in the gauged linear sigma model. The mathematics proof develops Gromov-Witten theory in the algebraic setting, beginning with the moduli spaces of curves and maps, and uses localization techniques to show that certain hypergeometric functions encode the Gromov-Witten invariants in genus zero, as is predicted by mirror symmetry. Part 5 is devoted to advanced topics in mirror symmetry, including the role of D-branes in the context of mirror symmetry, and some of their applications in physics and mathematics: topological strings and large N Chern-Simons theory; geometric engineering; mirror symmetry at higher genus; Gopakumar-Vafa invariants; and Kontsevich's formulation of the mirror phenomenon as an equivalence of categories.

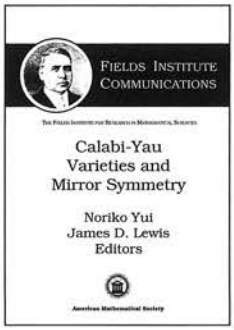
This one-of-a-kind book is suitable for graduate students and research mathematicians interested in mathematics and mathematical and theoretical physics.

Titles in this series are published by the AMS for the Clay Mathematics Institute (Cambridge, MA).

Contents: *Part 1. Mathematical Preliminaries:* Differential geometry; Algebraic geometry; Differential and algebraic topology; Equivariant cohomology and fixed-point theorems; Complex and Kähler geometry; Calabi-Yau manifolds and their moduli; Toric geometry for string theory; *Part 2. Physics Preliminaries:* What is a QFT?; QFT in $d = 0$; QFT in dimension 1: Quantum mechanics; Free quantum field theories $1 + 1$ dimensions; $\mathcal{N} = (2, 2)$ supersymmetry; Non-linear sigma models and Landau-Ginzburg models; Renormalization group flow; Linear sigma models; Chiral rings and topological field theory; Chiral rings and the geometry of the vacuum bundle; BPS solitons in $\mathcal{N} = 2$ Landau-Ginzburg theories; D-branes; *Part 3. Mirror Symmetry: Physics Proof:* Proof of mirror symmetry; *Part 4. Mirror Symmetry: Mathematics Proof:* Introduction and overview; Complex curves (non-singular and nodal); Moduli spaces of curves; Moduli spaces $\bar{\mathcal{M}}_{g,n}(X, \beta)$ of stable maps; Cohomology classes on $\bar{\mathcal{M}}_{g,n}$ and $(\tilde{\mathcal{M}})_{g,n}(X, \beta)$; The virtual fundamental class, Gromov-Witten invariants, and descendant invariants; Localization on the moduli space of maps; The fundamental solution of the quantum differential equation; The mirror conjecture for hypersurfaces I: The Fano case; The mirror conjecture for hypersurfaces II: The Calabi-Yau case; *Part 5. Advanced Topics:* Topological strings; Topological strings and target space physics; Mathematical formulation of Gopakumar-Vafa invariants; Multiple covers, integrality, and Gopakumar-Vafa invariants; Mirror symmetry at higher genus; Some applications of mirror symmetry; Aspects of mirror symmetry and D-branes; More on the mathematics of D-branes: Bundles, derived categories and Lagrangians; Boundary $\mathcal{N} = 2$ theories; References; Bibliography; Index.

Clay Mathematics Monographs, Volume 1

September 2003, 929 pages, Hardcover, ISBN 0-8218-2955-6, LC 2003052414, 2000 *Mathematics Subject Classification*: 14J32; 14-02, 14N10, 14N35, 32G81, 32J81, 32Q25, 81T30, **All AMS members $99**, List $124, Order code CMIM/1N



Calabi-Yau Varieties and Mirror Symmetry

Noriko Yui, *Queen's University, Kingston, ON, Canada*, and **James D. Lewis**, *University of Alberta, Edmonton, Canada*, Editors

The idea of mirror symmetry originated in physics, but in recent years, the field of mirror symmetry has exploded onto the mathematical scene. It has inspired many new developments in algebraic and arithmetic geometry, toric geometry, the theory of Riemann surfaces, and infinite-dimensional Lie algebras among others.

The developments in physics stimulated the interest of mathematicians in Calabi-Yau varieties. This led to the realization that the time is ripe for mathematicians, armed with many concrete examples and alerted by the mirror symmetry phenomenon, to focus on Calabi-Yau varieties and to test for these special varieties some of the great outstanding conjectures, e.g., the modularity conjecture for Calabi-Yau threefolds defined over the rationals, the Bloch-Beilinson conjectures, regulator maps of higher algebraic cycles, Picard-Fuchs differential equations, GKZ hypergeometric systems, and others.

The articles in this volume report on current developments. The papers are divided roughly into two categories: geometric methods and arithmetic methods. One of the significant outcomes of the workshop is that we are finally beginning to understand the mirror symmetry phenomenon from the arithmetic point of view, namely, in terms of zeta-functions and L-series of mirror pairs of Calabi-Yau threefolds.

The book is suitable for researchers interested in mirror symmetry and string theory.

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

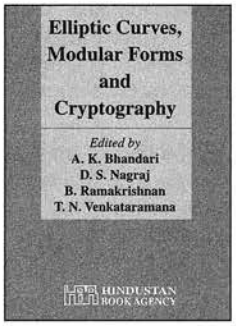
Contents: *Geometric methods:* **V. V. Batyrev** and **E. N. Materov**, Mixed toric residues and Calabi-Yau complete intersections; **L. Chiang** and **S.-s. Roan**, Crepant resolutions of $\mathbb{C}^n/A_1(n)$ and flops of n-folders for $n = 4, 5$; **P. L. del Angel** and **S. Müller-Stach**, Picard-Fuchs equations, integrable systems and higher algebraic K-theory; **S. Hosono**, Counting BPS states via holomorphic anomaly equations; **J. D. Lewis**, Regulators of Chow cycles on Calabi-Yau varieties; *Arithmetic methods:* **P. Candelas**, **X. de la Ossa**, and **F. Rodriguez-Villegas**, Calabi-Yau manifolds over finite fields, II; **L. Dieulefait** and **J. Manoharmayum**, Modularity of rigid Calabi-Yau threefolds over $\mathbb{Q}$; **Y. Goto**, $K3$ surfaces with symplectic group actions; **T. Ito**, Birational smooth minimal models have equal Hodge numbers in all dimensions; **B. H. Lian** and **S.-T. Yau**, The nth root of the mirror map; **L. Long**, On a Shioda-Inose structure of a family of K3 surfaces; **M. Lynker**, **V. Periwal**, and **R. Schimmrigk**, Black hole attractor varieties and complex multiplication; **F. Rodriguez-Villegas**, Hypergeometric families of Calabi-Yau manifolds; **R. Schimmrigk**, Aspects of conformal field theory from Calabi-Yau arithmetic; **J. Stienstra**, Ordinary Calabi-Yau-3 crystals; **J. Stienstra**, The ordinary limit for varieties over $\mathbb{Z}[x_1, \ldots, x_r]$; **N. Yui**, Update on the modularity of Calabi-Yau

varieties with appendix by Helena Verrill; **N. Yui** and **J. D. Lewis**, Problems.

Fields Institute Communications, Volume 38

October 2003, approximately 384 pages, Hardcover, ISBN 0-8218-3355-3, 2000 *Mathematics Subject Classification*: 14J32, **All AMS members $88**, List $110, Order code FIC/38N

Number Theory



Elliptic Curves, Modular Forms and Cryptography

A. K. Bhandari, *Panjab University, Chandigarh, India*, **D. S. Nagaraj**, *Institute of Mathematical Science, CIT Campus, Chennai, India*, **B. Ramakrishnan**, *Harish-Chandra Research Institute, Allahabad, India*, and **T. N. Venkataramana**, *Tata Institute of Fundamental Research, Mumbai, India*

The theory of elliptic curves has been the source of new approaches to classical problems in number theory, which have also found applications in cryptography. This volume represents the proceedings of the Advanced Instructional Workshop on Algebraic Number Theory held at the Harish-Chandra Research Institute. The theme of the workshop was algebraic number theory with special emphasis on elliptic curves.

The volume is in three parts, the first part contains articles in the field of elliptic curves, the second contains articles on modular forms. The third part presents some basics on cryptography, as well as some advanced topics. Each part contains an introduction, which, in some sense, gives the overall picture of the contents of that part. Most of the articles are presented in a self-contained style and they give a different flavor to the subject. In some cases, the authors have chosen to include material that is already available in textbooks in order to make this volume more complete. Graduate students who want to pursue their research career in number theory will benefit from this volume.

The book is suitable for graduate students and researchers in number theory and applications to cryptography.

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

A publication of the Hindustan Book Agency. Distributed exclusively by the American Mathematical Society in North America and worldwide on the AMS Bookstore.

Contents: *Part I. Elliptic Curves:* **D. S. Nagaraj**, An overview; **D. S. Nagaraj** and **B. Sury**, A quick introduction to algebraic geometry and elliptic curves; **B. Sury**, Elliptic curves over finite fields; **R. Tandon**, The Nagell-Lutz theorem; **C. S. Rajan**, Weak Mordell-Weil theorem; **D. S. Nagaraj** and **B. Sury**, The Mordell-Weil theorem; **E. Ghate**, Complex multiplication; **D. Prasad**, The main theorem of complex multiplication; **T. N. Shorey**, Approximations of algebraic numbers by rationals: A theorem of Thue; **S. D. Adhikari** and **D. S. Ramana**, Siegel's theorem: Finiteness of integral points; **A. F. Brown**, p-adic theta functions and Tate curves; **D. S. Nagaraj**, l-adic representation attached to an elliptic curve over a number field; **C. S. Dalawat**, Arithmetic on curves; *Part II. Modular Forms:* **B. Ramakrishnan**, Introduction; **P. Shastri**, Elliptic functions; **M. Manickam** and **B. Ramakrishnan**, An introduction to modular forms and Hecke operators; **C. S. Yogananda**, I-functions of modular forms; **T. N. Venkataramana**, On the Eichler-Shimura congruence relation; *Part III. Cryptography:* **A. K. Bhandari**, Cryptography; **R. Thangadurai**, Classical cryptosystems; **A. K. Bhandari**, The public key cryptography; **A. Nongkynrih**, Primality and factoring; **R. Balasubramanian**, Elliptic curves and cryptography.

Hindustan Book Agency

July 2003, 354 pages, Hardcover, ISBN 81-85931-42-9, 2000 *Mathematics Subject Classification*: 11-06, 11Fxx, 11Gxx, 11T71, 14H45, **All AMS members $42**, List $52, Order code HIN/14N

Classified Advertisements

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

CALIFORNIA

UNIVERSITY OF CALIFORNIA AT BERKELEY
Department of Mathematics
Berkeley, CA 94720
Charles B. Morrey Jr.
Assistant Professorships

We invite applications for these special (non-tenure-track) positions effective July 1, 2004. The terms of these appointments may range from two to three years. Applicants should have a recent Ph.D., or the equivalent, in an area of pure or applied mathematics. Applicants should send a résumé, reprints, preprints, and/or dissertation abstract, and ask three people to send letters of evaluation to the vice chair for faculty affairs at the above address. All letters of evaluation are subject to Berkeley campus policies on confidentiality of letters of evaluation, a summary of which can be found on our homepage (`http://math.berkeley.edu`) by clicking on available teaching position and then confidentiality policy. We request that applicants use the AMS standardized application form and indicate their subject area using the AMS subject classification numbers. The form is the Academic Employment in Mathematics, Application Cover Sheet and is available courtesy of the American Mathematical Society.

Applications must be postmarked by December 1, 2003. Applications postmarked after the deadline will not be considered. The University of California is an Equal Opportunity/Affirmative Action Employer.

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

Several temporary positions beginning in fall 2004 are anticipated for new and recent Ph.D.'s of any age in any area of pure or applied mathematics. The terms of these appointments may range from one to three years. Applicants for NSF or other postdoctoral fellowships are encouraged to apply for these positions. Mathematicians whose research interests are close to those of regular department members will be given some preference. Applicants should send a résumé and reprints, preprints, and/or dissertation abstract, and ask three people to send letters of evaluation to the vice chair for faculty affairs at the above address. All letters of evaluation are subject to Berkeley campus policies on confidentiality of letters of evaluation, a summary of which can be found on our homepage (`http://math.berkeley.edu`) by clicking on available teaching position and then confidentiality policy. We request that applicants use the AMS standardized application form and indicate their subject area using the AMS subject classification numbers. The form is the Academic Employment in Mathematics, Application Cover Sheet and is available courtesy of the American Mathematical Society.

Applications must be postmarked by December 1, 2003. Applications postmarked after the deadline will not be considered. The University of California is an Equal Opportunity/Affirmative Action Employer.

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

Pending budget approval, we invite applications for one or more positions effective July 1, 2004, at either the tenure-track (assistant professor) or tenured (associate or full professor) level in the general areas of pure or applied mathematics.

Tenure-track applicants are expected to have demonstrated outstanding research potential, normally including major contributions beyond the doctoral dissertation. Such applicants should send a résumé, reprint or preprints, and/or dissertation abstract, and ask three people to send letters of evaluation to the vice chair for faculty affairs at the above address. It is the responsibility of the tenure-track applicants to make sure that letters of evaluation are sent. All letters of evaluation are subject to Berkeley campus policies on confidentiality of letters of evaluation, a summary of which can be found on our homepage (`http://`

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 2003 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: October 2003 issue–July 30, 2003; November 2003 issue–August 28, 2003; December 2003 issue–October 1, 2003; January 2004 issue–October 28, 2003; February 2004 issue–November 21, 2003; March 2004 issue–December 29, 2003

U.S. laws prohibit discrimination in employment on the basis of color, age, sex, race, religion, or national origin. "Positions Available" advertisements from institutions outside the U.S. cannot be published unless they are accompanied by a statement that the institution does not discriminate on these grounds whether or not it is subject to U.S. laws. Details and specific wording may be found on page 1373 (vol. 44).

Situations wanted advertisements from involuntarily unemployed mathematicians are accepted under certain conditions for free publication. Call toll-free 800-321-4AMS (321-4267) in the U.S. and Canada or 401-455-4084 worldwide for further information.

Submission: Promotions Department, AMS, P.O. Box 6248, Providence, Rhode Island 02940; or via fax: 401-331-3842; or send email to `classads@ams.org`. AMS location for express delivery packages is 201 Charles Street, Providence, Rhode Island 02904. Advertisers will be billed upon publication.

math.berkeley.edu) by clicking on available teaching positions.

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

All applicants are requested to use the AMS standardized application form and to indicate their subject area using the AMS subject classification numbers. The form is the Academic Employment in Mathematics, Application Cover Sheet and is available courtesy of the American Mathematical Society.

Applications for both tenure-track and tenured applications must be postmarked by November 15, 2003. Applications postmarked after the deadline will not be considered. The University of California is an Equal Opportunity/Affirmative Action Employer.

UNIVERSITY OF CALIFORNIA, LOS ANGELES
Department of Mathematics

Subject to availability of resources and administrative approval, the following positions are available for the 2004–05 academic year.

1. Several E. R. Hedrick Assistant Professorships. Salary is $53,200. Three-year appointment. Teaching load: four quarter-courses per year, which may include one advanced course in the candidate's field.

2. Several Research Assistant Professorships in Computational and Applied Mathematics (CAM). Salary is $53,200. Three-year appointment. Teaching load: normally is reduced to two or three quarter-courses per year by research funding as available; may include one advanced course in the candidate's field.

3. Several Assistant Adjunct Professorships or Lectureships in the Program in Computing (PIC). Applicants for the adjunct position must show very strong promise in teaching and research in an area related to computing. Teaching load: four one-quarter programming courses each year and one seminar every two years. One-year initial appointment, with the option of applying for renewal for a second year and possibly longer, up to a maximum service of four years. Salary is $56,800. 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 one-quarter programming courses per year. One-year appointment, probably renewable one or more times, depending on the needs of the program. Salary is $43,152 or more, depending on experience.

4. Several VIGRE Assistant Professorships. Hedrick, CAM, or PIC applicants who are U.S. citizens or permanent residents may also apply for a VIGRE Assistant Professor position. Three-year appointment. Salary is $53,200. The successful recipient will receive a summer stipend of $6,500 for two summers and $2,500 per year for travel, equipment, and supplies for three years. Teaching load: 3 courses per year.

5. Several Assistant Adjunct Professorships and Research Postdocs. Normally one-year appointments, with the possibility of renewal. Strong research and teaching background required. Salary $48,900–$53,200. Teaching load for adjuncts: six quarter-courses per year.

6. Several visiting instructorships.

For more details, see http://www.math.ucla.edu/~search. To apply, complete the application on the website, or send e-mail to search@math.ucla.edu, or write to: Staff Search, Department of Mathematics, University of California, Los Angeles, CA 90095-1555. Preference will be given to applications completed by January 5, 2004.

UCLA is an Equal Opportunity/Affirmative Action Employer. Under federal law, the University of California may employ only individuals who are legally authorized to work in the United States as established by providing documents specified in the Immigration Reform and Control Act of 1986.

CONNECTICUT

YALE UNIVERSITY
Josiah Willard Gibbs Instructorships/Assistant Professorships

Description: Offered to men and women with the doctorate who show definite promise in research in pure mathematics. Applications from women and members of minority groups are welcome. Appointments are for two/three years. The teaching load is kept light to allow ample time for research. This will consist of 3 one-semester courses. Part of the teaching duties over the term of the appointment may consist of a one-semester course at the graduate level in the general area of the instructor's research. Grant Amount: The 2004–2005 salary will be at least $52,800. Deadline: January 1, 2004. Application information: Inquiries and applications can be obtained at the website http://www.math.yale.edu/. Inquiries and application supporting documents should be sent to the Gibbs Committee, Department of Mathematics, Yale University, via e-mail: gibbs.committee@math.yale.edu. Yale University is an Affirmative Action/Equal Opportunity Employer.

GEORGIA

GEORGIA INSTITUTE OF TECHNOLOGY
School of Mathematics

The School of Mathematics at Georgia Tech expects to have several tenure-track and visiting positions available beginning fall 2004 and will consider applications in pure and applied mathematics and statistics at all ranks. Preference will be given to candidates who complement existing strengths in the School of Mathematics while adding expertise in new areas consistent with the goals and directions of the school. Candidates should have strong research and teaching records or potential. The school will also consider applications for NSF VIGRE Postdoctoral Fellowships. These are non-tenure-track positions, normally renewable annually to a maximum of three years. Eligibility is limited to U.S. citizens, nationals, and permanent residents who will have a Ph.D. and not be beyond 18 months from the completion of their degree at the time of the appointment.

The academic year salary for these positions is $45,000, with an additional $6,500 for research support in each of the first and second summers, and a $7,500 travel allowance over the term of the appointment. Preference will be given to applicants deemed likely to benefit from a mentoring relationship with one or more members of the current faculty of the school. Review of applications for all positions will begin in September 2003 and will continue until all positions have been filled. Candidates should arrange for a résumé, at least three letters of reference, and a summary of future research plans to be sent to the Hiring Committee, School of Mathematics, Georgia Institute of Technology, Atlanta, GA 30332-0160, USA. Georgia Tech, an institution of the University System of Georgia, is an Equal Opportunity/Affirmative Action Employer.

ILLINOIS

ILLINOIS WESLEYAN UNIVERSITY
Department of Mathematics and Computer Science
Bloomington, IL 61701

The Department of Mathematics and Computer Science at Illinois Wesleyan University invites applications for a tenure-track assistant professor in computer science. Employment would begin in August 2004, and the teaching load would be six courses per year. All candidates should have

a Ph.D. in computer science or a Ph.D. in a closely related field, with significant computing experience or significant graduate work in computer science. Candidates must be able to teach in the core CS curriculum, including computer organization. Preference may be given to candidates with expertise in any of the following areas: networking, computer architecture, or operating systems. The opportunity to participate in university-wide general education programs is available for interested faculty.

Illinois Wesleyan University is a highly selective undergraduate university of approximately 2,000 students located in Bloomington, Illinois, a community of about 120,000. This year the average ACT for Illinois Wesleyan's entering class of freshmen was 28. The Department of Mathematics and Computer Science is located in the Center for Natural Science Learning and Research, a $25,000,000 facility opened in 1995. The department operates five computer teaching classrooms and labs. For additional information on the computer science curriculum, facilities, and faculty interests, see http://www.iwu.edu/~mathcs.

Candidates for the position should submit a letter of application, a curriculum vitae, a teaching statement and a research statement, copies of transcripts, and should have three letters of recommendation sent separately to Melvyn Jeter, Department of Mathematics and Computer Science, Illinois Wesleyan University, P.O. Box 2900, Bloomington, IL 61702-2900. Email applications are strongly discouraged. Applications received after November 21, 2003, may not receive full consideration. Women and minorities are encouraged to apply. Illinois Wesleyan is an Equal Opportunity Employer. For further information see our jobs webpage at: http://www.iwu.edu/~iwujobs.

ILLINOIS WESLEYAN UNIVERSITY
Department of Mathematics and Computer Science
Bloomington, IL 61701

The Department of Mathematics and Computer Science at Illinois Wesleyan University invites applications for a tenure-track assistant professor in mathematics. Employment will begin in August 2004, and the teaching load will be six courses per year. All candidates should have a Ph.D. in mathematical statistics or actuarial mathematics and a dedication to excellent teaching in a liberal arts environment where undergraduate research is encouraged. Candidates must be able to teach the core mathematics curriculum at Illinois Wesleyan. We are seeking candidates who will work closely with students who want to become actuaries. The opportunity to participate in university-wide general education programs is available for interested faculty.

Illinois Wesleyan University is a highly selective undergraduate university of approximately 2,000 students located in Bloomington, Illinois, a community of about 120,000. This year the average ACT for Illinois Wesleyan's entering class of freshmen was 28. In recent years as many as 4% of the undergraduate population at Illinois Wesleyan University have declared majors in mathematics. The department maintains a healthy balance between applied mathematics and pure mathematics. Faculty areas of professional expertise include algebra, approximation theory, differential equations, number theory, dynamical systems, electrical engineering, linear algebra, logic, operations research, topology, topos theory, numerical analysis, and wavelet analysis. The Department of Mathematics and Computer Science is located in the Center for Natural Science Learning and Research, a $25,000,000 facility opened in 1995. The department operates five computer labs for students with around 80 SunSPARC and iMac computers. For additional information on the mathematics curriculum, facilities, and faculty interests, see http://www.iwu.edu/~mathcs.

Candidates for the position should submit a letter of application, a curriculum vitae, an AMS Standard Cover Sheet, a teaching statement and a research statement, copies of transcripts, and should have three letters of recommendation sent separately to Melvyn Jeter, Department of Mathematics and Computer Science, Illinois Wesleyan University, P.O. Box 2900, Bloomington, IL 61702-2900. Email applications are strongly discouraged. Preliminary interviews for this position will be held at the Joint Mathematics Meetings in Phoenix, Arizona (January 2004). Applications received after December 12, 2003, may not receive full consideration. Women and minorities are encouraged to apply. Illinois Wesleyan is an Equal Opportunity Employer. For further information see our jobs webpage at: http://www.iwu.edu/~iwujobs.

UNIVERSITY OF CHICAGO
Department of Mathematics

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

1. L. E. Dickson Instructor: This is open to mathematicians who have recently completed or will soon complete a doctorate in mathematics and whose work shows remarkable promise in mathematical research and teaching. The appointment is for two years, with the possibility of renewal for a third year. The teaching obligation is up to four one-quarter courses per year. For applicants who are U.S. citizens or permanent residents, there is the possibility of additional resources for summer support and travel from the department's VIGRE grant.

2. Assistant Professor: This is open to mathematicians who are further along in their careers, typically two or three years past the doctorate. These positions are intended for mathematicians whose work has been of outstandingly high caliber. Appointees are expected to have the potential to become leading figures in their fields. The appointment is for three years, and the teaching obligation is three one-quarter courses per year.

3. Postdoctoral Research Associate: This is open to mathematicians who have recently completed or will soon complete a doctorate in mathematics and who work in applied mathematics. These appointments are for up to two years. There is no teaching obligation.

Applicants will be considered for any of the positions above that seem appropriate. Complete applications consist of (a) an AMS cover sheet; (b) a curriculum vitae (including citizenship information); (c) three or more letters of reference, including one which addresses teaching ability; and (d) a description of previous research and plans for future research, including a brief (200 words or less) summary of your research interests. A statement describing your teaching experience and philosophy would be helpful. If you have applied for an NSF Mathematical Sciences Postdoctoral Fellowship, please include that information in your application, and let us know how you plan to use it if awarded. Applications should be sent to:

Appointments Secretary
Department of Mathematics
University of Chicago
5734 S. University Avenue
Chicago, IL 60637

Applications may also be submitted online through http://www.mathjobs.org. We will begin screening applications on December 1, 2003. Screening will continue until all available positions are filled. The University of Chicago is an Equal Opportunity/Affirmative Action Employer.

MARYLAND

JOHNS HOPKINS UNIVERSITY
Department of Mathematics

Subject to availability of resources and administrative approval, the following positions are available for the 2004–05 academic year.

(1) Tenure-track and senior positions in all areas of pure mathematics. (2) One non-tenure-track J. J. Sylvester Assistant Professor.

For more details, see http://mathnt.mat.jhu.edu/mathnew/jobs.html or send

email to math@math.jhu.edu. Applications should be sent to: Appointments Committee, Department of Mathematics, Johns Hopkins University, 404 Krieger Hall, Baltimore, MD 21218-2689; and should include a complete curriculum vitae, at least four letters of recommendation (including a letter concerning teaching), and a description of current and planned research. Applications received by November 1, 2003, will be given priority. Johns Hopkins University is an Affirmative Action/Equal Opportunity Employer. Minorities and women candidates are encouraged to apply.

MASSACHUSETTS

BOSTON UNIVERSITY
Center for BioDynamics
Predoctoral and Postdoctoral Positions

The Center for BioDynamics (CBD) at Boston University has predoctoral and postdoctoral positions available. The CBD is a multidisciplinary center devoted to research and training at the interfaces of dynamical systems, biology, and engineering. Current research themes include computational neurobiology, gene regulatory networks, pattern formation, fluid and solid mechanics, and applied biodynamics. We seek candidates interested in working across disciplinary boundaries with multiple members of the CBD.

The CBD is connected to many departments and other research centers at Boston University, providing a stimulating research environment. Associated senior faculty members are T. Kaper, N. Kopell, G. Wayne (Math), A. Baltazar, J. Collins, T. Gardner, K. Sen, J. White (Biomedical Engineering), M. Hasselmo (Psychology), P. Barbone and J. Baillieul (Aerospace and Mechanical Engineering), S. Redner (Physics). For further information about the CBD, please see our webpage at http://cbd.bu.edu.

To apply for a Postdoctoral Fellowship, please send (1) a statement that includes your background, career goals, how this position satisfies those goals, and your suitability for this position; (2) your C.V.; and (3) three letters of recommendation to:

Ms. Geri Duffy
Center for BioDynamics
Department of Mathematics
111 Cummington Street
Boston University
Boston, MA 02215

Applications for postdocs will be reviewed starting December 20, 2003. Interested Ph.D. candidates should apply to one of the associated departments and mention interest in the CBD. Please refer to the BU Graduate School Admissions Office (http://www.bu.edu/apply/#graduate) for all application materials.

Related predoctoral and postdoctoral positions are available in the Program in Mathematical and Computational Neuroscience (PMCN) (see ad #55).

BOSTON UNIVERSITY
Burroughs Wellcome Training Program in Mathematical and Computational Neuroscience (PMCN)
Predoctoral and Postdoctoral Fellowships

The goal of PMCN is to facilitate the transition of a small and outstanding set of predoctoral and postdoctoral fellows from the mathematical and physical sciences to a range of areas in neuroscience. Financial support for both Ph.D. candidates and postdoctoral fellows is available. The program features special seminars, mentoring by faculty and advanced trainees, and a dynamic and well-networked intellectual life provided by multiple supporting institutional modules. These include a new degree-granting Program in Neuroscience (PIN; http://www.bu.edu/pin), the graduate program of the Biomedical Engineering Department (BME; http://bme.bu.edu), and the Center for BioDynamics (CBD; http://cbd.bu.edu).

Predoctoral fellows will enroll in one of two Ph.D. programs (PIN or BME) that focus on the combination of experimental and computational neuroscience. Burroughs Wellcome Postdoctoral Fellows will design individualized programs that include neuroscience courses and one or more research projects that emphasize combined computational and experimental approaches to neuroscience. In addition, fellows may participate in the CBD, which helps physical scientists and engineers to address research problems at the interfaces between mathematics, physics, biology, and engineering.

PMCN is directed by H. Eichenbaum and N. Kopell. The senior faculty members are P. Cook, M. Wachowiak, A. Yamaguchi, (Biology), M. Hasselmo, H. Eichenbaum, D. Somers, C. Stern (Psychology), S. Colburn, J. Collins, K. Sen, J. White (Biomedical Engineering), T. Kaper, E. Kolaczyk, N. Kopell, G. Wayne (Math), B. Shinn-Cunningham (Cognitive and Neural Systems, Biomedical Engineering). For further information and instructions about applications, see our website at http://pmcn.bu.edu. Our mailing address is PMCN, c/o G. Duffy, Department of Mathematics, Boston University, 111 Cummington St., Boston, MA 02215.

Applications for postdocs will be reviewed starting December 20, 2003.

Related predoctoral and postdoctoral positions are available at the Center for BioDynamics (CBD) (see ad #54).

MICHIGAN

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NEW YORK

CORNELL UNIVERSITY
Department of Mathematics

The Department of Mathematics at Cornell University invites applications for the position of tenure-track assistant professor (or higher rank with administrative approval). Start date July 1, 2004. For information about fields of interest and application instructions, see: http://www.math.cornell.edu/Positions/facpositions.html. Deadline November 1, 2003. Early applications will be regarded favorably. Cornell University is an Affirmative Action/Equal Opportunity Employer.

CORNELL UNIVERSITY
Department of Mathematics

The Department of Mathematics invites applications for the following positions beginning July 1, 2004: (1) four H. C. Wang Assistant Professors, nonrenewable, 3-year term; (2) three VIGRE Postdoctoral Associates (contingent upon funding), nonrenewable, 3-year term, beginning August 16, 2004; (3) visiting positions, academic year or one-semester teaching positions (any rank). For information about our positions and application instructions, see: http://www.math.cornell.edu/Positions/facpositions.html. Applicants will be automatically considered for all eligible positions. Deadline December 1, 2003. Early applications will be regarded favorably. Cornell University is an Affirmative Action/Equal Opportunity Employer.

CORNELL UNIVERSITY
Department of Mathematics

The Cornell University Department of Mathematics invites applications for our Teaching Program Visiting Faculty Positions beginning August 16, 2004. Two or more half-time visiting positions (any rank) for mathematics professors on sabbatical/other leaves from colleges, universities, and engineering schools. Candidates with substantial experience teaching undergraduate mathematics and with teaching and research interests compatible with current faculty are sought. Successful candidates are expected to pursue a program

of study and/or research at Cornell. For information about these positions and application instructions, see: http://www.math.cornell.edu/Positions/facpositions.html. Deadline is December 1, 2003. Cornell University is an Affirmative Action/Equal Opportunity Employer.

AUSTRIA

THE JOHANNES KEPLER UNIVERSITY
School of Science and Technology

The Johannes Kepler University of Linz, Austria, School of Science and Technology, welcomes all applications for the position of Professor in Computational Science (Symbolic Computation) (succession of Prof. Bruno Buchberger) at the Institute for Symbolic Computation (RISC-Linz). The position is to be filled at the earliest possible date. For further details see also the web page http://www.risc.uni-linz.ac.at/institute/Ausschreibung.

CANADA

FIELDS INSTITUTE FOR RESEARCH IN MATHEMATICAL SCIENCES
Toronto, Ontario
Director

The Fields Institute invites applications and nominations for the position of Director, effective July 1, 2004.

The Institute carries on specialized year-long programs, seminars, workshops, short courses, and a broad spectrum of activities across the mathematical sciences that bring together experts, young mathematicians, and graduate students to work on issues of current interest.

The Director is the chief executive officer with responsibility for scientific leadership and overall operations. Candidates should have a strong international stature in the mathematical sciences as well as proven administrative experience. The term of office is three to five years renewable once.

For further information: http://www.fields.utoronto.ca.

Search committee: Derek Corneil, Alan George (Chair), Bradd Hart, Richard Kane, Philip Siller, and Margaret Wright.

Director Search, Fields Institute, 222 College Street, Toronto, Ontario M5T 3J1 Canada.

CYPRUS

UNIVERSITY OF CYPRUS
Department of Mathematics and Statistics

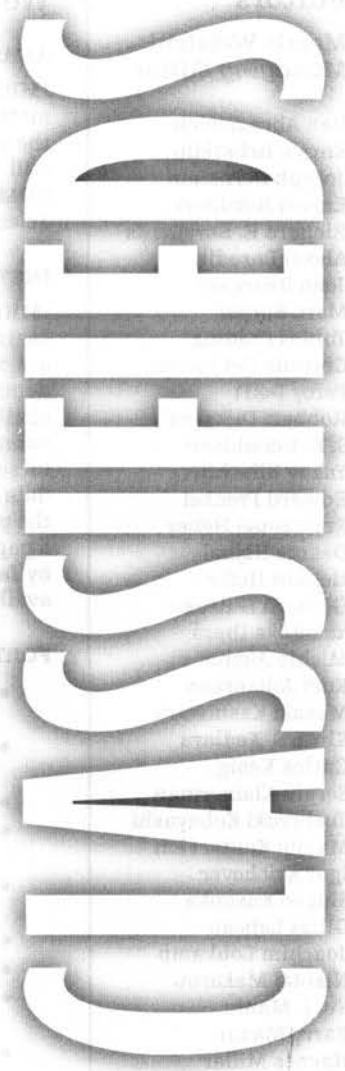
The department invites applications for one position in analysis at the rank of associate professor or professor. The official languages of the university are Greek and/or Turkish. The deadline for applications is September 29, 2003.

For more information, see http://www.mas.ucy.ac.cy/positions.html.

The University of Cyprus does not discriminate on the grounds of age, sex, religion, race, or national origin.

WRITER WANTED

NEEDED: The help of a mathematician to write an introduction based on Mintz's completed work; Mintz's website: http://www.euclidchallenge.org, which includes: Euclid Challenge—Successful Response; Review by an American professor of mathematics; Pierre Wantzel (19th century): When using "Traditional Euclidian Methods"; Comparison: Archimedes, Hippias Quadratrix, Milton A. Mintz; Use of Euclid tools: Unmarked straightedge and compass only; Mintz methods include proof of accuracy; Mintz methods: (1) trisection of any angle, (2) square a circle. Milton A. Mintz, email: milton@euclidchallenge.org.



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- A Parametrization of the Theta Divisor of the Quartic Double Solid, *D. G. Markushevich and A. S. Tikhomirov*
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- Coboundary Dynamical Poisson Groupoids and Integrable Systems, *Luen-Chau Li*
- Connected Components of the Space of Surface Group Representations, *Nan-Kuo Ho and Chiu-Chu Melissa Liu*
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- Geometric Crystal and Tropical R for $D_n^{(1)}$, *A. Kuniba, M. Okado, T. Takagi, and Y. Yamada*
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- The Number of Linear Series on Curves with Given Ramification, *Brian Osserman*
- The Zero-Dispersion Limit for the Odd Flows in the Focusing Zakharov-Shabat Hierarchy, *Nicholas M. Ercolani, Shan Jin, C. David Levermore, and Warren D. MacEvoy Jr.*
- Welschinger Invariant and Enumeration of Real Rational Curves, *Ilia Itenberg, Viatcheslav Kharlamov, and Eugenii Shustin*

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California Institute of Technology

Computational Science and Engineering

The conventional theory-experiment basis for scientific inquiry has expanded to include simulation, especially of complex phenomena, which is an increasingly important component of many pursuits. Every order-of-magnitude increase in computing power allows new science to be addressed by scientific simulation and expands the application of computation in the experimental arena. Adding to its strong foundations in experimental and theoretical science, the California Institute of Technology (Caltech) has long been engaged in the development and exploitation of computation as an indispensable adjunct. At present, a significant fraction of scientific research at Caltech relies on large-scale distributed computing, scalable algorithms and data structures, the recording, handling, processing, and visualization of large data sets, and the organization of, and access to, large data bases. These and related endeavors in applied mathematics and computer science are recognized as an area of research in its own right: Computational Science and Engineering (CSE).

Caltech is initiating an Institute-wide program in CSE, hosted by the Division of Engineering and Applied Science (E&AS), which will coordinate the academic and research activities in CSE that transcend disciplinary boundaries. A goal of this program is to advance the tools of CSE, and further integrate them into fundamental science across the Institute.

Applications are solicited for two professorial positions. The emphasis of this search is on applicants with a record in fundamental CSE research and its applications. While the preference at this time is to make junior tenure-track appointments, serious consideration will be also given to eminent scholars in CSE at the tenured level. The successful candidates will be expected to lead the establishment of a research and educational program in CSE fundamentals that has connections to applications and the broad research missions of the Institute. Areas of significant interest include (but are not limited to) development and analysis of scalable distributed algorithms, grid–based computing, large-scale visualization, and data mining.

Caltech's research programs are organized along Divisional lines and faculty receive appointments in one or more of these divisions. The six Divisions are Biology, Chemistry and Chemical Engineering, Engineering and Applied Science, Geology and Planetary Science, Humanities and Social Sciences, and Physics, Mathematics and Astronomy. The Division of Engineering and Applied Science hosts active research groups in Applied and Computational Mathematics, Computer Science as well as significant research activities in areas closely allied with CSE, often across Divisional boundaries. It is anticipated that successful applicants will be appointed in the Division of Engineering and Applied Science but, if appropriate, may hold a joint appointment in another Caltech Division. They will also participate actively in the Institute-wide CSE program which is currently under development.

The term of the initial appointment is normally four years, and appointment is contingent upon completion of the Ph.D. degree. Applicants should include a statement of research accomplishments and objectives, their Curriculum Vitae, copies of three papers that best describe their research, as well as a list of suggested references and should have three letters of recommendation sent to the address below.

Applications must be initiated online at www.cse.caltech.edu/search. Hard copy materials associated with an application should be sent to:

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Pasadena, CA 91125

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New Releases in *de Gruyter Studies in Mathematics:*

Vol. 27

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■ Stochastic Finance

An Introduction in Discrete Time

2002. ix, 422 pages. Hardcover.
US$ 59.95
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This book is an introduction to financial mathematics. It is intended for graduate students in mathematics and for researchers working in academia and industry.

Vol. 28

Valerii I. Gromak / Ilpo Laine / Shun Shimomura

■ Painlevé Differential Equations in the Complex Plane

2002. viii, 303 pages. Hardcover.
US$ 89.95
ISBN 3-11-017379-4

This book is the first comprehensive treatment of Painlevé differential equations in the complex plane. Due to the present important role of Painlevé equations in physical applications, this monograph should be of interest to mathematicians and physicists both in research and in postgraduate studies.

Vol. 29

Werner Fenchel / Jakob Nielsen

■ Discontinuous Groups of Isometries in the Hyperbolic Plane

Edited by Asmus L. Schmidt

2003. xxi, 364 pages. 112 figures. 2 plates.
US$ 79.95
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This is an introductory textbook on isometry groups of the hyperbolic plane. Examples appear in number theory (modular groups and triangle groups), the theory of elliptic functions, and the theory of linear differential equations in the complex domain (giving rise to the alternative name Fuchsian groups).

Vol. 30

Liviu I. Nicolaescu

■ The Reidemeister Torsion of 3-Manifolds

2003. xiv, 249 pages. Hardcover.
US$ 79.95
ISBN 3-11-017383-2

This is a state-of-the-art introduction to the work of Franz-Reidemeister, Meng-Taubes, Turaev, and the author on the concept torsion and its generalizations. It is addressed to mathematicians with geometric interests who want to become comfortable users of this versatile invariant. It should be accessible to graduate students who are familiar with the fundamentals of algebraic topology taught in a first year graduate course.

Vol. 31

Susanne Schmitt / Horst G. Zimmer

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A Computational Approach

2003. Approx. 350 pages. Hardcover.
Approx. US$ 89.95
ISBN 3-11-016808-1

The purpose of the present textbook is to give an elementary introduction to elliptic curves. Since this branch of number theory is particularly accessible to computer-assisted calculations, the authors make use of it by approaching the theory under a computational point of view. Specifically, the computer-algebra package SIMATH can be applied on several occasions.
However, the book can be read also by those not interested in any computations. Of course, the theory of elliptic curves is very comprehensive and becomes correspondingly sophisticated. That is why the authors made a choice of the topics treated. Topics covered include the determination of torsion groups, computations regarding the Mordell-Weil group, height calculations, *S*-integral points. The contents is kept as elementary as possible. In this way it becomes obvious in which respect the book differs from the numerous textbooks on elliptic curves nowadays available.

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Candidacy for the Nemmers Prize in Mathematics is open to those with careers of outstanding achievement in mathematics as demonstrated by major contributions to new knowledge or the development of significant new modes of analysis. Individuals of all nationalities and institutional affiliations are eligible except current or recent members of the Northwestern University faculty and recipients of the Nobel Prize.

The recipient of the 2004 Nemmers Prize in Mathematics will deliver a public lecture and participate in other scholarly activities at Northwestern University for 10 weeks during the 2004-05 academic year.

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Nominations may be sent to:

nemmers@northwestern.edu

or

Secretary
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College of Science

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The positions will remain open until filled but applications received before 15th October 2003 will receive strongest consideration. The University will reserve the right not to make an appointment. Interested candidates are requested to send applications including cover letter, CV and names, email addresses and fax numbers of three referees quoting our Ref: ADV/SCI/MA.ST-2/06/03, to the address below:

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JANUARY—DECEMBER

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32 Several complex variables and analytic spaces
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35 Partial differential equations
37 Dynamical systems and ergodic theory
39 Difference and functional equations
40 Sequences, series, summability
41 Approximations and expansions
42 Fourier analysis
43 Abstract harmonic analysis
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Reciprocity member (please verify)[3]	☐$72	☐$108	☐$144
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[1] ***Student Verification*** (sign below)
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[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.

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- ☐ Sociedad Española de Matemática Aplicada
- ☐ Sociedad de Matemática de Chile
- ☐ Sociedad Matemática de la Republica Dominicana
- ☐ Sociedad Matemática Mexicana
- ☐ Sociedad Uruguaya de Matemática y Estadística
- ☐ Sociedade Brasileira Matemática
- ☐ Sociedade Brasileira de Matemática Aplicada e Computacional
- ☐ Sociedade Paranaense de Matemática
- ☐ Sociedade Portuguesa de Matemática
- ☐ Societat Catalana de Matemàtiques
- ☐ Societatea de Ştiinţe Matematice din România
- ☐ Societatea Matematicienilor din Romania
- ☐ Société Mathématique de France
- ☐ Société Mathématique du Luxembourg
- ☐ Société Mathématique Suisse
- ☐ Société Mathématiques Appliquées et Industrielles
- ☐ 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
- ☐ Ukrainian Mathematical Society
- ☐ Union Mathemática Argentina
- ☐ Union of Bulgarian Mathematicians
- ☐ Union of Czech Mathematicians and Physicists
- ☐ Union of Slovak Mathematicians and Physicists
- ☐ Unione Matematica Italiana
- ☐ Vijnana Parishad of India
- ☐ Wiskundig Genootschap

Order Form

ORDERED BY

Name _____

Address _____

_____

City _____

State _____

Zip _____

Country _____

Code _____

e-mail _____

MAIL TO (IF DIFFERENT)

Name _____

Address _____

_____

City _____

State _____

Zip _____

Country _____

Code _____

e-mail _____

Qty.	Code	Title	Price	Total
			Shipping and Handling	
			Residents of Canada, please include 7% GST.	
			Total	

Shipping and Handling:
- Orders shipped to U.S. addresses, add $3.50 for the first item and 50 cents for each additional item.
- Orders shipped surface mail to addresses outside the U.S., add $5.00 for the first item and $1.00 for each additional item. For International Air, add $13.00 for the first item and $6.00 for each additional item.

For orders with remittances:
(Payment must be made in U.S. currency drawn on a U.S. bank.)
American Mathematical Society
P.O. Box 845904
Boston, MA 02284-5904, USA

For credit card orders:
American Mathematical Society
P.O. Box 6248
Providence, RI 02940-6248, USA
1-800-321-4AMS (4267)
1-401-455-4000, worldwide
fax 1-401-455-4046
cust-serv@ams.org

PAYMENT METHOD

☐ Check or Money Order ☐ American Express ☐ Discover
☐ MasterCard ☐ VISA

Card Number _____ Expiration Date _____

Signature _____

Please send me information about AMS membership

☐ individual
☐ institutional
☐ corporate
☐ institutional associate

CHARGE BY PHONE IN US AND CANADA 800.321.4AMS

Publications, videotapes, and miscellaneous items are sent via UPS to U.S. addresses and as printed matter elsewhere unless another delivery method is requested. Prices subject to change without notice.

AMS Textbooks: Books marked "Recommended Text" are available as examination copies for possible course adoption. To request an exam copy, please write to us on departmental letterhead specifying the book requested, course title and number, term taught, anticipated enrollment, expected decision date, and the text currently in use.

VISIT THE AMS BOOKSTORE AT www.ams.org/bookstore

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Membership and Customer Services
AMERICAN MATHEMATICAL SOCIETY
P.O. Box 6248
Providence, RI 02940-4248 USA

Fold here

Change of Address

Members of the Society who move or change positions are urged to notify the Providence Office as soon as possible.

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

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

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

If your address has changed or will change within the next two or three months, please fill out this form, supply any other information appropriate for the AMS records, and mail it to:

Customer Services
AMS
P.O. Box 6248
Providence, RI
02940-6248 USA

or send the information on the form by e-mail to:
amsmem@ams.org or
cust-serv@ams.org

Name _____

Customer code _____

Change effective as of _____

Old mailing address

_____

_____

_____

New mailing address

_____

_____

_____

New position _____

If mailing address is not that of your employer,

please supply the following information:

New employer _____

Location of employer (city, state, zip code, country)

_____

_____

_____

Telephone/home: _____ **office:** _____

Fax: _____

e-mail _____

Recent honors and awards

_____

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Providence, RI 02940-4248 USA

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Mathematical Sciences Employment Center

Phoenix Civic Plaza, Phoenix, Arizona
January 7, 8, 9, and 10, 2004

2004 Employment Center Schedule

Wednesday, January 7

7:30 a.m.–4:00 p.m. Registration and materials pick-up.

9:00 a.m.–9:30 a.m. Short (optional) orientation session.

9:30–4:00 p.m. Submission of Scheduled Employment Register interview request forms for both Thursday and Friday interviews. No request forms can be accepted after 4:00 p.m. Wednesday.

9:30 a.m.–6 p.m. Interview Center open.

No Scheduled Employment Register interviews are held on Wednesday.

Thursday, January 8

7:00 a.m.–8:15 a.m. Distribution of interview schedules for both Thursday and Friday for those participating in the Scheduled Employment Register.

8:15 a.m.–4:40 p.m. Scheduled Employment Register interviews in 4 sessions: *Session 1:* 8:15 a.m.–9:50 a.m., *Session 2:* 10:00 a.m.–11:35 a.m., *Session 3:* 1:00 p.m.–2:35 p.m., *Session 4:* 3:00 p.m.–4:35 p.m.

8:00 a.m.–7:30 p.m. Interview Center open (doors open at 7:30 a.m.; do not schedule before 8:00 a.m.).

Friday, January 9

8:15 a.m.–4:40 p.m. Scheduled Employment Register interviews in 4 sessions: *Session 5:* 8:15 a.m.–9:50 a.m., *Session 6:* 10:00 a.m.–11:35 a.m., *Session 7:* 1:00 p.m.–2:35 p.m., *Session 8:* 3:00 p.m.–4:35 p.m.

8:00 a.m.–7:30 p.m. Interview Center open (doors open at 7:30 a.m.; do not schedule before 8:00 a.m.).

Saturday, January 10

9:00 a.m.–12 noon Interview Center open.

Note: Any participant who plans to use the Scheduled Employment Register must appear at the Employment Center on Wednesday by 4:00 p.m. to turn in the Interview Request/Availability Form. If unexpected delays occur while travelling, contact the AMS at 800-321-4267, ext. 4107.

Overview of the Employment Center

The Employment Center (formerly the Employment Register) serves as a meeting place and information center for employers and Ph.D.-level job seekers attending the Joint Mathematics Meetings. Most applicants and employers began the search process in the fall and are looking for an opportunity to meet in person with those with whom they've already had communication. Some, however, use the Employment Center as a way to make some initial contacts, gather information, and distribute their own information. This is a less effective, but common, use of the program. The Employment Center allows everyone to choose a comfortable level of participation by seeking interviews for any of the open hours or by limiting schedules to certain days or hours.

The Employment Center is a three-day program which takes place on the Wednesday, Thursday, Friday, and Saturday (morning only) of the Joint Meetings. Most participants register in advance (by the October 24 deadline), and their brief résumé or job description is printed in a booklet which is mailed to participants in advance.

The Employment Center houses two services: the computer-scheduled interview tables (the Scheduled Employment Register) and the employer-scheduled interview tables (the Interview Center). Following three or four years of a job market favorable to candidates, the Employment Center applicant/employer ratio took a sharp turn in 2003. At the 2003 Employment Center, 424 candidates and 129 employers participated, giving an overall applicant-to-employer ratio of 3.2:1 (compared with 370 applicants and 151 employers in 2002, a ratio of 2.4:1). Each applicant ends up with roughly 5 to 15 interviews of various types. Those with the most interviews are those requested most by employers, usually as a result of a careful application process during the months before the Employment Center takes place.

At the January 2004 Employment Center, job candidates will be able to choose how to participate. Two forms of participation will be available:

> All Employment Center services (computer-scheduling system, form posted in *Winter List of Applicants*, *Winter List of Employers* received

by mail, use of Employment Message Center, availability for employer-scheduled Interview Center).

Message Center and *Winter Lists* only (form posted in *Winter List of Applicants*, *Winter List of Employers* received by mail, use of Employment Message Center, availability for employer-scheduled Interview Center, BUT NOT use of the computer-scheduling system).

No matter which option is chosen, advance registration works best so that the Applicant Form (received by October 24, 2003) can be printed in the *Winter List* distributed to employers.

Employer forms submitted by registered employers have no connection with the AMS online job ads (EIMS). Submitted forms are not available for browsing on the Web. They are reproduced in the *Winter List* booklet for use by Employment Center participants.

The Mathematical Sciences Employment Center is sponsored by the American Mathematical Society, the Mathematical Association of America, and the Society for Industrial and Applied Mathematics; it is managed by members of the AMS staff, with the general guidance of the AMS-MAA-SIAM Committee on Employment Opportunities.

Employers: Choose one or both of these tables:

Computer-scheduled Employment Register table

Employer-scheduled Interview Center table

The Employment Register Computer-Scheduling System

Employers register in advance by the October 24 deadline, and their job listings ("Employer Forms") are printed and distributed in mid-December to applicants. Employers receive the book of brief, numbered applicant résumés in mid-December. Participants decide on Wednesday, January 7, which of the eight sessions (of five interviews each) they will participate in and submit their Availability/Interview Request Forms by 4:00 p.m. Wednesday. Employers can reserve time for other Joint Meetings events by marking "unavailable" for one or more of the eight sessions. Employers can request ten specific applicants per day, assuming they are available for all four sessions that day. Usually those requests will be filled by the scheduling algorithm, provided the applicants are present, except in the case of the few most-requested applicants. The rest of their interviews will be with applicants who ask to see them. Employers should be specific about their requirements on the Employer Form to avoid interviews with inappropriate candidates.

Schedules are distributed for all Thursday and Friday interviews on Thursday morning. The schedule allows 15-minute interviews, with 5 minutes between for note taking. One or more interviewers for the same position(s) may interview at the table separately, together, or in shifts (however, no more than two may sit at the table at one time). For follow-up interviews, the scheduled tables will also be available for use until 7:30 p.m. on Thursday and Friday and on Saturday morning from 9:00 a.m. to noon.

Participation in the scheduling program has become optional for applicants, so employers will notice some applicant résumés in the *Winter List of Applicants* with no applicant number. An employer can arrange to interview such an applicant outside of the scheduled interview sessions—for instance, between 4:40 p.m. and 7:30 p.m. Thursday or Friday, or on Saturday morning—or during sessions which they left unscheduled.

Employers who are interviewing for two distinct positions may wish to pay for two tables. See the instructions under "How to Register". Employers should bring school catalogs, corporate reports, or more lengthy job descriptions to the Employment Center early on Wednesday for perusal by applicants prior to interviews.

The Employer-Scheduled Interview Center

The Interview Center allows any employer to reserve a table in an area adjacent to the Employment Center. Employers will arrange their own schedule of interviews, either in advance or on site, by using the Employment Message Center. Employers who have never used the Employment Center before might want to try conducting interviews at this convenient location. Since they will be setting their own schedules, employers will have complete control over whom they'll see, for how long, and when they'll be interviewing. This allows employers to pursue other activities at the Joint Meetings.

The center will be open only during the following hours:

Wednesday, January 7, 2004, 9:30 a.m.–6:00 p.m.
Thursday, January 8, 2004, 8:00 a.m.–7:30 p.m.
Friday, January 9, 2004, 8:00 a.m.–7:30 p.m.
Saturday, January 10, 2004, 9:00 a.m.–noon

The fee for use of this area is the same as the normal employer fee, $220. It is requested that all employers fill out an Employer Form for inclusion in the *Winter List*. This should clarify to Employment Center applicants what type of position is being filled. If an employer is unable to accept new applicants because the deadline has passed, that should be stated on the form.

The *Winter List of Applicants*, containing information about the candidates present at the Employment Center, will be mailed to all employers in advance of the meeting.

Employers scheduling interviews in advance should tell applicants to find the table with the institution's name in the Interview Center (not the numbered-table area). Employers can schedule any time during the open hours listed above. To schedule interviews after arriving in Phoenix, leave messages for Employment Center applicants in the Employment Message Center. Paper forms will be provided to help speed the invitation process. Each employer will be provided with a box in the Message Center where applicants can leave items.

Employers should have at most two interviewers per table at any time due to space limitations. There will be no outlets or electricity available at the interviewing tables.

Only banners which can be draped over the four-foot table can be accommodated.

About the *Winter List of Applicants*

This booklet contains hundreds of résumés of applicants registered by October 24 for the Employment Center. It will be mailed to all employers who register by October 24 who indicate on their Joint Meetings registration form that they would like their materials mailed. Employers should be aware that there will be hundreds of brief résumés to look through and should be sure to obtain the *Winter List of Applicants* as early as possible.

Employers Not Planning to Interview

Employers who do not plan to participate in the Employment Center at all may place a job description in the book of employers. This description must be submitted on the Employer Form, which appears in the back of this issue, with the appropriate box checked, indicating that no interviews will take place. A fee of $50 is charged for this service (paid through the Joint Meetings registration form). The form must be received in the Providence office (with payment or purchase order) by the October 24 deadline to appear in the *Winter List of Employers.* Forms received in the Providence office after that deadline will be displayed at the meeting. Those wishing to bring a one-page job description to the Employment Center desk for display during the meetings may do so at no charge.

Employers: How to Register

The interviewer should register and pay for the Joint Mathematics Meetings. They should register for the Employment Center by completing the following steps:

> Indicate on the Joint Meetings registration form (available either electronically after September 2, 2003, at `www.ams.org/amsmtgs/2078_intro.html` or in the back of the October issue of the *Notices*) that you are also paying the Employment Center employer fee. Indicate your choice of tables. Mark all that apply.
>
> Submit an Employer (job listing) Form electronically at www.ams.org/emp-reg, or use the print version in the back of this issue. Be sure the form indicates which type or types of tables will be used. This form will be printed in the *Winter List of Employers.*

It is important to register by the October 24 deadline in order for your form to be included in the *Winter List of Employers.* However, registration will be accepted up to December 12 for the normal fees or on site in Phoenix at the on-site rates. Call 800-321-4267, ext. 4060, with any questions or deadline problems.

Any representatives of the institution can sit at the table, together or working in shifts (however, the limit is two at one time). If possible, their names should be listed on the Employer Form as a reference point for the applicants. Employment Center fees should be paid only for each table required, not for each person.

In a few unusual cases an institution will be conducting interviews in the Employment Center for two or more distinct positions and will not want to conduct these interviews at one table. In that case, two or more Employer Forms should be submitted, and separate tables and employer numbers will be provided. Applicants will then be able to request interviews for the appropriate job by employer number. First and second table fees should be paid.

The fee for all employers to register in advance is $220 for the first table and $65 for each additional table. On-site registration fees (any registrations after 12/12/03) are $300 for the first table and $100 for each additional table. Employers must also register for the Joint Meetings and pay the appropriate Joint Meetings fee.

Employers: Registration on Site

Employers who do not register for the Joint Mathematics Meetings and the Employment Center by December 12 may register on site in Phoenix at the Joint Meetings registration desk. They must bring their receipt to the Employment Center desk between 7:30 a.m. and 4:00 p.m. on Wednesday, January 7, to receive their materials. A typed copy of the Employer Form (found in the back of this issue) can be brought to the Employment Center for posting on site (or the form can be handwritten on site). If registering for the employer-scheduled Interview Center only, registration on Thursday is possible.

Applicants: Use of the computer-scheduled program is now optional

In 2004 applicants will be given flexibility in deciding how to participate in the Employment Center. There are two options:

> All Employment Center services (computer-scheduling system, form posted in *Winter List of Applicants, Winter List of Employers* received by mail, use of Employment Message Center, availability for employer-scheduled Interview Center).
>
> Message Center and *Winter Lists* only (form posted in *Winter List of Applicants, Winter List of Employers* received by mail, use of Employment Message Center, availability for employer-scheduled Interview Center, BUT NOT use of the computer-scheduling system). This option is available at a slightly lower price.

Applicants who participate in the 2004 Employment Center will find themselves talking with employers in two different settings:

1. A computer-scheduling program sets 15-minute interviews at the Employment Register numbered tables. This is the choice that has now become optional for applicants. Applicants do not have to hand in a computer-scheduling form at all.

2. There is also an Interview Center, where employers set their own schedules. These employers do not participate in the scheduling program, so applicants have no automatic access to interviews with them. They determine their own schedules and make their own appointments privately, either in advance or on site using the Employment Message Center. These interviews have always been "optional" for applicants, since they may turn down any written invitation they receive. Applicants are reminded to respond to all invitations promptly.

The Schedule

For applicants using all services there is a certain scheduling burden placed on them to juggle these simultaneous services. However, computer-scheduled sessions are in small blocks, for a total of eight sessions over the two days of interviews (Thursday and Friday). This allows applicants, once they receive invitations to interview in the Interview Center, to accept, knowing that when they submit the computer schedule request on Wednesday they can mark that they are unavailable for one or more of these sessions without seriously jeopardizing their chances of obtaining scheduled interviews. Likewise, applicants who are scheduled to give a talk can avoid interviews for that time. Applicants are encouraged to schedule their time in advance in this manner and not wait for the computer schedule to be distributed Thursday morning.

Interviews

Applicants should understand that the Employment Center provides no guarantees of interviews or jobs. It is simply a convenient meeting place for candidates and employers who are attending the Joint Meetings. Those who have not yet begun their job search efforts may go unnoticed at the Employment Center (although applicants will likely receive a minimum of between one and three interviews in the scheduled program). Attention generally goes to candidates who already have applied for open positions or to those who are well suited for teaching positions at liberal arts colleges.

Data from recent Employment Centers show that women represent about half of the most sought-after applicants, although they make up less than half of the total Employment Center applicant pool. Those without permanent authorization to work in the United States will find themselves far less requested than U.S. citizens or permanent residents. Newer Ph.D.'s tend to be invited for more interviews than those who have been working longer. Most jobs listed require a doctorate.

Preparations

Candidates just beginning a job search should realize that employers have no method to judge their credentials other than the brief résumé form, and they should make an effort to make it distinct and interesting.

Applicants who register in advance will receive the *Winter List of Employers* in mid-December. If time permits, they should apply for suitable open positions they notice in the *Winter List of Employers* after they receive it. Applicants are advised to bring a number of copies of their vita or résumé so that they may leave them with prospective employers. It is a good idea in the fall for applicants to alert any employer to whom applications are made that they plan to be present at the Joint Meetings. Also, they should bring enough materials with them to accompany requests for interviews they may want to leave in the Message Center boxes of the Interview Center employers.

Applicants are also encouraged to leave some extra copies of their résumés in their own message folders so that interested employers may find them there. Photocopying costs at a convention are high, so applicants should come prepared with a reasonably large number of copies. A brightly colored form in each folder gives applicants an opportunity to present for public perusal some information about their availability during the meetings.

The *Winter List of Applicants* is mailed to all employers in advance, so it is vital that the Joint Meetings registration form, applicant résumé form, and payments be received by the October 24 deadline so the Applicant Form can be printed in the book. This greatly increases an applicant's chances of being invited to the Interview Center.

Applicants should keep in mind that interviews arranged by the Employment Center represent only an initial contact with the employers and that hiring decisions are not ordinarily made during or immediately following such interviews.

Applicants: Register Early

Applicants need to complete the following steps by the advance deadline of October 24, 2003.

1. Pay fees

Register for the Joint Mathematics Meetings (see form in the back of the October issue of the *Notices* or the electronic information available after September 2, 2003, at www.ams.org/amsmtgs/ 2078_intro.html). You cannot participate in the Employment Center unless you are a meetings participant. Mark one of the two "Employment Center Applicant Fee" boxes on the Joint Meetings registration form and make payments. The fee in advance for applicants is $40; "Message Center and *Winter List* ONLY" registration is $20.

2. Send form

Submit the Applicant Form (a brief résumé form) electronically at `www.ams.org/emp-reg/`, or use the print version in the back of this issue.

After Registration

Submission of the Applicant Form electronically will result in an email acknowledgement almost immediately. For registration and payments, the Meetings Service Bureau acknowledges all payments. When payments AND the Applicant Form have been received, another acknowledgement will go out by email, if possible, or by mail. Please allow a week or so for processing, but after that contact staff (AMS 800-321-4267, ext. 4105) if you do not receive acknowledgement from the Employment Center.

Around December 15 the *Winter List of Employers* will be mailed to all registered applicants unless they request otherwise.

Registering after the Deadline

After October 24 applicants can still register for the Employment Center at the same prices until the final deadline of December 12. However, the Applicant Form will NOT be included in the *Winter List of Applicants* but will be posted on site at the Employment Center (a serious disadvantage). Those who do not register by December 12 must register on site at the Joint Meetings registration desk and pay higher fees ($75 Employment Center fee; however, the "Message Center and *Winter List* ONLY" fee is always just $20).

It is worthwhile to submit the applicant form even if you miss the October 24 deadline. An unexpected delay in publishing may allow your late form to get into the book. At the very least, your printed-out form will be brought to the meetings by staff and displayed there (after all the fees have been paid).

When to Arrive

All participants in the scheduled section of the Employment Center must submit their Interview Request/Availability forms in person between 9:30 a.m. and 4:00 p.m. on Wednesday, January 7, 2004, or they will not be included when the interview-scheduling program runs Wednesday night. Should unexpected delays occur while travelling, contact the AMS at 800-321-4267, ext. 4107. Be sure to keep Employment Center materials with you, because in an emergency you can report your interview requests over the phone.

Applicants: Registering on Site

Feel free to enter the Employment Center area first to consult staff about the decision to register on site and to check on which employers are participating. Full registration on site early Wednesday is allowed for a higher fee but is severely discouraged. Most employers will not notice an Applicant Form which arrives on Wednesday. Therefore, these individuals will receive only a couple of computer-scheduled interviews. Registration on site is advisable only for those who know they will be interviewed in the Interview Center and would like a Message Center folder for employers to leave messages in. Registering on site for a mailbox only is possible, at the $20 rate, on Wednesday and Thursday. Pay the fees at the Joint Meetings registration area and then bring your receipt to the Employment Center desk to register yourself.

EMPLOYMENT CENTER

Instructions for Applicant and Employer Forms

Applicant forms submitted for the Employment Center by the October 24 deadline will be reproduced in a booklet titled *Winter List of Applicants*. Employer forms submitted by the October 24 deadline will be reproduced for the *Winter List of Employers*.

Please use the electronic versions of Applicant and Employer forms (`http://www.ams.org/emp-reg/`). Paper forms should be submitted only by those who do not have access to the AMS website.

If submitting a paper form, please type carefully. **Do not type outside the box or beyond the lines indicated. Extra type will be omitted.**

All forms must be received by the Society by **October 24, 2003**, in order to appear in the *Winter List*. However, meeting registration (and payment of fees) is required before the forms can be processed.

00 General
01 History and biography
03 Mathematical logic and foundations
05 Combinatorics
06 Order, lattices, ordered algebraic structures
08 General algebraic systems
11 Number theory
12 Field theory and polynomials
13 Commutative rings and algebras
14 Algebraic geometry
15 Linear and multilinear algebra, matrix theory
16 Associative rings and algebras
17 Nonassociative rings and algebras
18 Category theory, homological algebra
19 K-theory
20 Group theory and generalizations
22 Topological groups, Lie groups
26 Real functions
28 Measure and integration
30 Functions of a complex variable
31 Potential theory
32 Several complex variables and analytic spaces
33 Special functions
34 Ordinary differential equations
35 Partial differential equations
37 Dynamical systems and ergodic theory
39 Difference and functional equations
40 Sequences, series, summability
41 Approximations and expansions
42 Fourier analysis
43 Abstract harmonic analysis
44 Integral transforms, operational calculus
45 Integral equations
46 Functional analysis
47 Operator theory
49 Calculus of variations and optimal control; optimization
51 Geometry
52 Convex and discrete geometry
53 Differential geometry
54 General topology
55 Algebraic topology
57 Manifolds and cell complexes
58 Global analysis, analysis on manifolds
60 Probability theory and stochastic processes
62 Statistics
65 Numerical analysis
68 Computer science
70 Mechanics of particles and systems
74 Mechanics of deformable solids
76 Fluid mechanics
78 Optics, electromagnetic theory
80 Classical thermodynamics, heat transfer
81 Quantum theory
82 Statistical mechanics, structure of matter
83 Relativity and gravitational theory
85 Astronomy and astrophysics
86 Geophysics
90 Operations research, mathematical programming
91 Game theory, economics, social and behavioral sciences
92 Biology and other natural sciences
93 Systems theory; control
94 Information and communication, circuits
97 Mathematics education

EMPLOYER FORM

MATHEMATICAL SCIENCES EMPLOYMENT REGISTER
JANUARY 7–10, 2004
PHOENIX, ARIZONA

1. Forms should be accessed and submitted electronically if possible. The URL for accessing Employment Register information and forms is `http://www.ams.org/emp-reg/`.
2. Paper or electronic forms are due, along with payment and your Advance Registration/ Housing Form, by October 24 (to AMS, P. O. Box 6887, Providence, RI 02940) in order to be included in the *Winter List of Employers*.
3. Please list all potential interviewers, for reference by applicants, but pay fees only for each separate table.
4. Forms will not be processed until registration and payment of fees have been received.

EMPLOYER CODE:

Institution _____

Department _____

Mailing address _____

_____

E-mail address (one only) _____

URL (or other contact info) _____

Name(s) of Interviewer(s) 1. _____

2. _____

3. _____

4. _____

Specialties sought _____

_____

Title(s) of position(s) _____

Number of positions _____

Starting date _____ (Month) / _____ (Year)

Term of appointment _____ (Years)

Renewal

☐ Possible ☐ Impossible

Tenure-track position

☐ Yes ☐ No

Teaching hours per week _____

Degree preferred _____

Degree accepted _____

Duties _____

_____

_____

Experience preferred _____

_____

_____

Significant other requirements, needs, or restrictions which will influence hiring decisions _____

_____

_____

This position will be subject to a security clearance which will require U.S. citizenship: ☐ Yes ☐ No

THE EMPLOYER PLANS TO USE THE FOLLOWING SERVICES (check all that apply):

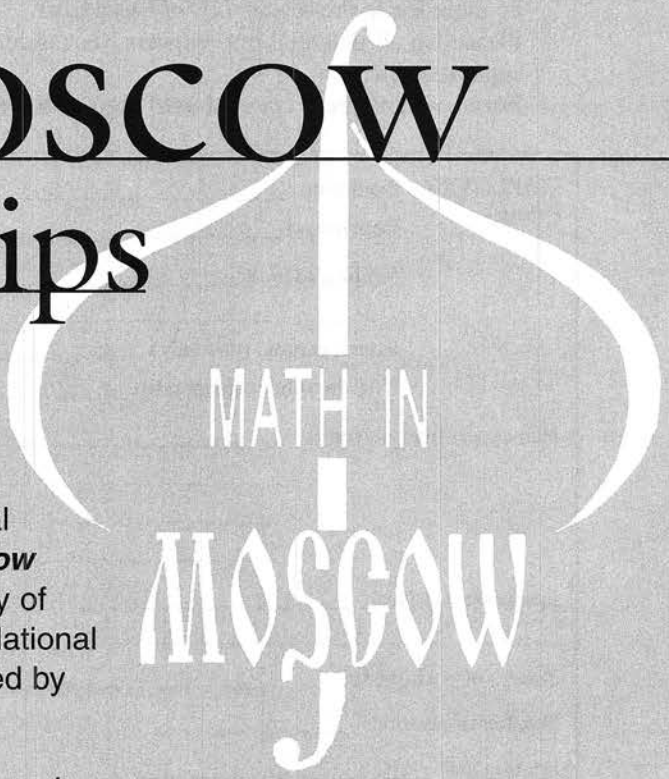
☐ One or more computer-scheduled Interview Tables

☐ One or more self-scheduled Interview Tables

☐ Placing this form for information only (not using a table)

AMERICAN MATHEMATICAL SOCIETY

Math in Moscow Scholarships



The AMS invites undergraduate mathematics and computer science majors in the U.S. to apply for a special scholarship to attend a ***Math in Moscow*** semester at the Independent University of Moscow. Funding is provided by the National Science Foundation and is administered by the AMS.

The ***Math in Moscow*** program offers a unique opportunity for intensive mathematical study and research, as well as a chance for students to experience life in Moscow. Instruction during the semester emphasizes in-depth understanding of carefully selected material: students explore significant connections with contemporary research topics under the guidance of internationally recognized research mathematicians, all of whom have considerable teaching experience in English.

The application deadline for spring semesters is September 30, and fall semesters deadline is April 15.

For more information, see **www.ams.org/careers-edu/mimoscow.html**.

Contact: Professional Services Department, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294, USA; tel. 800-321-4267, ext. 4105; email: prof-serv@ams.org.

AMS
AMERICAN MATHEMATICAL SOCIETY
www.ams.org

APPLICANT RÉSUMÉ FORM

MATHEMATICAL SCIENCES EMPLOYMENT REGISTER
JANUARY 7–10, 2004
PHOENIX, ARIZONA

1. Forms should be accessed and submitted electronically if possible. The URL for accessing Employment Register information and forms is `http://www.ams.org/emp-reg/`.
2. Paper or electronic forms are due, along with payment and your Advance Registration/ Housing Form, by October 24 (to AMS, P. O. Box 6887, Providence, RI 02940) in order to be included in the *Winter List of Applicants*.
3. Forms will not be processed until registration and payment of fees have been received.

APPLICANT CODE:

Last name _____ First name _____

Mailing address (include zip code) _____

_____

E-mail address (one only) _____

URL (or other contact info) _____

Specialties _____

_____

(use MR classification codes plus text if possible; applicants will be indexed by first number only)

DESIRED POSITION:

Academic: ☐ Research ☐ University Teaching College Teaching: ☐ 4-year ☐ 2-year

Would you be interested in nonacademic employment? ☐ Yes ☐ No Available mo. _____ /yr. _____

Computer skills _____

Significant requirements (or restrictions) which would limit your availability for employment _____

_____

PROFESSIONAL ACCOMPLISHMENTS:

Significant achievements, research or teaching interests _____

_____

_____

_____

_____

Paper to be presented at this meeting or recent publication _____

_____

Degree	Year (expected)	Institution
_____	_____	_____
_____	_____	_____
_____	_____	_____

Number of refereed papers accepted/published _____

PROFESSIONAL EMPLOYMENT HISTORY:

	Employer	Position	Years
1.	_____	_____	_____ to _____
2.	_____	_____	_____ to _____
3.	_____	_____	_____ to _____

References (Name and Institution only)

_____

_____

_____

_____

Work authorization status: (check one) ☐ U.S. Citizen ☐ Non-U.S. Citizen, authorized to work permanently in U.S. ☐ Other

This applicant will be using: ☐ ALL Employment Center services ☐ Message Center and Winter List ONLY

AMERICAN MATHEMATICAL SOCIETY

Resources for Undergraduates in Mathematics

Visit the AMS Undergraduate Web page
www.ams.org/careers-edu/undergrad.html

Find out about:

- Applying to graduate school
- REUs
- Special semester programs in mathematics
- Math problems
- Internships
- College math clubs
- Biographies of mathematicians
- Undergraduate math conferences
- Pi Day
- Undergraduate math journals
- Honor societies
- Mathematical contests
- Undergraduate math prizes
- Math Careers

Contact: Professional Services Department, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294, USA; telephone: 800-321-4267, ext. 4105; email: prof-serv@ams.org.

AMS
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Meetings & Conferences of the AMS

IMPORTANT INFORMATION REGARDING MEETINGS PROGRAMS: AMS Sectional Meeting programs do not appear in the print version of the *Notices*. However, comprehensive and continually updated meeting and program information with links to the abstract for each talk can be found on the AMS website. See `http://www.ams.org/meetings/`. Programs and abstracts will continue to be displayed on the AMS website in the Meetings and Conferences section until about three weeks after the meeting is over. Final programs for Sectional Meetings will be archived on the AMS website in an electronic issue of the *Notices* as noted below for each meeting.

Boulder, Colorado

University of Colorado

October 2–4, 2003

Thursday–Saturday

Meeting #989

Western Section
Associate secretaries: Susan J. Friedlander and Michel L. Lapidus
Announcement issue of *Notices*: August 2003
Program first available on AMS website: August 21, 2003
Program issue of electronic *Notices*: October 2003
Issue of *Abstracts*: Volume 24, Issue 4

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: August 12, 2003

Invited Addresses

J. Brian Conrey, American Institute of Mathematics, *Random matrix theory and the Riemann zeta-function.*

Giovanni Forni, Northwestern University, *Title to be announced.*

Juha M. Heinonen, University of Michigan, *Nonsmooth calculus.*

Joseph D. Lakey, New Mexico State University, *Recent progress in time-frequency analysis.*

Albert Schwarz, University of California Davis, *Maximally supersymmetric gauge theories.*

Brooke E. Shipley, Purdue University, *Title to be announced.*

Avi Wigderson, Institute for Advanced Study, *Some insights of computational complexity theory* (Erdős Memorial Lecture).

Special Sessions

Algebraic Geometry (Code: AMS SS M1), **Holger Kley**, **Rick Miranda**, and **Chris Peterson**, Colorado State University.

Algebras, Lattices and Varieties (Code: AMS SS A1), **Keith A. Kearnes**, University of Colorado, Boulder, **Agnes Szendrei**, Bolyai Institute, and **Walter Taylor**, University of Colorado, Boulder.

Analysis on Singular Spaces (Code: AMS SS L1), **Mario Bonk**, University of Michigan, and **Juha Heinonen**, Mathematical Sciences Research Institute.

Applications of Number Theory and Algebraic Geometry to Coding (Code: AMS SS B1), **David R. Grant**, University of Colorado, Boulder, **Jose Felipe Voloch**, University of Texas at Austin, and **Judy Leavitt Walker**, University of Nebraska, Lincoln.

Associative Rings and Their Modules (Code: AMS SS J1), **Gene Abrams**, University of Colorado at Colorado Springs, and **Kent Fuller**, University of Iowa.

Computational and Mathematical Biology (Code: AMS SS S1), **Harvey J. Greenberg**, University of Colorado at Denver.

Computational Number Theory (Code: AMS SS R1), **Brian Conrey** and **Michael Rubinstein**, American Institute of Mathematics.

Dynamics of Rational Polygonal Billiards and Related Systems (Code: AMS SS K1), **Giovanni Forni**, Northwestern University.

Finite Geometries (Code: AMS SS N1), **Stanley E. Payne**, University of Colorado, Denver, and **Robert Allen Liebler**, Colorado State University.

Geometric Methods in Partial Differential Equations (Code: AMS SS C1), **Jeanne N. Clelland**, University of Colorado, Boulder, and **George R. Wilkins**, University of Hawaii.

Graphs and Diagraphs (Code: AMS SS H1), **Michael Jacobson**, University of Colorado, Denver, and **Richard J. Lundgren**, University of Colorado, Denver.

Groupoids in Analysis and Geometry (Code: AMS SS D1), **Lawrence Baggett**, University of Colorado, Boulder, **Jerry Kaminker**, Indiana University-Purdue University Indianapolis, and **Judith Packer**, University of Colorado, Boulder.

Homotopy Theory (Code: AMS SS F1), **Daniel Dugger**, University of Oregon, and **Brooke E. Shipley**, Purdue University.

Noncommutative Geometry and Geometric Analysis (Code: AMS SS E1), **Carla Farsi**, **Alexander Gorokhovsky**, and **Siye Wu**, University of Colorado.

Nonlinear Waves (Code: AMS SS P1), **Bernard Deconinck**, Colorado State University, and **Harvey Segur**, University of Colorado, Boulder.

Structured Population and Epidemic Models: Periodicity, Chaos, and Extinction (Code: AMS SS G1), **Linda J. S. Allen**, Texas Tech University, and **Sophia R.-J. Jang**, University of Louisiana at Lafayette.

Ubiquitous Heat Kernel (Code: AMS SS Q1), **Jay Jorgenson**, City College of New York, and **Lynne Walling**, University of Colorado, Boulder.

Binghamton, New York

Binghamton University

October 11–12, 2003

Saturday–Sunday

Meeting #990

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: August 2003
Program first available on AMS website: August 28, 2003
Program issue of electronic *Notices*: October 2003
Issue of *Abstracts*: Volume 24, Issue 4

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: August 19, 2003

Invited Addresses

Peter Kuchment, Texas A&M University, *Quantum graphs and their applications.*

Zlil Sela, Einstein Institute of Mathematics, *Diophantine geometry over groups and the elementary theory of free and hyperbolic groups.*

Zoltan Szabo, Princeton University, *Holomorphic disks and Floer homology for knots.*

Jeb F. Willenbring, Yale University, *Symmetric pairs.*

Special Sessions

Biomolecular Mathematics (Code: AMS SS A1), **Thomas J. Head** and **Dennis G. Pixton**, Binghamton University, **Mitsunori Ogihara**, University of Rochester, and **Carlos Martin-Vide**, Universitat Rovira i Virgili.

Boundary Value Problems on Singular Domains (Code: AMS SS C1), **Juan B. Gil**, Temple University, and **Paul A. Loya**, Binghamton University.

Character Theory of Finite Groups and Algebraic Combinatorics (Code: AMS SS P1), **Kenneth W. Johnson**, Pennsylvania State University, and **Eirini Poimenidou**, New College of Florida.

Dowling Lattices: The 30th Anniversary (Code: AMS SS N1), **Thomas Zaslavsky**, Binghamton University of SUNY.

Finite Solvable Groups and Their Representations (Code: AMS SS K1), **Ben Brewster**, SUNY at Binghamton, and **Arnold Feldman**, Franklin & Marshall College.

Geometric Group Theory (Code: AMS SS B1), **Zlil Sela**, Einstein Institute of Mathematics, and **Ross Geoghegan**, Binghamton University.

Homotopy Theory: Honoring Peter Hilton on His Eightieth Birthday (Code: AMS SS J1), **Martin Bendersky** and **Joseph Roitberg**, Hunter College (CUNY).

Infinite Groups and Group Rings (Code: AMS SS D1), **Luise-Charlotte Kappe**, Binghamton University, and **Derek J. S. Robinson**, University of Illinois, Urbana-Champaign.

Inverse Problems and Tomography (Code: AMS SS H1), **Peter Kuchment**, Texas A&M University, **Leonid A. Kunyansky**, University of Arizona, and **Eric Todd Quinto**, Tufts University.

Lie Algebras, Conformal Field Theory, and Related Topics (Code: AMS SS E1), **Chongying Dong**, University of California Santa Cruz, and **Alex J. Feingold** and **Gaywalee Yamskulna**, Binghamton University.

Manifold Theory (Code: AMS SS L1), **Erik K. Pedersen**, Binghamton University, and **Ian Hambleton**, McMaster University.

Noncommutative Ring Theory (Code: AMS SS M1), **Howard E. Bell** and **Yuanlin Li**, Brock University.

Probability Theory (Code: AMS SS F1), **Miguel A. Arcones**, Binghamton University, and **Evarist Gine**, University of Connecticut.

Quasigroups and Loops (Code: AMS SS R1), **Tuval S. Foguel**, North Dakota State University, and **J. D. Phillips**, Wabash College.

Statistics (Code: AMS SS G1), **Miguel A. Arcones**, **Anton Schick**, and **Qiqing Yu**, Binghamton University.

Topological Combinatorics (Code: AMS SS Q1), **Laura M. Anderson**, Binghamton University, and **Edward B. Swartz**, Cornell University.

Chapel Hill, North Carolina

University of North Carolina at Chapel Hill

October 24–25, 2003

Friday–Saturday

Meeting #991

Southeastern Section
Associate secretary: John L. Bryant
Announcement issue of *Notices*: August 2003
Program first available on AMS website: September 11, 2003
Program issue of electronic *Notices*: October 2003
Issue of *Abstracts*: Volume 24, Issue 4

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: September 3, 2003

Invited Addresses

James N. Damon, University of North Carolina, *Scale-based geometry and its role for computer imaging.*

Erica L. Flapan, Pomona College, *Title to be announced.*

Mary Ann Horn, Vanderbilt University, *Mathematical modeling and challenges in the development of drug resistance.*

Helmut Voelklein, University of Florida, *Interactions between group theory and algebraic curves via Riemann's Existence Theorem.*

Special Sessions

Algebras and Their Representations (Code: AMS SS M1), **Edward L. Green**, Virginia Polytech Institute & State University, and **Ellen E. Kirkman**, Wake Forest University.

Association Schemes: 1973–2003 (Code: AMS SS F1), **William J. Martin**, Worcester Polytechnic Institute, and **Dijen K. Ray-Chaudhuri**, Ohio State University.

Banach Algebras and Several Complex Variables (Code: AMS SS J1), **John T. Anderson**, College of the Holy Cross, and **Alexander J. Izzo**, Bowling Green State University.

Commutative Rings and Monoids (Code: AMS SS K1), **Scott Chapman**, Trinity University.

Current Topics in Optical Communications Systems (Code: AMS SS Q1), **Rudy Horne** and **Tobias Schaefer**, University of North Carolina.

Group Actions on Curves (Code: AMS SS A1), **Kay Magaard**, Wayne State University and University of Florida, and **Helmut Voelklein**, University of Florida.

Group Cohomology in Algebra and Geometry (Code: AMS SS E1), **Richard M. Hain**, Duke University, and **Kevin P. Knudson**, Mississippi State University.

Homological Physics (Code: AMS SS I1), **Thomas J. Lada**, North Carolina State University, and **James Stasheff**, University of North Carolina at Chapel Hill.

Knots, Links, and Embedded Graphs (Code: AMS SS C1), **Joel S. Foisy**, SUNY at Potsdam, and **Erica L. Flapan**, Pomona College.

Linear Operators on Function Spaces (Code: AMS SS G1), **Nathan S. Feldman**, Washington and Lee University, and **William T. Ross**, University of Richmond.

Mathematical Modeling in Physiology and Medicine (Code: AMS SS N1), **Mary Ann Horn**, Vanderbilt University.

Mathematical Molecular Biology (Code: AMS SS P1), **Dorothy Buck**, Brown University.

Measurable, Complex, and Symbolic Dynamics (Code: AMS SS D1), **Jane M. Hawkins** and **Karl E. Petersen**, University of North Carolina at Chapel Hill.

Multi-scale Challenges in Soft Matter Materials (Code: AMS SS L1), **Gregory M. Forest**, University of North Carolina, **Qi Wang**, Florida State University, and **Ruhai Zhou**, University of North Carolina.

Nonlinear Wave Phenomena: Stability and Interactions (Code: AMS SS H1), **Christopher Jones**, University of North Carolina at Chapel Hill, and **Bjorn Sandstede**, The Ohio State University.

Bangalore, India

India Institute of Science

December 17–20, 2003

Wednesday–Saturday

Meeting #992

First Joint AMS-India Mathematics Meeting
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: To be announced
Program first available on AMS website: Not applicable
Program issue of electronic *Notices*: Not applicable
Issue of *Abstracts*: Not applicable

Deadlines

For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: September 1, 2003

Invited Addresses

R. Balasubramanian, Institute for Mathematical Sciences, *Title to be announced.*

George C. Papanicolaou, Stanford University, *Title to be announced.*

M. S. Raghunathan, Tata Institute of Fundamental Research, *Title to be announced.*

Peter Sarnak, Princeton University and New York University-Courant Institute, *Title to be announced.*

K. B. Sinha, India Statistical Institute, *Title to be announced.*

Vladimir Voevodsky, Institute for Advanced Study, *Title to be announced.*

Special Sessions

Algebraic and Geometric Methods in Multivariable Operator Theory, **Ronald G. Douglas**, Texas A&M University, and **Gadadhar Misra**, Indian Statistical Institute.

Algebraic and Geometric Topology, **Parameswaren Sankaran**, Institute of Mathematical Sciences, and **P. B. Shalen**, University of Illinois.

Automorphic Forms and Functoriality, **James Cogdell**, Oklahoma State University, and **T. N. Venkataramana**, Tata Institute of Fundamental Research.

Buildings and Group Theory, **N. S. Narasimha Sastry**, Indian Statistical Institute, and **Richard M. Weiss**, Tufts University.

Commutative Algebra and Algebraic Geometry, **Sudhir Ghorpade**, Indian Institute of Technology Bombay, **Hema Srinivasan**, University of Missouri, and **Jugal K. Verma**, Indian Institute of Technology Bombay.

Cycles, K-Theory, and Motives, **Eric M. Friedlander**, Northwestern University, **Steven Lichtenbaum**, Brown University, **Kapil Paranjape**, Institute of Mathematical Sciences, and **Vasudevan Srinivas**, Tata Institute of Fundamental Research.

Differential Equations and Applications to Population Dynamics, Epidemiology, Genetics and Microbiology, **Bindhyachal Rai**, University of Allahabad, **Sanjay Rai**, Jacksonville University, **Terrance Quinn**, Ohio University Southern, and **Sunil Tiwari**, Sonoma State University.

History of Indian Mathematics, **Gerard G. Emch**, University of Florida, and **R. Sridharan**, Chennai Mathematical Institute.

L-Functions, Automorphic Forms and Cryptography, **R. Balasubramanian**, Institute of Mathematical Sciences, and **K. Soundararajan**, University of Michigan.

The Many Facets of Linear Algebra and Matrix Theory, **Richard Brualdi**, University of Wisconsin, and **Rajendra Bhatia**, Indian Statistical Institute.

PDE and Applications, **Susan B. Friedlander**, University of Illinois, and **P. N. Srikanth**, Tata Institute of Fundamental Research.

Probability Theory, **Rajeeva Karandikar**, Indian Statistical Institute, and **Srinivasa R.S. Varadhan**, New York University-Courant Institute.

Quantum Dynamics, **William Arveson**, University of California Berkeley, and **B. V. Rajarama Bhat**, Indian Statistical Institute.

Reductive Groups: Arithmetic, Geometry and Representation Theory, **Vikram Mehta** and **R. Parimala**, Tata Institute of Fundamental Research, and **Gopal Prasad**, University of Michigan, Ann Arbor.

Spectral and Inverse Spectral Theories of Schrödinger Operators, **Peter David Hislop**, University of Kentucky, and **Krishna Maddaly**, Institute of Mathematical Sciences.

Phoenix, Arizona

Phoenix Civic Plaza

January 7–10, 2004

Wednesday–Saturday

Meeting #993

Joint Mathematics Meetings, including the 110th Annual Meeting of the AMS, 87th Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), the winter meeting of the Association for Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).

Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: October 2003
Program first available on AMS website: November 1, 2003
Program issue of electronic *Notices*: January 2004
Issue of *Abstracts*: Volume 25, Issue 1

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: October 1, 2003
For summaries of papers to MAA organizers: September 9, 2003

Joint Invited Addresses

Bonnie Berger, Massachusetts Institute of Technology, *Title to be announced* (AMS-MAA).

Stephen Wolfram, Wolfram Research Inc., *Title to be announced* (AMS-MAA).

Joint Special Sessions

Classical and Nonlinear Special Functions (Code: SS 9A), **Peter A. Clarkson**, University of Kent, **Francisco Marcellan**, Universidad Carlos III, and **Peter A. McCoy**, U. S. Naval Academy (AMS-SIAM).

Coding, Geometry, and Hyperbolic Dynamics (Code: SS 21A), **Svetlana R. Katok**, Pennsylvania State University, and **Boris Hasselblatt**, Tufts University (AMS-AWM).

History of Mathematics (Code: SS 6A), **Joseph W. Dauben**, Lehman College (CUNY), and **David E. Zitarelli**, Temple University (AMS-MAA).

Infinite Combinatorics and Inner Model Theory (Code: SS 22A), **Matthew D. Foreman** and **Martin Zeman**, University of California Irvine (AMS-ASL).

Mathematical Techniques in Musical Analysis (Code: SS 1A), **Judith L. Baxter**, University of Illinois at Chicago, and **Robert W. Peck**, Louisiana State University (AMS-MAA).

Mathematics and Education Reform (Code: SS 17A), **William H. Barker**, Bowdoin College, **Jerry L. Bona** and **Naomi Fisher**, University of Illinois at Chicago, **Kenneth C. Millett**, University of California Santa Barbara, and **Bonnie Saunders**, University of Illinois at Chicago (AMS-MAA-MER).

Research in Mathematics by Undergraduates (Code: SS 20A), **Darren A. Narayan**, **Carl V. Lutzer**, and **Tamara A. Burton**, Rochester Institute of Technology (AMS-MAA-SIAM).

AMS Invited Addresses

Michael Aschbacher, California Institute of Technology, *The status of the classification of the finite simple groups.*

Hyman Bass, University of Michigan, *Title to be announced* (AMS Retiring Presidential Address).

Sun-Yang Alice Chang, Princeton University, *Conformal invariants and partial differential equations* (Colloquium Lectures).

Eric Lander, Whitehead Institute for Biomedical Research, *Title to be announced* (Josiah Willard Gibbs Lecture).

Gregory F. Lawler, Cornell University, *Random planar curves and conformal invariance.*

Eva Tardos, Cornell University, *Title to be announced.*

James A. Yorke, University of Maryland, *Properties of "almost every" C^1 image of compact sets.*

AMS Special Sessions

Arithmetical Algebraic Geometry (Code: SS 33A), **Kirti Joshi**, **Minhyong Kim**, and **Adrian Vasiu**, University of Arizona.

Celestial Mechanics (Code: SS 10A), **Samuel R. Kaplan**, University of North Carolina at Asheville, and **Gareth E. Roberts**, College of the Holy Cross.

Coding and Design-Theoretic Applications of Polynomials (Code: SS 2A), **Donald D. Mills**, Southern Illinois University, Carbondale, **Patrick S. Mitchell**, Midwestern State University, and **Kent M. Neuerburg**, Southeastern Louisiana University.

Competitive and Adaptative Dynamics in Ecology (Code: SS 15A), **Carlos Castillo-Chavez**, Los Alamos National Laboratory, **Yang Kuang**, Arizona State University, **Bai-Lian Li**, University of California Riverside, and **Horst R. Thieme**, Arizona State University.

Continued Fractions (Code: SS 26A), **James G. McLaughlin** and **Nancy J. Wyshinski**, Trinity College.

Current Events (Code: SS 18A), **David Eisenbud**, Mathematical Sciences Research Institute and University of California Berkeley.

Discrete Dynamics and Difference Equations (Code: SS 16A), **Saber N. Elaydi**, Trinity University, **Jim M. Cushing**, University of Arizona, **Gerasimos Ladas**, University of Rhode Island, and **James A. Yorke**, University of Maryland, College Park.

Fixed Points: Theory and Application (Code: SS 4A), **Robert F. Brown** and **Mark S. Burgin**, University of California Los Angeles.

Geometric Structures on Manifolds (Code: SS 31A), **Tedi C. Draghici**, **Gueo V. Grantcharov**, and **Philippe Rukimbira**, Florida International University.

Geometry and Combinatorics (Code: SS 32A), **Michael J. Falk**, Northern Arizona University, **Eva-Maria Feichtner**, ETH Zurich, and **Dmitry N. Kozlov**, Bern University.

Low-Dimensional Topology (Code: SS 7A), **Tim D. Cochran**, Rice University.

The Many Lives of Lattice Theory and the Theory of Ordered Sets, with Connections to Combinatorics (Code: SS 29A), **Jonathan D. Farley**, Massachusetts Institute of Technology, and **Stefan E. Schmidt**, New Mexico State University.

Mathematical Modeling in Neuroscience, Biomedicine, Genetics, and Epidemiology (Code: SS 14A), **Steven M. Baer**, Arizona State University, **Ivo D. Dinov**, University of California Los Angeles, and **Frank C. Hoppensteadt** and **Hal L. Smith**, Arizona State University.

Mathematics in Natural Resource Modeling (Code: SS 11A), **Catherine A. Roberts**, College of the Holy Cross, and **Suzanne M. Lenhart**, University of Tennessee.

Modern Function Theory (Code: SS 27A), **Beth Schaubroeck**, U. S. Air Force Academy, **Peter L. Duren**, University of Michigan, Ann Arbor, and **John A. Pfaltzgraff**, University of North Carolina at Chapel Hill.

Multiscale and Oscillatory Phenomena: Modeling, Numerical Techniques, and Applications (Code: SS 23A), **Richard Tsai**, Princeton University, and **Luminita A. Vese**, University of California Los Angeles.

Nonassociative Algebra (Code: SS 12A), **Murray R. Bremner**, University of Saskatchewan, **Irvin R. Hentzel**, Iowa State University, and **Luiz A. Peresi**, University of Sao Paulo.

Nonlinear PDEs and Variational Problems (Code: SS 5A), **David A. Hartenstine**, University of Utah, **Ahmed Mohammed**, Ball State University, **John M. Neuberger**, Northern Arizona State University, and **John W. Neuberger**, University of North Texas.

Nonlinear Partial Differential Equations and Conformal Geometry (Code: SS 34A), **Jie Qing**, University of California Santa Cruz, and **Yu Yuan**, University of Washington, Seattle.

Nonstandard Methods (Code: SS 8A), **Matt Insall**, University of Missouri at Rolla, **Peter A. Loeb**, University of Illinois at Urbana-Champaign, and **David A. Ross**, University of Hawaii.

Partial Differential Equations and Applications (Code: SS 24A), **Xin Lu**, University of North Carolina at Wilmington, **Yan-Wei Qi**, University of California Santa Barbara, **Weiqing Xie**, California State Polytech University, and **Hong-Ming Yin**, Washington State University.

Probability and Its Applications in Combinatorics and Algorithms (Code: SS 13A), **Russell D. Lyons**, Indiana University, and **Yuval Peres**, University of California Berkeley.

Smooth Dynamical Systems and Applications (Code: SS 30A), **Qiu-dong Wang** and **Maciej P. Wojtkowski**, University of Arizona.

Theory and Applications of Orthogonal Polynomials (Code: SS 25A), **Mourad E. H. Ismail**, University of South Florida, and **Barry Simon**, California Institute of Technology.

Time Scales and Applications (Code: SS 19A), **Martin J. Bohner**, University of Missouri at Rolla, **Billur Kaymakcalan**, Georgia Southern University, and **Allan C. Peterson**, University of Nebraska.

Topological Dynamics and Ergodic Theory (Code: SS 28A), **Alica Miller** and **Joseph Rosenblatt**, University of Illinois at Urbana-Champaign.

Value Distribution Theory in Classical and p-adic Function Theory (Code: SS 3A), **Alain Escassut**, Université Blaise Pascal, **Ilpo Laine**, University of Joensuu, and **Chung-Chun Yang**, Hong Kong University of Science and Technology.

Tallahassee, Florida

Florida State University

March 12–13, 2004

Friday–Saturday

Meeting #994

Southeastern Section
Associate secretary: John L. Bryant
Announcement issue of *Notices*: January 2004
Program first available on AMS website: January 29, 2004
Program issue of electronic *Notices*: March 2004
Issue of *Abstracts*: To be announced

Deadlines

For organizers: August 13, 2003
For consideration of contributed papers in Special Sessions: November 25, 2003
For abstracts: January 20, 2004

Athens, Ohio

Ohio University

March 26–27, 2004

Friday–Saturday

Meeting #995

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: January 2004
Program first available on AMS website: February 12, 2004
Program issue of electronic *Notices*: March 2004
Issue of *Abstracts*: To be announced

Deadlines

For organizers: August 26, 2003
For consideration of contributed papers in Special Sessions: December 9, 2003
For abstracts: February 3, 2004

Invited Addresses

Mario Bonk, University of Michigan, *Title to be announced.*

Irene M. Gamba, University of Texas at Austin, *Title to be announced.*

Rostislav I. Grigorchuk, Steklov Institute of Mathematics, *Title to be announced.*

Eric G. Zaslow, Northwestern University, *Title to be announced.*

Special Sessions

Differential Equations and Control Theory (Code: SS 1A), **Sergiu Aizicovici** and **Nicolai Pavel**, Ohio University.

Los Angeles, California

University of Southern California

April 3–4, 2004

Saturday–Sunday

Meeting #996

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: February 2004
Program first available on AMS website: February 19, 2004
Program issue of electronic *Notices*: April 2004
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For consideration of contributed papers in Special Sessions: December 16, 2003
For abstracts: February 10, 2004

Invited Addresses

Dan Boneh, Stanford University, *Title to be announced.*

Maria E. Schonbek, University of California Santa Cruz, *Title to be announced.*

Paul Smith, University of Washington, *Noncommutative algebraic geometry.*

Christopher Martin Thiele, University of California Los Angeles, *Title to be announced.*

Special Sessions

Contact and Symplectic Geometry (Code: SS 1A), **Dragomir Dragnev**, **Ko Honda**, and **Sang Seon Kim**, University of Southern California.

Lawrenceville, New Jersey

Rider University

April 17–18, 2004

Saturday–Sunday

Meeting #997

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: February 2004
Program first available on AMS website: March 4, 2004
Program issue of electronic *Notices*: April 2004
Issue of *Abstracts*: To be announced

Deadlines

For organizers: September 17, 2003
For consideration of contributed papers in Special Sessions: December 30, 2003
For abstracts: February 24, 2004

Invited Addresses

Sylvia Serfaty, New York University-Courant Institute, *Title to be announced.*

Wim F. Sweldens, Bell Laboratories, *Title to be announced.*

Gaoyong Zhang, Polytechnic University, *Title to be announced.*

Special Sessions

Automorphic Forms and Analytic Number Theory (Code: SS 1A), **Stephen Miller**, Rutgers University, and **Ramin Takloo-Bighash**, Princeton University.

Houston, Texas

University of Houston

May 13–15, 2004

Thursday–Saturday

Meeting #998

Sixth International Joint Meeting of the AMS and the Sociedad Matemática Mexicana (SMM).
Associate secretary: John L. Bryant
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Nashville, Tennessee

Vanderbilt University

October 16–17, 2004

Saturday–Sunday

Meeting #999

Southeastern Section
Associate secretary: John L. Bryant
Announcement issue of *Notices*: August 2004
Program first available on AMS website: September 2, 2004
Program issue of electronic *Notices*: October 2004
Issue of *Abstracts*: To be announced

Deadlines

For organizers: March 16, 2004
For consideration of contributed papers in Special Sessions: June 29, 2004
For abstracts: August 24, 2004

Albuquerque, New Mexico

University of New Mexico

October 16–17, 2004

Saturday–Sunday

Meeting #1000

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: August 2004
Program first available on AMS website: September 2, 2004
Program issue of electronic *Notices*: October 2004
Issue of *Abstracts*: To be announced

Deadlines

For organizers: March 16, 2004
For consideration of contributed papers in Special Sessions: June 29, 2004
For abstracts: August 24, 2004

Invited Addresses

Sara C. Billey, University of Washington, Seattle, *Title to be announced.*

Peter Ebenfelt, University of California San Diego, *Title to be announced.*

Theodore Stanford, New Mexico State University, *Title to be announced.*

Craig A. Tracy, University of California Davis, *Title to be announced.*

Evanston, Illinois

Northwestern University

October 23–24, 2004

Saturday–Sunday

Meeting #1001

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: August 2004
Program first available on AMS website: September 9, 2004
Program issue of electronic *Notices*: October 2004
Issue of *Abstracts*: To be announced

Deadlines

For organizers: March 23, 2004
For consideration of contributed papers in Special Sessions: July 7, 2004
For abstracts: August 31, 2004

Invited Addresses

Ian Agol, University of Illinois at Chicago, *Title to be announced.*

Robert W. Ghrist, University of Illinois, *Title to be announced.*

Yuri Manin, Northwestern University, *Title to be announced.*

Paul Siedel, Imperial College-London and University of Chicago, *Title to be announced.*

Pittsburgh, Pennsylvania

University of Pittsburgh

November 6–7, 2004

Saturday–Sunday

Meeting #1002

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 7, 2004
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Atlanta, Georgia

Atlanta Marriott Marquis and Hyatt Regency Atlanta

January 5–8, 2005

Wednesday–Saturday
Joint Mathematics Meetings, including the 111th Annual Meeting of the AMS, 88th Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association of Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association of Symbolic Logic (ASL).
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: October 2004
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2005
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 5, 2004
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

Bowling Green, Kentucky

Western Kentucky University

Spring Dates to Be Announced

Friday–Saturday
Southeastern Section
Associate secretary: John L. Bryant
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Newark, Delaware

University of Delaware

April 2–3, 2005

Saturday–Sunday
Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: To be announced

Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: September 2, 2004
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Lubbock, Texas

Texas Technical University

April 8–10, 2005

Friday–Sunday
Southeastern Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Mainz, Germany

June 16–19, 2005

Thursday–Sunday
Second Joint AMS-Deutsche Mathematiker-Vereinigung (DMV) Meeting
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Invited Addresses

Helene Esnault, University of Essen, *Title to be announced.*

Christian Krattenthaler, University of Lyon, *Title to be announced.*

Frank Natterer, University of Muenster, *Title to be announced.*

Johnson City, Tennessee

East Tennessee State University

October 15–16, 2005

Saturday–Sunday
Southeastern Section
Associate secretary: John L. Bryant
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: March 15, 2005
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Antonio, Texas

Henry B. Gonzalez Convention Center

January 12–15, 2006

Thursday–Sunday
Joint Mathematics Meetings, including the 112th Annual Meeting of the AMS, 89th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL).
Associate secretary: John L. Bryant
Announcement issue of *Notices*: October 2005
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2006
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 12, 2005
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

New Orleans, Louisiana

New Orleans Marriott and Sheraton New Orleans Hotel

January 4–7, 2007

Thursday–Sunday
Joint Mathematics Meetings, including the 113th Annual Meeting of the AMS, 90th Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL).
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: October 2006
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2007
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 4, 2006
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

San Diego, California

San Diego Convention Center

January 6–9, 2008

Sunday–Wednesday
Joint Mathematics Meetings, including the 114th Annual Meeting of the AMS, 91st Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Associaiton for Symbolic Logic (ASL).
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: October 2007
Program first available on AMS website: November 1, 2007
Program issue of electronic *Notices*: January 2008
Issue of *Abstracts*: Volume 29, Issue 1

Deadlines

For organizers: April 6, 2007
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

Washington, District of Columbia

Marriott Wardman Park Hotel and Omni Shoreham Hotel

January 7–10, 2009

Wednesday–Saturday
Joint Mathematics Meetings, including the 115th Annual Meeting of the AMS, 92nd Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL).
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: October 2008
Program first available on AMS website: November 1, 2008
Program issue of electronic *Notices*: January 2009
Issue of *Abstracts*: Volume 30, Issue 1

Deadlines

For organizers: April 7, 2008
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

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Meetings and Conferences of the AMS

Associate Secretaries of the AMS

Western Section: Michel L. Lapidus, Department of Mathematics, University of California, Sproul Hall, Riverside, CA 92521-0135; e-mail: lapidus@math.ucr.edu or lapidus@mathserv.ucr.edu; telephone: 909-787-3113.

Central Section: Susan J. Friedlander, Department of Mathematics, University of Illinois at Chicago, 851 S. Morgan (M/C 249), Chicago, IL 60607-7045; e-mail: susan@math.nwu.edu; telephone: 312-996-3041.

Eastern Section: Lesley M. Sibner, Department of Mathematics, Polytechnic University, Brooklyn, NY 11201-2990; e-mail: lsibner@duke.poly.edu; telephone: 718-260-3505.

Southeastern Section: John L. Bryant, Department of Mathematics, Florida State University, Tallahassee, FL 32306-4510; e-mail: bryant@math.fsu.edu; telephone: 850-644-5805.

The Meetings and Conferences section of the *Notices* gives information on all AMS meetings and conferences approved by press time for this issue. Please refer to the page numbers cited in the table of contents on this page for more detailed information on each event. Invited Speakers and Special Sessions are listed as soon as they are approved by the cognizant program committee; the codes listed are needed for electronic abstract submission. For some meetings the list may be incomplete. **Information in this issue may be dated. Up-to-date meeting and conference information** at www.ams.org/meetings/.

Meetings:

2003		
October 2–4	Boulder, Colorado	p. 1045
October 11–12	Binghamton, New York	p. 1046
October 24–25	Chapel Hill, North Carolina	p. 1047
December 17–20	Bangalore, India	p. 1047
2004		
January 7–10	Phoenix, Arizona Annual Meeting	p. 1048
March 12–13	Tallahassee, Florida	p. 1050
March 26–27	Athens, Ohio	p. 1050
April 3–4	Los Angeles, California	p. 1050
April 17–18	Lawrenceville, New Jersey	p. 1051
May 13–15	Houston, Texas	p. 1051
October 16–17	Nashville, Tennessee	p. 1051
October 16–17	Albuquerque, New Mexico	p. 1051
October 23–24	Evanston, Illinois	p. 1052
November 6–7	Pittsburgh, Pennsylvania	p. 1052
2005		
January 5–8	Atlanta, Georgia Annual Meeting	p. 1052
March 25–26	Bowling Green, Kentucky	p. 1052
April 2–3	Newark, Delaware	p. 1052
April 8–10	Lubbock, Texas	p. 1053
June 16–19	Mainz, Germany	p. 1053
October 15–16	Johnson City, Tennessee	p. 1053
2006		
January 12–15	San Antonio, Texas Annual Meeting	p. 1053
2007		
January 4–7	New Orleans, Louisiana Annual Meeting	p. 1054
2008		
January 6–9	San Diego, California Annual Meeting	p. 1054
2009		
January 7–10	Washington, D.C. Annual Meeting	p. 1054

Important Information regarding AMS Meetings

Potential organizers, speakers, and hosts should refer to page 108 in the January 2003 issue of the *Notices* for general information regarding participation in AMS meetings and conferences.

Abstracts

Several options are available for speakers submitting abstracts, including an easy-to-use interactive Web form. No knowledge of LaTeX is necessary to submit an electronic form, although those who use LaTeX may submit abstracts with such coding, and all math displays and similarily coded material (such as accent marks in text) must be typeset in LaTeX. To see descriptions of the forms available, visit http://www.ams.org/abstracts/instructions.html, or send mail to abs-submit@ams.org, typing help as the subject line; descriptions and instructions on how to get the template of your choice will be e-mailed to you.

Completed abstracts should be sent to abs-submit@ams.org, typing submission as the subject line. Questions about abstracts may be sent to abs-info@ams.org.

Paper abstract forms may be sent to Meetings & Conferences Department, AMS, P.O. Box 6887, Providence, RI 02940. There is a $20 processing fee for each paper abstract. There is no charge for electronic abstracts. Note that all abstract deadlines are strictly enforced. Close attention should be paid to specified deadlines in this issue. Unfortunately, late abstracts cannot be accommodated.

AMERICAN MATHEMATICAL SOCIETY

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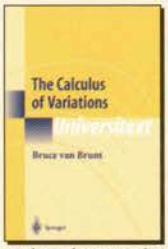


THE CALCULUS OF VARIATIONS

B. VAN BRUNT, Massey University, Palmerston North, New Zealand

This book is an introductory account of the calculus of variations suitable for advanced undergraduate and graduate students of mathematics, physics, or engineering. The mathematical background assumed of the reader is a course in multivariable calculus, and some familiarity with the elements of real analysis and ordinary differential equations. The book focuses on variational problems that involve one independent variable. The book can be used as a textbook for a one semester course on the calculus of variations, or as a book to supplement a course on applied mathematics or classical mechanics.

2003/302 PP., 24 ILLUS./HARDCOVER/$69.95
ISBN 0-387-40247-0
UNIVERSITEXT

FIXED POINT THEORY

A. GRANAS, Université de Montréal, Canada; and **J. DUGUNDJI,** Deceased

This monograph gives a carefully worked out account of the most basic principles and applications of the theory of fixed points. Until now, a treatment of many of the discussed topics has been unavailable in book form. The presentation is self-contained and is accessible to a broad spectrum of readers, including mathematically oriented people interested in applications. The main text is complemented by numerous exercises, comments and a comprehensive bibliography.

2003/552 PP., 13 ILLUS./HARDCOVER/$79.95
ISBN 0-387-00173-5
SPRINGER MONOGRAPHS IN MATHEMATICS

COMPLEX ANALYSIS

J.M. HOWIE, University of St. Andrews, UK

Complex analysis is one of the most attractive of all the core topics in an undergraduate mathematics course. Its importance to applications means that it can be studied both from a very pure perspective and a very applied perspective. This book takes account of these varying needs and backgrounds and provides a self-study text for students in mathematics, science and engineering. Clear and careful explanations are backed up with worked examples and more than 100 exercises, for which full solutions are provided.

2003/272 PP., 83 ILLUS./SOFTCOVER/$34.95
ISBN 1-85233-733-8
SPRINGER UNDERGRADUATE MATHEMATICS SERIES

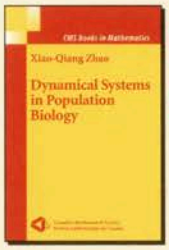
Springer
www.springer-ny.com

SCIENTIFIC COMPUTING WITH MATLAB

A. **QUARTERONI,** Ecole Polytechnique Fédérale de Lausanne, Switzerland and Politecnico di Milano, Italy; and **F. SALERI,** Politecnico di Milano, Italy

This textbook is an introduction to Scientific Computing, in which several numerical methods for the computer solution of certain classes of mathematical problems are illustrated. The authors show how to compute the zeros or the integrals of continuous functions, solve linear systems, approximate functions by polynomials and construct accurate approximations for the solution of differential equations. To make the presentation concrete and appealing, the programming environment Matlab is adopted as a faithful companion. All the algorithms introduced throughout the book are shown, thus furnishing an immediate quantitative assessment of their theoretical properties such as stability, accuracy and complexity. The book also contains the solution to several problems raised through exercises and examples, often originating from specific applications. A specific section is devoted to subjects which were not addressed in the book and indicate the bibliographical references for a more comprehensive treatment of the material.

2003/260 PP./SOFTCOVER/$49.95
ISBN 3-540-44363-0
TEXTS IN COMPUTATIONAL SCIENCE AND ENGINEERING, VOLUME 2

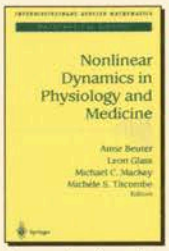


DYNAMICAL SYSTEMS IN POPULATION BIOLOGY

X.-Q. ZHAO, Memorial University of Newfoundland, St. John's, Canada

This research monograph provides an introduction to the theory of nonautonomous semiflows with applications to population dynamics. It develops dynamical system approaches to various evolutionary equations such as difference, ordinary, functional, and partial differential equations, and pays more attention to periodic and almost periodic phenomena. The presentation includes persistence theory, monotone dynamics, periodic and almost periodic semiflows, traveling waves, and global analysis of typical models in population biology. Research mathematicians working with nonlinear dynamics, particularly those interested in applications to biology, will find this book useful. It may also be used as a textbook or as supplementary reading for a graduate special topics course on the theory and applications of dynamical systems.

2003/296 PP./HARDCOVER/$79.95
ISBN 0-387-00308-8
CMS BOOKS IN MATHEMATICS, VOLUME 16



NONLINEAR DYNAMICS IN PHYSIOLOGY AND MEDICINE

A. BEUTER, Université de Montpellier 1, France; **L. GLASS, M.C. MACKEY,** and **M.S. TITCOMBE,** all, McGill University, Montreal, Canada (Eds.)

This books deals with the application of mathematics in modeling and understanding physiological systems, especially those involving rhythms. One novel feature of the book is the inclusion of classroom-tested computer exercises throughout, designed to form a bridge between the mathematical theory and physiological experiments. This volume will be of interest to students and researchers in the natural and physical sciences wanting to learn about the complexities and subtleties of physiological systems from a mathematical perspective.

2003/428 PP., 160 ILLUS./HARDCOVER/$59.95
ISBN 0-387-00449-1
INTERDISCIPLINARY APPLIED MATHEMATICS, VOLUME 25

GRADE INFLATION

A Crisis in College Education

V.E. JOHNSON, University of Michigan, Ann Arbor, MI

"...an outstanding contribution to the debate about the effects of ever rising grades in colleges and universities across the United States ...Johnson does an excellent job of making the sophisticated statistical results accessible and understandable. It should be read by every faculty member who serves on a personnel committee, as well as by all academic administrators."

—DR. MARK H. SHAPIRO, *THE IRASCIBLE PROFESSOR*

Grade inflation runs rampant at most colleges and universities, but faculty and administrators are seemingly unwilling to face the problem. This book explains why, exposing many of the misconceptions surrounding college grading. Based on historical research and the results of a year-long experiment, the effects of student grading on various educational processes, and their subsequent impact on student and faculty behavior, is examined. Principal conclusions of this investigation are that instructors' grading practices have a significant influence on end-of-course teaching evaluations, and that student expectations of grading practices play an important role in the courses that students decide to take.

2003/272 PP., 31 ILLUS./HARDCOVER/$27.50
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