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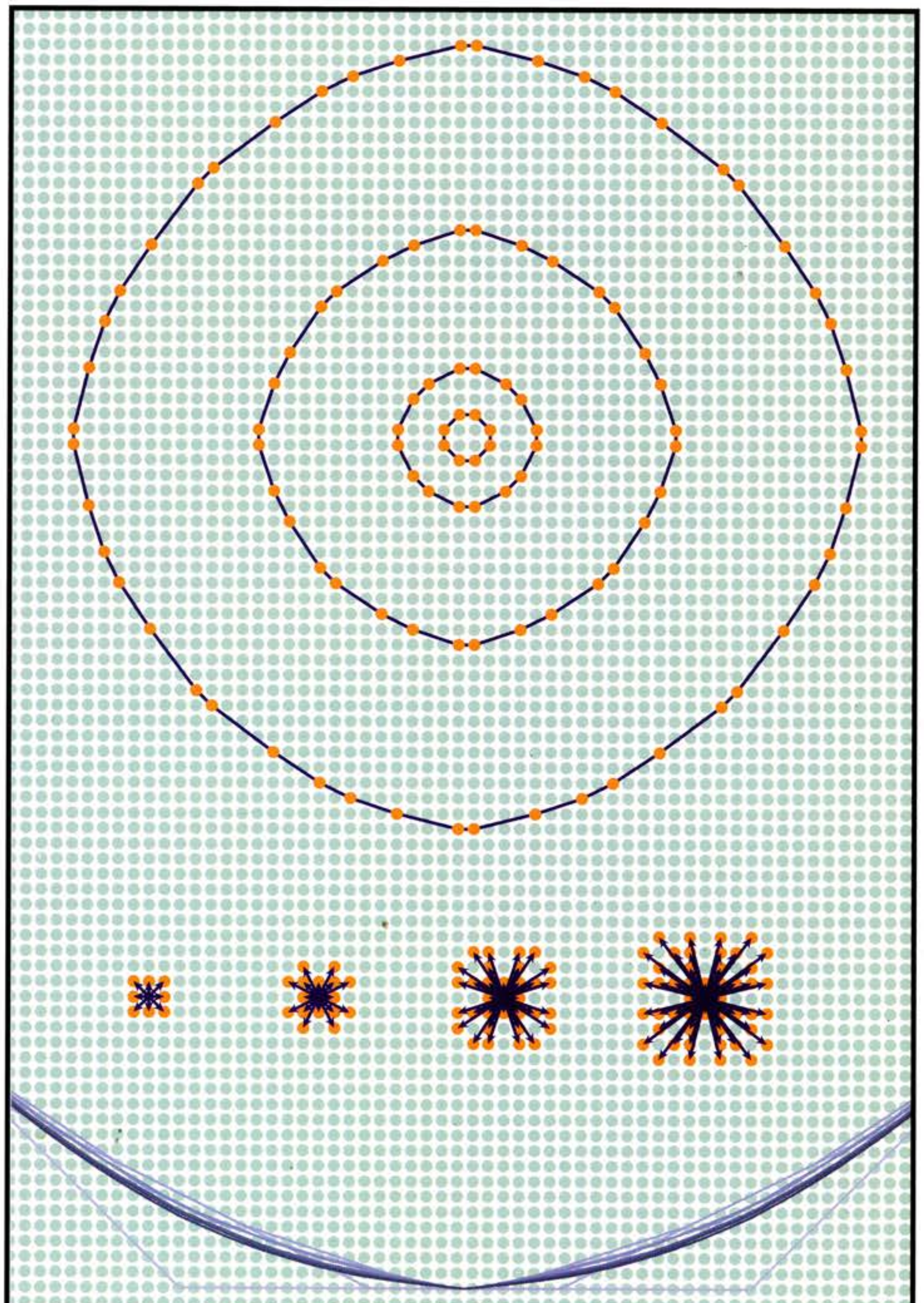
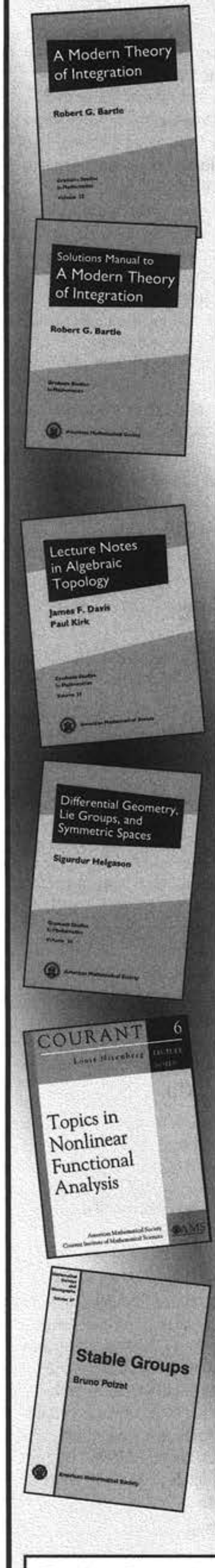


Jarník's Polygons (see page 576)

AMERICAN MATHEMATICAL SOCIETY

New Titles from the AMS



Recommended Text

A Modern Theory of Integration

Robert G. Bartle, *Eastern Michigan University, Ypsilanti, and University of Illinois, Urbana*

This book is an introduction to a relatively new theory of the integral (called the "generalized Riemann integral" or the "Henstock-Kurzweil integral") that corrects the defects in the classical Riemann theory and both simplifies and extends the Lebesgue theory of integration. Although this integral includes that of Lebesgue, its definition is very close to the Riemann integral that is familiar to students from calculus. One virtue of the new approach is that no measure theory and virtually no topology is required. Indeed, the book includes a study of measure theory as an application of the integral.

Included are many examples and a very rich collection of exercises. There are partial solutions to approximately one-third of the exercises. A complete solutions manual is available separately.

Graduate Studies in Mathematics, Volume 32; 2001; 458 pages; Hardcover; ISBN 0-8218-0845-1; List $59; All AMS members $47; Order code GSM/32NT167

Solutions Manual to A Modern Theory of Integration

Graduate Studies in Mathematics, Volume 32; 2001; 72 pages; Softcover; ISBN 0-8218-2821-5; List $14; All AMS members $11; Order code GSM/32.MNT167

Recommended Text

Lecture Notes in Algebraic Topology

James F. Davis and **Paul Kirk**, *Indiana University, Bloomington*

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To help students make this transition, the material in this book is presented in an increasingly sophisticated manner. It is intended to bridge the gap between algebraic and geometric topology, both by providing the algebraic tools that a geometric topologist needs and by concentrating on those areas of algebraic topology that are geometrically motivated.

A unique feature of the book is the inclusion, at the end of each chapter, of several projects that require students to present proofs of substantial theorems and to write notes accompanying their explanations. Working on these projects allows students to grapple with the "big picture", teaches them how to give mathematical lectures, and prepares them for participating in research seminars.

The book is designed as a textbook for graduate students studying algebraic and geometric topology and homotopy theory. Expositions are clear and special cases are presented over complex general statements.

Graduate Studies in Mathematics, Volume 35; 2001; 367 pages; Hardcover; ISBN 0-8218-2160-1; List $55; All AMS members $44; Order code GSM/35NT167

A Classic

Recommended Text

Differential Geometry, Lie Groups, and Symmetric Spaces

Sigurdur Helgason, *Massachusetts Institute of Technology, Cambridge*

From reviews for the First Edition:

Renders a great service in permitting the non-specialist, with a minimum knowledge of differential geometry and Lie groups, an initiation to the theory of symmetrical spaces.

—H. Cartan, Secretariat Mathématique, Paris

The mathematical community has long been in need of a book on symmetric spaces. S. Helgason has admirably satisfied this need with his book, Differential Geometry and Symmetric Spaces. *It is a remarkably well-written book ... a masterpiece of concise, lucid mathematical exposition ... it might be used as a textbook for "how to write mathematics".*

—Louis Auslander

Helgason begins with a concise, self-contained introduction to differential geometry. He then introduces Lie groups and Lie algebras, including important results on their structure. This sets the stage for the introduction and study of symmetric spaces, which form the central part of the book. The text concludes with the classification of symmetric spaces by means of the Killing-Cartan classification of simple Lie algebras over $\mathbf{C}$ and Cartan's classification of simple Lie algebras over $\mathbf{R}$.

The excellent exposition is supplemented by extensive collections of useful exercises at the end of each chapter. All the problems have either solutions or substantial hints, found at the back of the book.

For this latest edition, Helgason has made corrections and added helpful notes and useful references. The sequels to the present book are published in the AMS's Mathematical Surveys and Monographs Series: *Groups and Geometric Analysis*, Volume 83, and *Geometric Analysis on Symmetric Spaces*, Volume 39.

Graduate Studies in Mathematics, Volume 34; 2001; 641 pages; Hardcover; ISBN 0-8218-2848-7; List $69; All AMS members $55; Order code GSM/34NT167

A Classic

Recommended text

Topics in Nonlinear Functional Analysis

Louis Nirenberg, *New York University-Courant Institute of Mathematical Sciences, NY*

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These lecture notes are extremely stimulating.

—Zentralblatt für Mathematik

[The book] is short, concise, and to the point, and the proofs are unusually elegant, always with a geometric flavor and the best available.

—Mathematical Reviews

Since its first appearance as a set of lecture notes published by the Courant Institute in 1974, this book served as an introduction to various subjects in nonlinear functional analysis. The current edition is a reprint of these notes, with added bibliographic references. After more than 20 years, this book continues to be an excellent graduate level textbook and a useful supplementary course text.

Titles in this series are copublished with the Courant Institute of Mathematical Sciences at New York University.

Courant Lecture Notes, Volume 6; 2001; 145 pages; Softcover; ISBN 0-8218-2819-3; List $24; All AMS members $19; Order code CLN/6NT167

Stable Groups

Bruno Poizat, *Université Claude Bernard, Villeurbanne, France*

From a review of the French edition:

This is a beautiful book in which almost everything known about stable groups appears.

—Zentralblatt für Mathematik

This is the English translation of the book originally published in 1987. It is a faithful reproduction of the original, supplemented by a new Foreword and brought up to date by a short postscript. The book gives an introduction by a specialist in contemporary mathematical logic to the model-theoretic study of groups, i.e., into what can be said about groups, and for that matter, about all the traditional algebraic objects.

Mathematical Surveys and Monographs, Volume 87; 2001; 129 pages; Hardcover; ISBN 0-8218-2685-9; List $49; Individual member $29; Order code SURV/87NT167

Timely Topic

Chaotic Elections! A Mathematician Looks at Voting

Donald G. Saari, *University of California, Irvine*

Saari's book should be required reading for anyone who wants to understand not only what happened in the presidential election of 2000, but also how we can avoid similar problems from appearing anytime any group is making a choice using a voting procedure. Reading this book requires little more than high school mathematics and an interest in how the apparently simple situation of voting can lead to surprising paradoxes.

2001; 159 pages; Softcover; ISBN 0-8218-2847-9; List $23; All AMS members $18; Order code ELECTNT167

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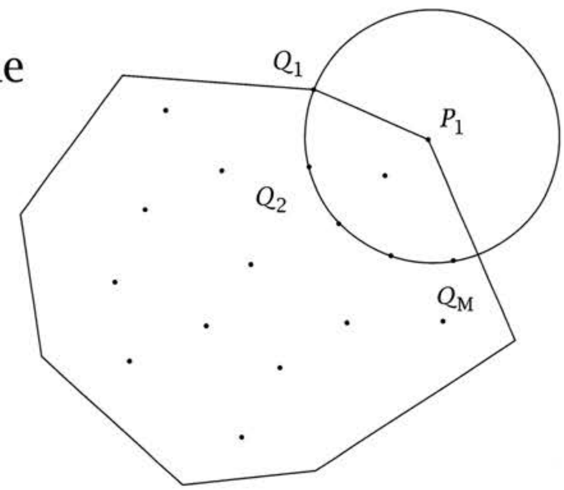
Notices of the American Mathematical Society

June/July 2001

Feature Articles



Communications

Commentary

Notices
of the American Mathematical Society

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Departments

From the AMS Secretary

Suggestions for the Mathematical Sciences Initiative

The NSF (National Science Foundation) has announced a Mathematical Sciences Initiative to substantially increase funding for mathematical research [1], [2] and has requested input from the mathematics community to help shape the specific details.

As we begin to think about how we might respond to this, I would like to suggest two areas for discussion.

1. The citizen/permanent resident requirement. According to [1], one of the programs to be emphasized is VIGRE (Vertical Integration of Research and Education in the Mathematical Sciences), which requires that all beneficiaries be either U.S. citizens or permanent residents. The same requirement pertains to the REU (Research Experiences for Undergraduates) program. (It should be noted that this requirement is not in force for the personnel involved in running these programs, such as graduate students who work with undergraduates in the REU component of a VIGRE grant, whereas the requirement does apply to graduate students receiving VIGRE support directly for their own benefit!) I believe this requirement is both discriminatory and counterproductive. As I am involved in the administration of both types of programs at Cornell, it gives me great pain to have to enforce this rule. We as a society have worked very hard to eliminate discrimination on the basis of a host of categories. Why should we now be inventing yet another category of discrimination (which may well become equally discredited in the future)? When a student comes to you and asks to join in some research activity, do you normally ask about the student's residency status? I hope not. But if you wish to support the student with one of these grants, you are forced to do this.

One purported reason behind this policy is that citizens/permanent residents are more likely to remain in the U.S. during their research careers. I see very little evidence for this. Most foreign students and postdocs at U.S. universities are very eager to remain here, largely because of our vibrant research community, not to mention the economic benefits. Many of them obtain tenure-track positions and become permanent residents within a few years. I also know quite a few U.S. citizens who have opted to take permanent positions in Europe, lured away by the quality of the research community there. I think that there would be no detectable difference in the impact of these NSF programs on the well-being of the U.S. mathematical research community if the citizen/permanent resident requirement were dropped.

Another possible justification for the requirement is that current citizens/permanent residents need some shelter from the competition posed by the outstanding foreign students who are, after all, the selected elite in their home countries. I can concede that there may be some merit to this argument, since U.S. taxpayers may be eager to see a boost in the accomplishments of home-grown students. Nevertheless, the inflexibility of the requirement strikes me as a vast overreaction to a limited problem. It would be much more reasonable to set a percentage goal (or even quota) for the number of citizen/permanent resident participants in these programs.

2. The teaching imperative. The current situation, with a large majority of permanent positions in mathematical research being university professorships, is that anyone contemplating a career in mathematical research faces the imperative of having to become involved in teaching. Perhaps this is not such a good situation. Mathematical researchers tend to run the gamut from those who are natural teachers to those who are completely hopeless at teaching to those in between who are capable of learning, with some effort, to function acceptably in the classroom. Those who find themselves at the negative end of the teaching-talent spectrum often find themselves struggling in a position that serves neither them nor their students very well. I know of cases where promising graduate students have dropped out after negative experiences as TAs, and I know a number of foreign mathematicians with high research achievement who cannot effectively obtain positions in this country because of the teaching requirement. So I believe there is the potential to improve the quality of the mathematical research community in this country by creating a substantial number of permanent research positions with no teaching duties.

The details of how such a program should operate will require a great deal of careful thought. There are many possible models: the Institute for Advanced Study, the French CNRS (Centre National de la Recherche Scientifique), the old Bell Labs, the Institute for Defense Analyses, to name just a few. The researchers could be housed in a separate facility or in existing mathematics departments and institutes. They could be allowed complete freedom to pursue individual research interests, or they could be given a certain amount of consulting or applied research duties.

I think that existing mathematics departments and institutes would be very happy to cooperate with such a program if it meant gaining the services of talented research mathematicians at little cost (for example, NSF pays salaries and benefits, and the department provides office space and technical support).

With an initiative of the size being discussed, it should be possible to include such a program without crowding out other priorities. What would be the cost of such a program, and would the benefits be worth the cost? These are questions that need to be looked at carefully, but I think this is an option worth serious consideration.

—Robert S. Strichartz
Cornell University

References

[1] ALLYN JACKSON, NSF launches major initiative in mathematics, *Notices* (February 2001), 190–192.

[2] PHILIPPE TONDEUR, NSF Mathematical Sciences Initiative, *Notices* (March 2001), 293.

Letters to the Editor

Divergence of the Harmonic Series

I read, with not inconsiderable interest, the article by Catherine C. McGeoch: "Experimental Analysis of Algorithms", *Notices of the AMS*, v. 48, n. 3, p. 304, 2001 March. Therein she asserted: "If you want to know how the process really works, implement the algorithm as a program and measure the running time (or another quantity of interest)." I believe I am aware of a rather striking counterexample to her thesis: the inability of the IEEE Standard 754 floating-point arithmetic adherent hardware implementations (ref. `http://www.cs.berkeley.edu/~wkahan/ieee754status/754story.html`) to demonstrate the well-known divergence property of the classical Harmonic Series (ref. `http://www.mathacademy.com/platonic_realms/encyclop/articles/serie.html`)!

I have attempted to demonstrate this classically known property on several modern computer platforms—all sans success! All I obtained was convergence, not the sought-after demonstration of divergence! This anomaly was apparent in C language implementations using "double" as well as "long double", and it was ubiquitous, so far as I am able to ascertain!

Therefore, by means of this rather simple counterexample, I must caution theoretical mathematicians of the possible failure of even modern platforms to fiducially reproduce well-known behavior.

However, it may be possible that I have overlooked something crucial in the successful resolution of this situation. I would, therefore, welcome any advice from your readership thereupon.

Tempus fugit et ad augusta per angusta.

—*Joseph Roy D. North*
District Heights, MD

(Received February 17, 2001)

Segal and Cosmology

I am bothered by "Einstein's static universe: An idea whose time has come back?", by Daigneault and Sangalli, which appeared in the January 2001 *Notices*. I can't discuss the Big Bang with any real expertise, but I have talked to cosmologists. Their work seems more serious and more credible to me than the article suggests. The article compares I. E. Segal to Giordano Bruno and the inflation theory and evolution of quasars to epicycles. I have to take these comments as allusions to Bruno's colleague Galileo, and they remind me of an aphorism of the physicist Robert Park: "Alas, to wear the mantle of Galileo it is not enough that you be persecuted by an unkind establishment, you must also be right" [What's New, 11 June 1999, `http://www.aps.org/WN/WN99/wn061199.html`].

In order for any theory in science to prevail, it ultimately has to be useful. If we want to help cosmologists, we have to engage them on their terms rather than ours. I don't know that Segal ever seriously tried to do so. I also think that the *Notices* should invite a cosmologist to respond to Daigneault and Sangalli. We might learn a lot if cosmologists explained why they think that the Big Bang is overwhelmingly likely and listed what they consider the real debates in cosmology today.

—*Greg Kuperberg*
University of California, Davis

(Received February 19, 2001)

Amplification

After receiving some feedback on my survey article "From rotating needles to stability of waves: Emerging connections between combinatorics, analysis, and PDE" in the March 2001 issue of the *Notices*, I feel that I should make some additional remarks to ward off any misconceptions that might have arisen from the original article.

Firstly, the results mentioned therein are only a small fraction of the large amount of work and progress accomplished on these problems, and due to space constraints I was able to give only a few representative results on each problem. (I was also advised to keep the reference list to under 10 articles.) Consequently, some authors and their results were mentioned only briefly or not at all, for which I apologize. Far more thorough treatments can be found in the references [1] and particularly [7] of the article. ([1] J. Bourgain, Harmonic analysis and combinatorics: How much may they contribute to each other?, *Mathematics: Frontiers and Perspectives*, IMU/Amer. Math. Soc., 2000, pp. 13–32; [7] T. Wolff, Recent work connected with the Kakeya problem, *Prospects in Mathematics* (Princeton, NJ, 1996), Amer. Math. Soc., Providence, RI, 1999, pp. 129–162.)

Secondly, the main point I was hoping to make in the article was that the open problems posed there appear to be extremely difficult and that deep ideas from other fields could be needed to make substantial new progress. However, this is not to disparage the considerable amount of progress and insight that have already been achieved; in recent years the breakthroughs of Jean Bourgain and Tom Wolff in particular have revolutionized the field. The arguments and ideas coming from these breakthroughs continue to yield further progress on these problems today. Nevertheless, it is my opinion that even with these powerful new techniques, we have about half of the pieces of the puzzle required to solve even the Kakeya problem (which should be the easiest of all the problems listed) and that further ingenious ideas or insights are still needed to obtain a complete resolution.

Shortly after the completion of the first draft of this article, I received the terrible news that Tom Wolff had died in a car accident. This was a great loss not only personally but also to the field; many of the recent developments in the field are due to or inspired by the work of Tom and his students. The rate of progress on these problems will be greatly diminished in his absence.

—*Terence Tao*
University of California, Los Angeles

(Received March 4, 2001)

The Continuum Hypothesis, Part I

W. Hugh Woodin

Introduction

Arguably the most famous formally unsolvable problem of mathematics is Hilbert's first problem:

Cantor's Continuum Hypothesis: *Suppose that $X \subseteq \mathbb{R}$ is an uncountable set. Then there exists a bijection $\pi : X \to \mathbb{R}$.*

This problem belongs to an ever-increasing list of problems known to be unsolvable from the (usual) axioms of set theory.

However, some of these problems *have* now been solved. But what does this actually mean? Could the Continuum Hypothesis be similarly solved? These questions are the subject of this article, and the discussion will involve ingredients from many of the current areas of set theoretical investigation. Most notably, both *Large Cardinal Axioms* and *Determinacy Axioms* play central roles. For the problem of the Continuum Hypothesis, I shall focus on one specific approach which has developed over the last few years. This should not be misinterpreted as a claim that this is the only approach or even that it is the best approach. However, it does illustrate how the various, quite distinct, lines of investigation in modern set theory can collectively yield new, potentially fundamental, insights into questions as basic as that of the Continuum Hypothesis.

The generally accepted axioms for set theory—but I would call these the twentieth-century choice—are the Zermelo-Fraenkel Axioms together with the Axiom of Choice, ZFC. For a discussion of these axioms and related issues, see [Kanamori, 1994].

The *independence* of a proposition ϕ from the axioms of set theory is the arithmetic statement: ZFC does not prove ϕ, and ZFC does not prove $\neg\phi$.

Of course, if ZFC is *inconsistent*, then ZFC proves anything, so independence can be established only by assuming at the very least that ZFC is consistent. Sometimes, as we shall see, even stronger assumptions are necessary.

The first result concerning the Continuum Hypothesis, CH, was obtained by Gödel.

Theorem (Gödel). *Assume* ZFC *is consistent. Then so is* ZFC + CH. □

The modern era of set theory began with Cohen's discovery of the method of *forcing* and his application of this new method to show:

Theorem (Cohen). *Assume* ZFC *is consistent. Then so is* ZFC + "CH *is false".* □

I briefly discuss the methodology for establishing that a proposition is unsolvable, reviewing some basic notions from mathematical logic. It is customary to work within set theory, though ultimately the theorems, fundamentally arithmetic statements, can be proved in number theory.

$\mathcal{L}(\hat{=}, \hat{\in})$ denotes the formal language for set theory; this is a countable collection of *formulas.* The formulas of $\mathcal{L}(\hat{=}, \hat{\in})$ with no unquantified occurrences of variables are sentences. Both $\hat{=}$ and $\hat{\in}$ are simply *symbols* of this formal language with no other a priori significance.

From elementary logic one has the notion of a *structure* for this language. This is a pair $\mathcal{M} = \langle M, E\rangle$, where M is a nonempty set and $E \subseteq M \times M$ is a binary relation on the set M. If ϕ is a sentence in the language $\mathcal{L}(\hat{=}, \hat{\in})$, then the structure $\mathcal{M}$ is a *model* of ϕ, written "$\mathcal{M} \models \phi$" if

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the sentence is true when interpreted as an assertion within the structure $\langle M, E\rangle$, where the symbol $\hat{\in}$ is interpreted by the binary relation E and $\hat{=}$ is interpreted by equality on M. Of course, one could consider structures of the form $\langle M, E, \sim\rangle$, where $\sim$ is an equivalence relation on M intended as the interpretation of $\hat{=}$, but then one could pass to the quotient structure $\langle M/\sim, E/\sim\rangle$. So nothing is really gained by this attempt at generality.

A *theory* is a set of sentences, and for a given theory T, I write "$\langle M, E\rangle \models T$" to indicate that $\langle M, E\rangle \models \phi$ for each sentence $\phi \in T$.

ZFC denotes a specific (infinite) theory. A model of ZFC is simply a structure $\langle M, E\rangle$ such that

$$\langle M, E\rangle \models \text{ZFC}.$$

This can be defined quite naturally without recourse to formal logic. For example, one of the axioms of ZFC is the *Axiom of Extensionality*, which is formally expressible as

$$\forall x_1 \forall x_2 (x_1 \hat{=} x_2 \leftrightarrow \forall x_3 (x_3 \hat{\in} x_1 \leftrightarrow x_3 \hat{\in} x_2))$$

and which informally is just the assertion that two sets are equal if they have the same elements.

Thus

$$\langle M, E\rangle \models \text{"Axiom of Extensionality"}$$

if and only if for all $a \in M$ and for all $b \in M$, if

$$\{c \in M \mid (c, a) \in E\} = \{c \in M \mid (c, b) \in E\},$$

then $a = b$.

Therefore $\langle \mathbb{R}, <\rangle \models$ "Axiom of Extensionality"; but if we define $E \subset \mathbb{N} \times \mathbb{N}$ by

$$E = \{(n, m) \mid \text{For some prime } p, \; p^{n+1} | m \text{ and } p^{n+2} \nmid m\},$$

then $\langle \mathbb{N}, E\rangle \not\models$ "Axiom of Extensionality".

Continuing by examining the remaining axioms, one can develop naturally the notion of a model of ZFC.

One can fairly easily define a model which satisfies all of the axioms of ZFC except for the crucial Axiom of Infinity. For example, let E_0 denote the binary relation on $\mathbb{N}$ just specified, and define an equivalence relation $\sim_0$ by $i \sim_0 j$ if $\{k \mid (k, i) \in E_0\} = \{k \mid (k, j) \in E_0\}$. Define a binary relation E_1 by $(i, k) \in E_1$ if $(j, k) \in E_0$ for some $j \sim_0 i$, and define $\sim_1$ from E_1 as $\sim_0$ was defined from E_0. Continue by induction to define increasing sequences $\langle \sim_n : n \in \mathbb{N}\rangle$ and $\langle E_n : n \in \mathbb{N}\rangle$. Let

$$\sim_\infty = \cup\{\sim_n \mid n \in \mathbb{N}\},$$

and let $E_\infty = \cup\{E_n \mid n \in \mathbb{N}\}$. The quotient structure $\langle \mathbb{N}/\sim_\infty, E_\infty/\sim_\infty\rangle$ satisfies all of the axioms of ZFC except the Axiom of Infinity. The Axiom of Infinity fails to hold, since for each $i \in \mathbb{N}$ the set of equivalence classes $\{[j]_{\sim_\infty} \mid (j, i) \in E_\infty\}$ is finite, for it is equal to the set $\{[j]_{\sim_\infty} \mid (j, i) \in E_0\}$, which evidently has cardinality at most i.

Building New Models of ZFC

Is there a model of ZFC? A consequence of Gödel's Second Incompleteness Theorem is that one cannot hope to *prove* the existence of a model of ZFC working just from the axioms of ZFC. Nevertheless, one can still study the problem of building new (hopefully interesting) models of ZFC from given models of ZFC.

Gödel solved the *substructure* problem in 1938, showing that if $\langle M, E\rangle \models$ ZFC, then there exists $M^* \subseteq M$ such that

$$\langle M^*, E \cap (M^* \times M^*)\rangle \models \text{ZFC} + \text{CH}.$$

Over 25 years later Cohen, arguably the Galois of set theory, solved the *extension* problem. The weakest version of Cohen's extension theorem is actually formally equivalent to the statement of Cohen's theorem given at the beginning of this article. This weak version simply asserts that if $\langle M, E\rangle \models$ ZFC, then there exists a structure

$$\langle M^{**}, E^{**}\rangle \models \text{ZFC} + \text{"CH is false"},$$

such that $M \subseteq M^{**}$ and such that $E = E^{**} \cap (M \times M)$.

Cohen's method has turned out to be quite powerful: it and its generalizations are the basic tools for establishing independence. Moreover, essentially no other effective method for building extensions of models of ZFC is known.

An important point is that neither Cohen's method of extension nor Gödel's method of restriction affects the arithmetic statements true in the structures, so the intuition of a *true* model of number theory remains unchallenged.

It seems that most mathematicians do believe that arithmetic statements are either true or false. No generalization of Cohen's method has yet been discovered to challenge this view. But this is not to say that such a generalization will never be found.

The empirical completeness of arithmetic coupled with an obvious failure of completeness for set theory has led some to speculate that the phenomenon of independence is fundamental, in particular that the continuum problem is *inherently vague* with no solution. It is in this view a question that is fundamentally devoid of meaning, analogous to asking, "What is the color of π?"

Wherein lies the truth? I shall begin by describing some classical questions of Second Order Number Theory—this is the theory of the integers together with all sets of integers—which are also not solvable from ZFC. Here I maintain there is a solution: there *are* axioms for Second Order Number Theory which provide a theory as canonical as that of number theory. These relatively new axioms provide insights to Second Order Number Theory which transcend those provided by even ZFC.

Can these axioms be extended to more complicated sets in order to solve the continuum problem? This question will be the focus of the second part of this article.

Some Preliminaries

For purposes of this article it is convenient to work within set theory. This can initially be conceptually confusing, for we shall work within set theory attempting to analyze set theory.

So let us assume that the universe of sets exists and that the axioms represent true assertions about this universe. We shall initially assume just the axioms of ZFC. Eventually we shall augment these axioms by some modest large cardinal axioms. The discussion to take place simply refers to objects in this universe.

Definition. A set X is *transitive* if each element of X is also a subset of X. The *transitive closure* of a set X is the set $\cap\{Y \mid Y \text{ is transitive and } X \subseteq Y\}$. □

Suppose that $\langle M, E\rangle$ is a model of ZFC. Then the model $\langle M, E\rangle$ is *transitive* if M is a transitive set and

$$E = \{(a, b) \mid a \in M, b \in M, \text{ and } a \in b\},$$

so that $\hat{\in}$ is interpreted by actual set membership. Transitive models of ZFC are particularly nice, but they are even harder to come by than arbitrary models. The existence of a model of ZFC does not imply the existence of a transitive model of ZFC.

The theorems of Cohen and Gödel on perturbing models of ZFC are best understood when the initial structure $\langle M, E\rangle$ is transitive and M is countable. In the case that $\langle M, E\rangle$ is transitive, the structure $\langle M^*, E^*\rangle$ produced by Gödel's construction is again transitive. If $\langle M, E\rangle$ is transitive and M is countable, then the structures $\langle M^{**}, E^{**}\rangle$ produced by Cohen's method can, without loss of generality, be assumed to also be transitive.

The ordinals are those sets X which are transitive and totally ordered by the membership relation. Thus a transitive set X is an ordinal if and only if for all $a \in X$ and for all $b \in X$, if $a \neq b$, then either $a \in b$ or $b \in a$. A consequence of the axioms is that if $(L, <)$ is a totally ordered set which is *well ordered* (every (nonempty) subset of L has a $<$-least element), then there is an ordinal X such that the total orders $(L, <)$ and $(X, \in)$ are isomorphic. Collectively the ordinals are well ordered by the membership relation, and this ordering is exactly the ordering arising from the comparison of the order types of well-orders.

The first three ordinals are $\emptyset, \{\emptyset\}, \{\emptyset, \{\emptyset\}\}$. The finite ordinals are the nonnegative integers; ω denotes the least infinite ordinal, and ω_1 denotes the least uncountable ordinal. Finally, an ordinal κ is a *cardinal* if there is no bijection of κ with α for any ordinal $\alpha < \kappa$. The finite ordinals are cardinals, as are ω and ω_1. The assertion that a set X has cardinality $\aleph_1$ is the assertion that there exists a bijection of X with ω_1. Similarly, X has cardinality $2^{\aleph_0}$, or c, if there is a bijection of X with $\mathcal{P}(\mathbb{N})$, *powerset* of $\mathbb{N}$, which is the set of all subsets of $\mathbb{N}$.

The ordinals measure height in the universe of sets. Suppose that M is a transitive set and that $\langle M, \in\rangle \models \text{ZFC}$. Then it follows that the set

$$\{a \in M \mid \langle M, \in\rangle \models \text{“}a \text{ is an ordinal”}\}$$

is precisely the set of all ordinals, $\alpha \in M$. Moreover, this is an initial segment of the ordinals. Thus the height of M is precisely the ordinal $M \cap \text{Ord}$, where Ord denotes the class of all ordinals.

Definition. Suppose κ is an infinite cardinal. $H(\kappa)$ denotes the set of all sets X whose transitive closure has cardinality less than κ. □

Every set belongs to $H(\kappa)$ for sufficiently large cardinals κ. This in the context of the other axioms is equivalent to the Axiom of Choice.

The answer to the continuum problem lies in understanding $H(\omega_2)$, where ω_2 is the smallest cardinal greater than ω_1. This suggests an incremental approach. One attempts to understand in turn the structures $H(\omega)$, $H(\omega_1)$, and then $H(\omega_2)$. A little more precisely, one seeks to find the relevant axioms for these structures. Since the Continuum Hypothesis concerns the structure of $H(\omega_2)$, any reasonably complete collection of axioms for $H(\omega_2)$ will resolve the Continuum Hypothesis.

The first of these structures, $H(\omega)$, is a familiar one in disguise: $\langle \mathbb{N}, +, \cdot\rangle$. In fact, it can be shown that the structures $\langle H(\omega), \in\rangle$ and $\langle \mathbb{N}/\sim_\infty, E_\infty/\sim_\infty\rangle$ are isomorphic, where the latter is defined in the discussion immediately preceding the discussion of building new models of ZFC. Thus number theory is simply set theory in the presence of the negation of the Axiom of Infinity.

The next structure, $H(\omega_1)$, is also a familiar one. It is essentially just the structure $\langle \mathcal{P}(\mathbb{N}), \mathbb{N}, +, \cdot, \in\rangle$, which is the standard structure for Second Order Number Theory.

Of course, neither $\langle \mathbb{N}, +, \cdot\rangle$ nor $\langle \mathcal{P}(\mathbb{N}), \mathbb{N}, +, \cdot, \in\rangle$ is a structure for the language $\mathcal{L}(\hat{=}, \hat{\in})$, but each is naturally a structure for a specific formal language which is easily defined.

There are natural questions about $H(\omega_1)$ which are not solvable from ZFC. However, there are axioms for $H(\omega_1)$ which resolve these questions, providing a theory as canonical as that of number theory, and which are clearly *true*. But the truth of these axioms became evident only *after* a great deal of work. For me, a remarkable aspect of this is that it demonstrates that the discovery of mathematical truth is not a purely formal endeavor.

The second part of this article will focus on the attempt to find a generalization of these axioms for $H(\omega_2)$. Here is where the answer to the continuum problem lies, for the Continuum Hypothesis is expressible as a proposition about $H(\omega_2)$. The surprising answer is that there *are* generalizations but that any generalization which yields a theory which is *strongly* canonical in a certain specific sense must imply that CH is false.

In the course of this discussion I will have to defend the claim that $\langle H(\omega_2), \in\rangle$, rather than $\langle \mathcal{P}(\mathbb{R}), \mathbb{R}, +, \cdot, \in\rangle$, is the correct immediate generalization of the structure $\langle H(\omega_1), \in\rangle$ (or, equivalently, of $\langle \mathcal{P}(\mathbb{N}), \mathbb{N}, +, \cdot, \in\rangle$). The structure $\langle \mathcal{P}(\mathbb{R}), \mathbb{R}, +, \cdot, \in\rangle$, which is naturally given by the powerset of $\mathbb{R}$, has more traditionally been viewed as the next stop on the journey into the transfinite. The method used to analyze the possibilities for strongly canonical theories for $\langle H(\omega_2), \in\rangle$ actually shows that there can be no strongly canonical theory for $\langle \mathcal{P}(\mathbb{R}), \mathbb{R}, +, \cdot, \in\rangle$. If CH holds, then these two structures, $\langle H(\omega_2), \in\rangle$ and $\langle \mathcal{P}(\mathbb{R}), \mathbb{R}, +, \cdot, \in\rangle$, are in essence the same (each can be interpreted in the other), just as are the structures $\langle H(\omega_1), \in\rangle$ and $\langle \mathcal{P}(\mathbb{N}), \mathbb{N}, +, \cdot, \in\rangle$. If CH fails, then these two structures can be very different, with the former structure possibly being fundamentally *simpler* than the latter structure.

The First Step, $H(\omega_1)$

Consider the following basic operations for subsets of $\mathbb{R}^n$; these generate the *projective sets* from the closed sets.

(Projection) Suppose $X \subseteq \mathbb{R}^{n+1}$. The *projection* of X to $\mathbb{R}^n$ is the image of X under the projection map,

$$\pi : \mathbb{R}^{n+1} \to \mathbb{R}^n,$$

defined by $\pi(a_1, \ldots, a_n, a_{n+1}) = (a_1, \ldots, a_n)$.

(Complements) Suppose $X \subseteq \mathbb{R}^n$. The *complement* of X is the set

$$X^* = \{(a_1, \ldots, a_n) \mid (a_1, \ldots, a_n) \notin X\}.$$

Definition (Luzin). A set $X \subseteq \mathbb{R}^n$ is a *projective set* if for some integer k it can be generated from a closed subset of $\mathbb{R}^{n+k}$ in finitely many steps, applying the basic operations of taking projections and complements. □

I caution that because we are working in the Euclidean spaces, it generally requires three applications of our basic operations to reach anything interesting. The projection of a closed subset of $\mathbb{R}^{n+2}$ yields a subset of $\mathbb{R}^{n+1}$ which is easily seen to be expressible as a countable union of closed sets. Complementing and projecting again take one beyond the Borel sets and into the *analytic sets*. More formally, a set $X \subseteq \mathbb{R}^n$ is an analytic set if there exists a closed set $C \subseteq \mathbb{R}^{n+2}$ such that X is the projection of $\mathbb{R}^{n+1} \setminus Y$, where Y is the projection of C.

Why consider the projective sets? The answer is simply that the structure of $H(\omega_1)$ can be reinterpreted as the structure of the projective sets. More formally, the projective sets correspond to sets $A \subseteq H(\omega_1)$ for which there is a formula $\phi(x_1, x_2)$ of $\mathcal{L}(\hat{=}, \hat{\in})$ and an element $a \in H(\omega_1)$ such that

$$A = \{b \in H(\omega_1) \mid \langle H(\omega_1), \in\rangle \models \phi[a, b]\}.$$

Such sets A are *definable*, from parameters, in the structure $\langle H(\omega_1), \in\rangle$. This is a common method of logic: study a structure by studying the sets and relations which can be defined in the structure.

The Axiom of Choice implies the existence of many bizarre sets. A well-known example is the Banach-Tarski Paradox: there exists a finite partition of the unit ball of $\mathbb{R}^3$ into pieces from which two copies of the unit ball can be manufactured using only rigid motions. Such a partition is a *paradoxical partition*.

To guide our discussion, consider the following question.

Question. *Can there be a paradoxical partition of the unit ball of $\mathbb{R}^3$ into pieces, each of which is a projective set?*

Every analytic subset of $\mathbb{R}^n$ is Lebesgue measurable; this was first proved by Luzin in 1917. As a corollary there can be no paradoxical partition of the unit ball of $\mathbb{R}^3$ into pieces, each of which is in the σ-algebra generated by analytic sets. This is because any paradoxical partition *must* include pieces which are not Lebesgue measurable.

Of course, our pilot question on projective paradoxical partitions really suggests the more fundamental question:

Question. *Are the projective sets Lebesgue measurable?*

By the 1920s the difficulty of this question was apparent:

> [Luzin, 1925] one does not know *and one will never know* [of the projective sets whether or not they are each Lebesgue measurable.]

Curiously, Gödel's basic method of showing the (relative) consistency of CH with ZFC yielded a surprising bonus to which Gödel himself attached a significance comparable to that of his results on CH.

Theorem (Gödel). *Assume* ZFC *is consistent. Then so is* ZFC + "There is a nonmeasurable projective set". □

In fact, an immediate corollary of the proof of this theorem is the (relative) consistency with the axioms of set theory of the statement:

> There exists a paradoxical partition of the unit ball of $\mathbb{R}^3$ into pieces, each of which is the projection of the complement of an analytic set.

So Luzin's theorem on the Lebesgue measurability of the analytic sets was in fact the strongest theorem one could hope to prove working *just* from the axioms ZFC.

The consistency with ZFC that every projective set is Lebesgue measurable, while *true*, cannot be proved assuming just the consistency of ZFC. Nevertheless, an immediate corollary of Solovay's results on the measure problem for the projective sets is that if ZFC is consistent, then so is ZFC, together with the statement

> There is no paradoxical partition of the unit ball of $\mathbb{R}^3$ into pieces, each of which is a projective set.

Thus already at $H(\omega_1)$ there are natural structural questions which are formally unsolvable. The resolution of these questions, if indeed they can be resolved, requires the discovery of new axioms.

Both Gödel's method of restriction and Cohen's method of extension can alter $H(\omega_1)$ in the sense of the models, even in the case that the initial and final models are transitive. Informally, restricting generally deletes sets of integers, and new sets of integers can appear in a Cohen extension. Thus it is not at all obvious that these questions about the projective sets are any more tractable than the Continuum Hypothesis.

> [Gödel, 1947] There might exist axioms so abundant in their verifiable consequences, shedding so much light upon a whole discipline, and furnishing such powerful methods for solving given problems (and even solving them, as far as possible, in a constructivistic way) that quite irrespective of their intrinsic necessity they would have to be assumed at least in the same sense as any established physical theory.

I now discuss one candidate for such an axiom.

Determinacy

Fix $A \subseteq [0,1]$. I define the game G_A, which is an infinite game with two players.

Player I and Player II alternate choosing

$$\epsilon_i \in \{0,1\},$$

so that Player I chooses ϵ_i for i odd, and Player II chooses ϵ_i for i even. Player I begins by choosing ϵ_1; Player II then picks ϵ_2 and so forth.

Player I wins if

$$\sum_{i=1}^{\infty} \epsilon_i 2^{-i} \in A;$$

otherwise Player II wins.

Let SEQ be the set of all finite binary sequences. A *strategy* τ is a function

$$\tau : \mathrm{SEQ} \to \{0,1\}.$$

A run $\langle \epsilon_i : i \in \mathbb{N} \rangle$ of the game is generated according to τ by Player I if $\epsilon_1 = \tau(\emptyset)$ and for all $k \in \mathbb{N}$,

$$\epsilon_{2k+1} = \tau(\epsilon_1, \cdots, \epsilon_{2k}).$$

Similarly the run is generated according to τ by Player II if for all $k \in \mathbb{N}$, $\epsilon_{2k} = \tau(\epsilon_1, \cdots, \epsilon_{2k-1})$.

A strategy τ is a *winning strategy* for Player I if every run of the game generated according to τ by Player I is winning for Player I. Similarly, τ is a *winning strategy* for Player II if every run of the game generated according to τ by Player II is winning for Player II.

Definition. Suppose that $A \subseteq [0,1]$. The game G_A is *determined*—briefly, A is determined—if there is a winning strategy for one of the players. □

The Axiom of Choice yields a set A such that G_A is *not* determined. This is a simple diagonalization argument. There are only $2^{\aleph_0}$ many possible strategies, and for each strategy τ the assertion that τ is a winning strategy for one of the players in the game G_A effectively makes $2^{\aleph_0}$ many predictions about membership in A.

However, the undetermined set given by the Axiom of Choice is not in general a projective set. This (essentially, Mycielski-Steinhaus, 1962) suggests the following axiom:

> ***Projective Determinacy:*** Suppose that A is a projective subset of $[0,1]$. Then the game G_A is determined.

It has to be acknowledged at this point in our discussion that the axiom Projective Determinacy is not only *not* obviously true, it is not even obviously consistent. It is, however, a fruitful axiom, but (a logician's joke) so is the axiom $0 = 1$.

In this article, the first of a two-part series, my main objective is to present some of the compelling evidence that the axiom Projective Determinacy is the "right axiom" for the projective sets. The evidence I present is really a small fraction of what is now available. The subject of the projective sets has expanded in ways not foreseen or even imagined by its founders.

In 1964 Mycielski and Swierczkowski proved that if the axiom Projective Determinacy holds, then every projective set is Lebesgue measurable. Consequently, this axiom implies that there is no paradoxical partition of the unit ball of $\mathbb{R}^3$ into projective pieces.

The axiom also implies that every uncountable projective set has cardinality $2^{\aleph_0}$. In fact much more is true. Davis proved, again shortly after the axiom was introduced, that the axiom implies that every uncountable projective set contains an uncountable closed subset.

This establishes that there is no *formal* counterexample to CH to be found among the projective sets (assuming Projective Determinacy).

Surprisingly, the actual relationship between CH and the projective sets is quite subtle, *even* assuming Projective Determinacy. This will be the starting point for the second part of this article.

One can also naturally analyze versions of the Axiom of Choice for the projective sets.

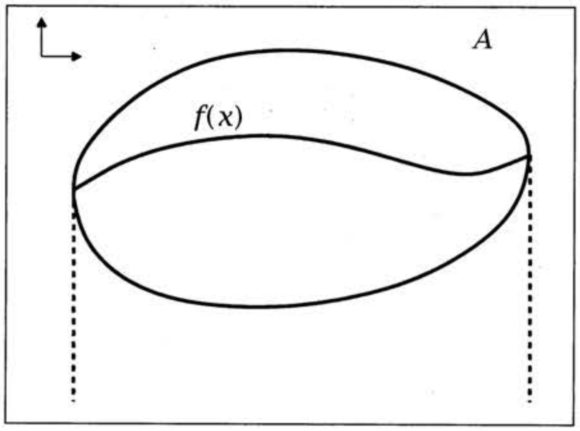
Suppose that $A \subseteq \mathbb{R}^2$. For each $x \in \mathbb{R}$ let

$$A_x = \{y \in \mathbb{R} \mid (x, y) \in A\}$$

be the section of A at x.

Let B be the projection of A, $B = \{x \mid A_x \neq \emptyset\}$.

A function $f : B \to \mathbb{R}$ *uniformizes* the set A if for each $x \in B$, $f(x) \in A_x$; see the figure below. The



function f is projective if its graph is a projective subset of $\mathbb{R}^2$.

In 1930 Luzin asked if every projective subset of the plane can be uniformized by a projective function. Nearly half a century later Moschovakis proved that the answer is affirmative if Projective Determinacy holds.

Thus, assuming Projective Determinacy, one has a complete analysis of the Axiom of Choice at the projective level, which can be summarized as follows. For this summary it is convenient to generalize the notion of a projective subset of $\mathbb{R}^n$ to the notion of a general projective set. So let's say that a set A is a *general projective set* if there exists a surjection $\pi : \mathbb{R} \to M$, where M is the transitive closure of $\{A\}$, such that

$$\{(x, y) \mid \pi(x) \in \pi(y)\}$$

is a projective subset of $\mathbb{R}^2$. The two notions coincide for subsets of $\mathbb{R}^n$; a set $A \subseteq \mathbb{R}^n$ is a general projective set if and only if it is a projective set.

Projective sets are by definition subsets of $\mathbb{R}^n$; general projective sets can be ordinals, functions, etc. Here is the promised summary.

1. The *Axiom of Choice* fails projectively in that there is no projective well-ordering of the reals.
2. The *Axiom of Choice* holds projectively in that if $F : \mathbb{R} \to V$ is a general projective set, then there is a choice function for F which is also a general projective set.

Projective Determinacy and Large Cardinals

One might attempt to analyze Projective Determinacy incrementally.

In 1953 Gale-Stewart proved that every open subset of $[0, 1]$ is determined, and they boldly asked whether every Borel set is determined. Two decades later, in a technical tour de force, Martin proved the answer is affirmative. A remarkable aspect of Martin's proof is that Friedman [Friedman, 1971] had previously shown that the determinacy of all Borel sets could *not* be proved in Zermelo set theory with the Axiom of Choice. This is the axiom system ZC, i.e., ZFC without the Axiom(s) of Replacement. Most mathematicians, realizing it or not, work in this restricted axiom system.

Roughly, Martin's method was to associate to a Borel set A, by induction on the Borel rank of A, an open set $A^* \subset Z^{\mathbb{N}}$ where Z is discrete. A^* is constructed so that from the determinacy of the game associated to A^* (here the players play elements of Z), one infers the determinacy of A. The Gale-Stewart Theorem applies to show that A^* is determined, and so one obtains the determinacy of A. As A ranges over the possible Borel sets, the associated sets Z range over

$$\{\mathcal{P}^{\alpha}(\mathbb{R}) \mid \alpha < \omega_1\},$$

increasing in cardinality with the Borel rank of A. Here $\mathcal{P}^{\alpha}(\mathbb{R})$ denotes the α-th iterated powerset of $\mathbb{R}$, which is defined by induction as follows, where for each set X, $\mathcal{P}(X) = \{Y \mid Y \subseteq X\}$. $\mathcal{P}(X)$ is the *powerset* of X. $\mathcal{P}^0(\mathbb{R}) = \mathbb{R}$, $\mathcal{P}^{\alpha+1}(\mathbb{R}) = \mathcal{P}(\mathcal{P}^{\alpha}(\mathbb{R}))$, and

$$\mathcal{P}^{\alpha}(\mathbb{R}) = \cup\{\mathcal{P}^{\beta}(\mathbb{R}) \mid \beta < \alpha\}$$

if $\alpha > 0$ and α is a limit ordinal.

In Zermelo set theory one cannot prove that $\mathcal{P}^{\omega}(\mathbb{R})$ even exists, and so as Friedman's theorem predicted, Martin's proof cannot be implemented assuming just the axioms ZC.

The determinacy of all analytic sets $A \subseteq [0, 1]$ cannot be proved in ZFC. This is because the theory ZFC is simply not strong enough. Thus Martin's theorem on the determinacy of all Borel sets is the strongest theorem one can hope to prove without appealing to new axioms. Here enter large cardinal axioms, which informally are axioms which assert the existence of "large" cardinals. Perhaps best known among these is the axiom which asserts the existence of a measurable cardinal. An uncountable cardinal κ is a *measurable cardinal* if there exists a nonprincipal ultrafilter U on the subsets of κ which is κ-complete; i.e., if

$X \subset U$ and X has cardinality less than κ, then $\cap\{A \subset \kappa \mid A \in X\} \in U$.

Around 1970, almost five years before he proved all Borel sets are determined, Martin proved that if there is a measurable cardinal, then all analytic sets are determined (every Borel set is an analytic set, and so this also established that all Borel sets are determined, but *not* in the theory ZFC).

But Solovay showed that one cannot hope to prove Projective Determinacy from just the existence of a measurable cardinal. The reason, as before, is a lack of strength: ZFC + "Projective Determinacy" implies the consistency of ZFC + "There is a measurable cardinal". Therefore, by Gödel's Second Incompleteness Theorem one cannot infer Projective Determinacy from the existence of a measurable cardinal. Still stronger axioms are necessary, and the special case of proving the determinacy of all $\underset{\sim}{\Sigma}^1_2$ subsets of $[0, 1]$ became a central problem (the $\underset{\sim}{\Sigma}^1_2$ sets are those projective sets which can be represented as the projection of the complement of an analytic set). Some speculated that *no* large cardinal axiom *known* was sufficient in strength to imply this fragment of Projective Determinacy. In 1978 Martin succeeded in proving the determinacy of all $\underset{\sim}{\Sigma}^1_2$ sets by using essentially the strongest large cardinal hypothesis known at the time. Finally, in 1983 I proved the determinacy of all projective sets using large cardinal axioms in a natural hierarchy which begins with the large cardinal axiom used by Martin to establish the determinacy of all $\underset{\sim}{\Sigma}^1_2$ sets.

The natural character of these determinacy proofs suggested that essentially optimal large cardinal assumptions were being used. But this picture, though quite appealing (at least to Martin and me), was completely wrong. The large cardinal axioms used to prove Projective Determinacy, including the axiom used by Martin to prove the determinacy of all $\underset{\sim}{\Sigma}^1_2$ sets, were *far stronger* than necessary. The first indications that the picture was incorrect came from a surprising direction: the evidence was discovered by Foreman-Magidor-Shelah in their seminal work on Martin's Maximum, a maximal forcing axiom which I shall discuss below. This ultimately led to the following theorem from 1984.

Theorem (Shelah-Woodin). *Assume there exist infinitely many Woodin cardinals. Then every projective set is Lebesgue measurable.* □

I shall not give the definition of a Woodin cardinal, but instead simply note that this large cardinal axiom is much weaker than those used in the determinacy proofs just discussed.

The *Inner Model Program* attempts to generalize Gödel's substructure construction to models satisfying various large cardinal axioms (and the stronger the axiom, the harder the problem). More precisely, fixing a large cardinal axiom Ψ, for each model $\langle M, E\rangle$ of ZFC + Ψ one seeks a substructure $\langle M^*, E \cap (M^* \times M^*)\rangle$ which is also a model of ZFC + Ψ and which satisfies various sentences true in Gödel's substructure. For example, if Ψ is the large cardinal axiom "There is a Woodin cardinal", simply requiring that in the substructure produced, the sentence "There is a projective set which is not Lebesgue measurable" holds yields a difficult problem. For stronger large cardinal axioms there are generalizations of this requirement which yield similarly nontrivial problems.

For the large cardinal axiom "There is a measurable cardinal", the correct generalization of Gödel's construction was discovered by Solovay and then further analyzed in work of Kunen and Silver. With these results the Inner Model Program began.

The fact that from infinitely many Woodin cardinals one can prove the projective sets are Lebesgue measurable is strong evidence that from the same assumption one should be able to prove Projective Determinacy. In 1985, using techniques developed in the Inner Model Program, Martin-Steel succeeded in doing this. Surprisingly, the combinatorial properties of Woodin cardinals responsible for their discovery—for example, those aspects yielding the measurability of all projective sets—play no role in this determinacy proof.

Theorem (Martin-Steel). *Assume there exist infinitely many Woodin cardinals. Then every projective set is determined.* □

How are large cardinals used in determinacy proofs? The basic strategy is the same as for Martin's proof of the determinacy of all Borel sets, though Martin's proof of the determinacy of all analytic sets from the existence of a measurable cardinal is a more accurate prototype. Given a set $A \subseteq [0, 1]$, one again associates to the set A an open set $A^* \subset Z^{\mathbb{N}}$, where Z is a discrete set carefully constructed such that from the determinacy of the game naturally associated to A^*, one obtains the determinacy of the initial set A. The Gale-Stewart Theorem shows that A^* is determined, and so as before one obtains the determinacy of A. For a typical projective set A the associated set Z is *very* large, of cardinality on the order of the large cardinals one is assuming to exist.

The connection between Projective Determinacy and large cardinal axioms is fundamental. This claim is supported by the following theorem from 1987, which shows that this time the picture is correct.

Theorem (Woodin). *The following are equivalent:*

1. Projective Determinacy.
2. *For each $k \in \mathbb{N}$ there exists a countable transitive set M such that*

$\langle M, \in\rangle \models$ ZFC + "*There exist k Woodin cardinals*"

and such that M is countably iterable. □

The notion that M is *countably iterable* is a technical one from the Inner Model Program.

The *Core Model Program*, which is more ambitious than the Inner Model Program, originates in seminal work of Dodd and Jensen. It is more ambitious simply because it attempts to build the substructures of the Inner Model Program *without* necessarily assuming that the (relevant) large cardinal axioms even hold in the initial structure.

The extension of the Core Model Program to the realm of Woodin cardinals is due primarily to Steel [Steel, 1996], and with this development it has become clear that Projective Determinacy is actually implied by a vast number of seemingly unrelated combinatorial propositions. Projective Determinacy is ubiquitous in set theory.

In fact, this is an instance of a more pervasive phenomenon where propositions are calibrated, on the basis of consistency, by large cardinal axioms. There are now numerous examples of this phenomenon. Many early results of this kind were proved using Jensen's *Covering Lemma*. In fact, using the *Covering Lemma*, one can prove the determinacy of all analytic sets from a perhaps bewildering array of propositions. I refer the reader to [Kanamori, 1994] for further details.

A recent example where methods from the Core Model Program are used to establish Projective Determinacy involves axioms which attempt to solve the continuum problem by explicitly making the Continuum Hypothesis false.

Forcing Axioms

Forcing Axioms are in essence axioms asserting generalizations of the *Baire Category Theorem*. The connection lies in the technical aspects of Cohen's method of constructing extensions of models of ZFC.

Suppose that $\langle M, E\rangle \models$ ZFC. The Cohen extensions associated to the structure $\langle M, E\rangle$ correspond to complete Boolean algebras in the sense of $\langle M, E\rangle$, i.e., to elements $b \in M$ such that

$\langle M, E\rangle \models$ "b is a complete Boolean algebra".

If b is trivial, for example, if

$\langle M, E\rangle \models$ "b is a finite Boolean algebra",

then the associated extension is simply $\langle M, E\rangle$. But if

$\langle M, E\rangle \models$ "b is the measure algebra[1] of the product space $\prod_{\omega_2}[0,1]$",

then the Continuum Hypothesis necessarily *fails* in the associated extension. Another quite interesting feature of this extension is that in this extension there exists a countably additive measure on $\mathbb{R}^3$, *extending* Lebesgue measure, which measures all projective sets and which is invariant under rigid motions. So in this extension the following statement holds:

> There is no paradoxical partition of the unit ball of $\mathbb{R}^3$ into projective pieces.

This extension, first defined and analyzed by Solovay, is sometimes referred to as a *Solovay extension*.

If Ω is a compact Hausdorff space, then the *regular open algebra* of Ω is the complete Boolean algebra given by the lattice of regular open subsets of Ω (open sets $O \subseteq \Omega$ which are the interior of their closure) ordered by set inclusion. Forcing axioms are naturally motivated by the following feature of Cohen's original extension; this extension is defined from $b \in M$ such that

$\langle M, E\rangle \models$ "b is the regular open algebra of the product space $\prod_{\omega_2}[0,1]$".

The interesting feature of this extension is that in it the following generalization of the Baire Category Theorem holds:

> The unit interval $[0,1]$ is not the $\aleph_1$ union of meager sets.

A compact Hausdorff space Ω is *ccc* if every collection of pairwise disjoint open subsets of Ω is countable.

> ***Martin's Axiom*** (ω_1): Suppose that Ω is a compact Hausdorff space which is ccc. Then Ω is not the union of $\aleph_1$ many meager subsets of Ω.

A simple motivation for such an axiom is that if CH is to be false, then sets of cardinality $\aleph_1$ should behave, as much as possible, like countable sets.

One can attempt to strengthen the axiom, allowing a larger class of compact Haudorff spaces. But one *cannot* allow arbitrary compact Hausdorff spaces. The maximum possible class was identified by Foreman–Magidor–Shelah. The definition involves the notion of a closed unbounded subset of ω_1: a cofinal set $C \subset \omega_1$ is *closed and unbounded* if it is closed in the order topology of ω_1.

Suppose that $\mathbb{B}$ is a complete Boolean algebra. Every set $S \subseteq \mathbb{B}$ has a greatest lower bound, denoted by $\bigwedge S$, and a least upper bound which is denoted by $\bigvee S$.

Definition (Foreman–Magidor–Shelah). Suppose that $\mathbb{B}$ is a complete Boolean algebra. The Boolean algebra $\mathbb{B}$ is *stationary set preserving* if the following holds. Suppose that b is a nonzero element of $\mathbb{B}$ and that $\langle b_\alpha : \alpha < \omega_1\rangle$ is a sequence of

[1] *The Boolean algebra of Borel subsets modulo null sets.*

elements of $\mathbb{B}$. Then there exist $0 < c \leq b$ such that either $c \wedge b_\alpha = 0$ for sufficiently large α or there exists a closed unbounded set $C \subset \omega_1$ such that for all $\gamma \in C$

$$c \wedge \left(\bigwedge_{\alpha<\gamma} \left(\bigvee_{\alpha<\eta<\gamma} b_\eta \right) \right) \neq 0. \qquad \square$$

The class of compact Hausdorff spaces whose regular open algebras are stationary set preserving is the largest class for which one can hope to generalize Martin's Axiom(ω_1).

Theorem (Foreman-Magidor-Shelah). *Suppose that Ω is a compact Hausdorff space and that for each open, nonempty set $O \subseteq \Omega$ the set O is not the union of $\aleph_1$ many meager subsets of Ω. Then the regular open algebra of Ω is stationary set preserving.* $\square$

This suggests the definition of Martin's Maximum. The main theorem of [Foreman-Magidor-Shelah, 1988] is that the consistency of this axiom with ZFC follows from the consistency, with ZFC, of (suitable) large cardinal axioms; in other words, this maximum can be realized.

> ***Martin's Maximum:*** Suppose that Ω is a compact Hausdorff space whose regular open algebra is stationary set preserving. Then Ω is not the union of $\aleph_1$ many meager subsets of Ω.

Forcing Axioms by design imply that the Continuum Hypothesis is false. In fact, Martin's Maximum (as opposed to the weaker Martin's Axiom(ω_1)) gives quite a bit more information about the cardinality of the continuum.

Theorem (Foreman-Magidor-Shelah). *Suppose that the axiom Martin's Maximum holds. Then* $2^{\aleph_0} = \aleph_2$. $\square$

Subsequent investigations have revealed that this theorem actually holds for almost any forcing axiom which is nontrivially stronger than Martin's Axiom(ω_1). So, curiously, insisting that sets of cardinality $\aleph_1$ resemble countable sets necessitates that $2^{\aleph_0} = \aleph_2$.

The large cardinal axioms used to establish the consistency of Martin's Maximum are far stronger than the large cardinal axioms used to prove Projective Determinacy. It is therefore natural to speculate that Martin's Maximum might *imply* Projective Determinacy, even though Martin's Maximum is *not* a large cardinal axiom in the accepted sense of what a large cardinal axiom is.

I noted that the work of Foreman-Magidor-Shelah on Martin's Maximum inspired the discovery of the correct large cardinal axioms for Projective Determinacy. The next theorem is therefore perhaps a fitting conclusion to this part of the story. I state a slightly stronger version involving a weakening of Martin's Maximum. The weakening is Martin's Maximum(c), which is the axiom that Martin's Maximum holds for all compact Hausdorff spaces Ω whose regular open algebra is stationary set preserving and for which there is a base for the topology of Ω with cardinality at most c. Thus Martin's Maximum(c) is an axiom concerned with only relatively "small" compact Hausdorff spaces.

Theorem (Woodin). *Suppose that the axiom Martin's Maximum(c) holds. Then Projective Determinacy holds.* $\square$

There is no known direct proof of this theorem. The method of the proof is to use machinery developed in the Core Model Program to show, assuming Martin's Maximum(c), that for each $n < \omega$ there exists a countable transitive set M such that

$$\langle M, \in \rangle \models \text{ZFC} + \text{ ``There exist } n \text{ Woodin cardinals''}$$

and such that M is (countably) iterable.

One obtains Projective Determinacy from the existence of these sets by, essentially, the theorem unifying Projective Determinacy with Large Cardinals. This methodology can and has been used to prove Projective Determinacy from a large number of combinatorial statements, many of which, like Martin's Maximum, have no obvious relationship to the projective sets. Hence the claim: Projective Determinacy is ubiquitous in set theory.

To summarize the current state of affairs for the theory of the projective sets:

- Projective Determinacy is the **correct** axiom for the projective sets; the ZFC axioms are *obviously* incomplete and, moreover, incomplete in a fundamental way.
- Assuming Projective Determinacy, there are no essential uses of the Axiom of Choice in the analysis of the structure $\langle H(\omega_1), \in \rangle$ (or, equivalently, in the analysis of $\langle \mathcal{P}(\mathbb{N}), \mathbb{N}, +, \cdot, \in \rangle$, the standard structure for Second Order Number Theory).
- The only known examples of unsolvable problems about the projective sets, in the context of Projective Determinacy, are analogous to the known examples of unsolvable problems in number theory: Gödel sentences and consistency statements.

In brief, one has the following analogy of axioms for structures:[2]

$$\frac{\text{Peano Axioms}}{\langle \mathbb{N}, +, \cdot \rangle} \sim \frac{\text{Projective Determinacy} + \text{ Peano Axioms}}{\langle \mathcal{P}(\mathbb{N}), \mathbb{N}, +, \cdot, \in \rangle}.$$

Can the understanding of the structure $\langle H(\omega_1), \in \rangle$, achieved through the discovery of the

[2] *Here the precise formulation of Projective Determinacy incorporates* Σ_0-Comprehension.

correct axioms for this structure, be extended to an understanding of the structure $\langle H(\omega_2), \in\rangle$? This question will be the main topic of the second, and final, part of this article.

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Curvature, Combinatorics, and the Fourier Transform

Alex Iosevich

This article is dedicated to the memory of Thomas Wolff

In their 1978 paper "Problems in harmonic analysis related to curvature" [SteinWainger78], E. M. Stein and S. Wainger studied a variety of operators defined over hypersurfaces and other lower-dimensional submanifolds of $\mathbb{R}^d$. The recurring theme is that the behavior of these operators is governed, to various degrees, by the Gaussian curvature of the underlying manifold—the determinant of the differential of the Gauss map taking a point on the manifold to the unit normal at that point. In recent years these ideas have undergone further development, not only in the context of harmonic analysis, but also in related problems in combinatorics and analytic number theory. This article is not intended to be an exhaustive survey of the most recent advances in these areas. Rather, the purpose of this article is to describe some of these connections by way of examples accessible to a wide range of mathematicians.

The Erdős Distance Problem

One of the most dramatic examples of the role of Gaussian curvature occurs in a discrete setting. When S is a set of N distinct points in $\mathbb{R}^d$, let $D(S)$ denote the set of distances between pairs of points of S: namely, $D(S) = \{|x - y| : x, y \in S\}$, where $|\cdot|$ is a distance function. The total number of distances between different elements of S is, of course, $\frac{N!}{2!(N-2)!}$. However, some of these distances may be equal. P. Erdős posed the question: What is the smallest number of distinct distances that can actually occur when the cardinality of S is large? Although this problem is open, the answer remarkably depends on whether the "distance" between x and y is the standard Euclidean distance

$$\sqrt{(x_1 - y_1)^2 + \cdots + (x_d - y_d)^2}$$

or the taxi-cab distance $|x_1 - y_1| + \cdots + |x_d - y_d|$. The reason is that the boundary of the unit ball in the Euclidean distance has nonvanishing curvature, while the curvature of the boundary of the unit ball in the taxi-cab distance vanishes at most points (the points where it is defined). To put this bluntly, squares have flat sides, and circles have curved boundaries. This simple-looking theme drives most of the concepts described in this article.

Let $i_d(N, 2)$ denote the minimum possible number of distinct Euclidean distances between points of a set of cardinality N in $\mathbb{R}^d$. Similarly, let $i_d(N, 1)$ denote the minimum possible number of distinct taxi-cab distances. We will first show that $i_d(N, p) \gtrsim N^{\frac{1}{d}}$ for both $p = 1$ and $p = 2$. Then we will show that the presence of curvature when $p = 2$ allows for a significant improvement in this estimate.[1]

Curvature-Independent Estimate

This was first proved by Erdős in 1946 [Erdős46]. Suppose we are working in the plane, so that $d = 2$. If N points are specified, then their convex hull is some polygon. Let P_1 denote an arbitrary vertex of that polygon, and let K denote the number of different distances occurring among the distances P_1P_i for $i = 2, \dots, N$. If M is the maximum number of times that the same distance occurs, then $KM \geq N - 1$. If r is a distance that occurs M times,

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[1]*Notation: Throughout this article $a \lesssim b$ means that there exists a uniform constant C such that $|a| \leq C|b|$. The symbol $a \gtrsim b$ is defined analogously, and $a \approx b$ means that both $a \lesssim b$ and $a \gtrsim b$.*

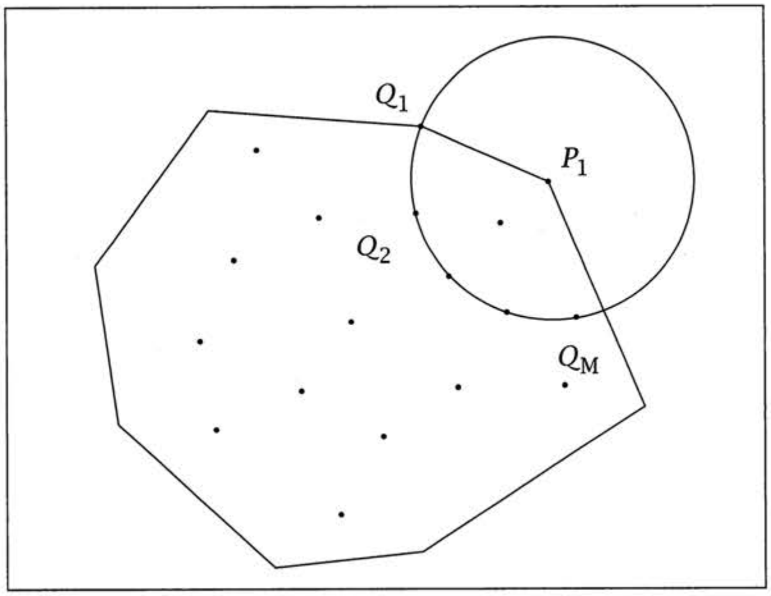

Figure 1.

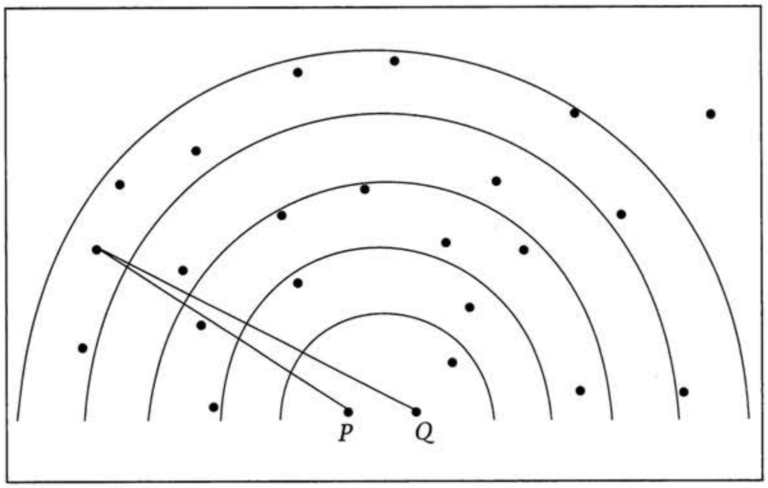

Figure 2.

then there are M of the points on the circle with center P_1 and radius r, all of which lie on the same semicircle, since P_1 is a vertex of a convex polygon containing the P_i. (See Figure 1.) We may label these points by $Q_1, \dots, Q_M$ in such a way that $Q_1Q_2 < Q_1Q_3 < \cdots < Q_1Q_M$. It follows that $i_2(N,p) \geq \max\{M-1, \frac{N-1}{M}\}$, which is minimal when $M(M-1) = N-1$. Thus $i_2(N,p) \gtrsim N^{\frac{1}{2}}$. A similar argument in higher dimensions proves that $i_d(N,p) \gtrsim N^{\frac{1}{d}}$. (When $p = 1$, namely, when we are working with the taxi-cab metric, this argument needs a slight modification because the string of inequalities $Q_1Q_2 < Q_1Q_3 < \cdots < Q_1Q_M$ need not hold. However, these inequalities do hold if the points $Q_1, \dots, Q_M$ lie on a single edge of the "circle" in the taxi-cab metric. We cannot be sure that they all lie on the same edge, but there must be an edge that contains at least a quarter of these points, and the rest of the argument goes through.)

What Makes Us Think That Curvature Will Help?

Consider a subset of the two-dimensional integer lattice $L_N = \{(k_1, k_2) \in \mathbb{Z}^2 : 0 \leq k_i \leq \sqrt{N}\}$. If we consider the $l^1(\mathbb{R}^2)$ (taxi-cab) distance defined above, it is not difficult to see that the number of distinct distances among the points of L_N is, approximately, a constant multiple of $\sqrt{N}$. It follows that $i_2(N,1) \lesssim N^{\frac{1}{2}}$, which in view of the previous paragraph means that $i_2(N,1) \approx N^{\frac{1}{2}}$.

On the other hand, when the distance is Euclidean ($p = 2$), a fact from elementary number theory (see, e.g., [Landau69]) says that the number of distances among the points of L_N is, approximately, $N/\sqrt{\log(N)}$. This example leads to a conjecture that $i_2(N,2) \gtrsim N/\sqrt{\log(N)}$, which is much better than the result for $i_2(N,1)$.

Curvature to the Rescue

The conjecture we just formulated is still open. However, we can use an argument of L. Moser to obtain a significant improvement of the curvature-independent estimate $i_d(N,2) \gtrsim N^{\frac{1}{d}}$ by exploiting the nonvanishing Gaussian curvature of the ball in the Euclidean metric.

For simplicity, suppose that the dimension $d = 2$, and let S be a planar set of cardinality N. Via dilation, we may assume that the minimal distance between distinct points of S is 1. Moreover, suppose that S is well distributed in the sense that every Euclidean ball of radius 10 whose center lies in the convex hull of S contains points of S. (This latter assumption does not hold in general, but it is valid in the applications we shall discuss later in this article.) For example, the lattice L_N defined above easily satisfies these conditions. We shall see[2] that $i_2(N,2) \gtrsim N^{\frac{3}{4}}$. Indeed, choose two points P and Q in S such that $|P - Q| = 1$. Draw enough concentric half-annuli of width 1 centered at the midpoint of P and Q to cover a positive fraction of the points in S. (See Figure 2.) Let us consider the "worst case" scenario where we need $\approx N^{\frac{1}{2}}$ such annuli. At the moment, by measuring distances from the points in these annuli to either P or Q, we already have $\approx N^{\frac{1}{2}}$ distances, which is exactly the result obtained above without any assumptions on the distance function. However, we are using the Euclidean distance function, so it is time to take advantage of it!

By the pigeon-hole principle a positive proportion of our annuli actually have $\approx N^{\frac{1}{2}}$ points, since the cardinality of S is N. Consider one of these annuli more closely. Suppose that by measuring distances to P and Q we find that the points of this annulus contribute exactly k distances d_1,

[2] *This result, and in fact a stronger estimate $i_2(N,2) \gtrsim N^{\frac{6}{7}}$ due to J. Solymosi and C. D. Tóth, still holds without the assumption that S is well distributed. An earlier estimate with the exponent $\frac{4}{5}$ is due to F. Chung, E. Szemerédi, and W. T. Trotter.*

$d_2, \ldots, d_k$. Let A_i ($i = 1, 2, \ldots, k$) denote the set of points in the annulus whose distance to P is d_i, and let $B_1, B_2, \ldots, B_k$ be defined similarly with respect to Q. By the pigeon-hole principle, perhaps after a relabeling of the A_i's and B_i's, at least one A_i contains $\gtrsim \frac{N^{\frac{1}{2}}}{k}$ elements of S. On the other hand,

$$A_i = \bigcup_{j=1}^{k} A_i \cap B_j, \tag{1.1}$$

and each of the intersections can support at most one point, since the intersection of two semicircles with different centers is at most one point. This is where the curvature is being used, since a similar assertion about two circles with respect to the taxi-cab distance would be false! It follows from (1.1) that

$$\frac{N^{\frac{1}{2}}}{k} \lesssim k, \tag{1.2}$$

which implies that $k \gtrsim N^{\frac{1}{4}}$. We conclude that $i_2(N,2) \gtrsim N^{\frac{3}{4}}$, as claimed. It is straightforward to check that when $p > 1$, the argument for the Euclidean distance works just as well for the $l^p(\mathbb{R}^d)$ distance defined in dimension d by

$$(|x_1 - y_1|^p + \cdots + |x_d - y_d|^p)^{\frac{1}{p}}.$$

Thus, $i_d(N,p) \gtrsim N^{\frac{1}{d}}$ when $p \geq 1$, and $i_d(N,p) \gtrsim N^{\frac{3}{2d}}$ when $1 < p < \infty$. In other words, even a little bit of curvature suffices to improve the estimate.

Applications to the Fuglede Conjecture

Which domains can be used to tile Euclidean space? For example, we can tile the plane either with squares or with hexagons. B. Fuglede conjectured that domains whose translates tile Euclidean space can be characterized through Fourier analysis. A domain D in $\mathbb{R}^d$ is called *spectral* if there exists a discrete subset A of $\mathbb{R}^d$ such that the set of exponential functions $\{e^{2\pi i x\cdot a}\}_{a\in A}$ forms an orthogonal basis for the space $L^2(D)$ of square-integrable functions on D.

In the celebrated example where D is the cube $[0,1]^d$, one can take the set A to be the integer lattice. If D is the regular hexagon, one can take A to be the "honeycomb" lattice. In both cases, D tiles $\mathbb{R}^2$ by translation (that is, one can cover $\mathbb{R}^2$ by translates of D without overlaps, except possibly at the boundary). On the other hand, Fuglede proved by a direct computation that the disc is not spectral. Since the disc does not tile $\mathbb{R}^2$ by translation, this led Fuglede to conjecture that D is spectral if and only if D tiles by translation. Fuglede proved this conjecture under an additional hypothesis that either a spectrum or a tiling set for D is a lattice, in which case the problem essentially reduces to the Poisson Summation Formula, which relates the sum of a function restricted to the integer lattice to the sum of the Fourier transform of this function restricted to the appropriately defined dual lattice.

The Fuglede conjecture is far from being proved in any dimension, though there is considerable recent progress.[3] N. Katz, S. Pedersen, and the author proved that the unit ball B_d is not spectral in any dimension $d \geq 2$. Let us see how curvature enters the proof. Suppose that B_d were spectral, and let A denote a putative spectrum. We want to estimate both the number of points of A in a cube of sidelength R and the number of distances between these points. Our method is to study the Fourier transform of the characteristic function χ_{B_d} of B_d (the function that is equal to 1 when $x \in B_d$ and 0 otherwise). Recall that the Fourier transform is defined by the formula

$$\widehat{f}(\xi) = \int e^{-2\pi i x\cdot\xi} f(x)\,dx. \tag{1.3}$$

From the assumption that the set of exponentials $\{e^{2\pi i x\cdot a}\}_{a\in A}$ is complete, it is not difficult to show that $\sum_{a\in A} |\widehat{\chi}_{B_d}(\xi - a)|^2 \equiv 1$. Next, we claim that the cardinality of the intersection of A with a cube of sidelength R is $\approx R^d$. To see this, consider a cube $Q_r(y)$ of sidelength r centered at any point y in this intersection. We have

$$1 \equiv \sum_{a\in A} |\widehat{\chi}_{B_d}(\xi - a)|^2 = \sum_{a\in Q_r(y)\cap A} |\widehat{\chi}_{B_d}(\xi - a)|^2 + \sum_{a\notin Q_r(y)} |\widehat{\chi}_{B_d}(\xi - a)|^2.$$

One can check that if A is a spectrum, then the second sum is smaller than $\frac{1}{2}$ when r exceeds some number r_0 depending only on the geometric properties of B_d. It follows that $Q_r(y) \cap A$ is not empty for $r > r_0$, and our claim is established if R is sufficiently large.

The explicit form of the Fourier transform $\widehat{\chi}_{B_d}(\xi)$ of the characteristic function of the unit ball is

$$\int_{B_d} e^{-2\pi i x\cdot\xi}\,dx. \tag{1.4}$$

The assumption of orthogonality implies that if a and a' are distinct points of A, then the integral in (1.4) equals 0 when $\xi = a - a'$. It follows that the distance between any two points of A is bounded below by some positive number. It is a classical result that the Fourier transform of a radial function (a function that depends only on the Euclidean distance of its argument from a point) is also radial. This tells us that the integral in (1.4) depends only on $|\xi|$. Moreover, the zeroes of this function are very close to the zeroes of $\cos\left(|\xi| - \frac{\pi d}{4}\right)$. See, for example, [SteinWeiss71] for this fact and related background. It follows that in the intersection of

[3] *A number of interesting breakthroughs on the Fuglede conjecture have recently been made by P. Jorgensen, M. Kolountzakis, I. Łaba, J. Lagarias, J. Reeds, T. Tao, Y. Wang, and others.*

A and the cube of radius R there are $\approx R^d$ points connected by only $\approx R$ distinct distances. We saw in the previous section that the curvature of the Euclidean distance function makes this impossible.

Distribution of Lattice Points in Convex Domains

Gauss observed in the middle of the nineteenth century that if D is a convex domain in $\mathbb{R}^d$, then the number $N(t)$ of lattice points inside the scaled domain tD equals $t^d|D|$, up to an error $R(t) \lesssim t^{d-1}$. This is because the error cannot exceed the number of lattice points that live a distance at most $\frac{\sqrt{d}}{2}$ away from the boundary. In general, this result cannot be improved. We will show that curvature leads to a better bound on the error term $R(t)$.

If we take D to be the square $[-1,1]^d$, then if t is an integer, the number of lattice points on the boundary of tD is $\approx t^{d-1}$. It follows that the estimate $R(t) \lesssim t^{d-1}$ cannot be improved for the square. Let us now try to take advantage of curvature. The estimate we just used in the case of the square does not work for the unit ball, for example, because, roughly speaking, the boundary of the ball is curved, which allows it to avoid collecting many lattice points. It is a classical result due to E. Landau that if the boundary of D has everywhere nonvanishing Gaussian curvature, then $R(t) \lesssim t^{d-2+\frac{2}{d+1}}$.

V. Jarník proved in dimension 2 that the power $d-2+\frac{2}{d+1}$ is "natural" in the sense that one can construct a convex domain of diameter $\approx t$ such that the curvature is bounded below by $\approx \frac{1}{t^2}$ and the boundary contains $\approx t^{\frac{2}{3}}$ lattice points. Jarník's construction was recently refined by E. Sawyer, A. Seeger, and the author. They constructed a *fixed* convex planar set D, whose boundary has everywhere nonvanishing Gaussian curvature, such that the boundary of tD contains $\approx t^{\frac{2}{3}}$ lattice points for a sequence of t's going to infinity. However, for planar domains with some smoothness, better estimates on $R(t)$ are possible. A recent result of M. Huxley says that if the boundary has everywhere nonvanishing curvature and is three times continuously differentiable, then $R(t) \lesssim t^{\frac{46}{73}}$. In higher dimensions, there has also been a series of improvements by E. Krätzel and W. G. Nowak and, most recently, by W. Müller. The case of the ball is completely solved in dimensions ≥ 4, partly because the number-theoretic problem of determining the number of ways of writing an integer as a sum of four or more squares is sufficiently well understood. See [Huxley96] and the references contained therein.

Let us briefly get technical to see how to exploit curvature to prove Landau's estimate for the remainder term $R(t)$. Suppose that the Gaussian curvature of the boundary of D is bounded below by 1. Let ρ be a smooth compactly supported function whose integral is 1, and let $\rho_\epsilon(x) = \epsilon^{-d}\rho(x/\epsilon)$. The convolution of two functions f and g is defined by

$$(f * g)(x) = \int f(x-y)g(y)\,dy. \tag{2.1}$$

Convolving with the approximate identity ρ_ϵ smooths a function out without changing its values much. Consequently,

$$N_\epsilon(t) = \sum_{k\in\mathbb{Z}^d} (\chi_{tD} * \rho_\epsilon)(k) \tag{2.2}$$

approximately counts the number of lattice points in tD.

It is a classical result that the Fourier transform of the convolution of two functions is the product of the Fourier transforms of the two functions. In view of the Poisson Summation Formula, (2.2) becomes

$$\begin{aligned} N_\epsilon(t) &= t^d|D| + t^d \sum_{k\neq(0,\dots,0)} \widehat{\chi}_D(tk)\widehat{\rho}(\epsilon k) \\ &= t^d|D| + R_\epsilon(t). \end{aligned} \tag{2.3}$$

Using the presence of curvature, we will see that $|R_\epsilon(t)| \lesssim t^{\frac{d-1}{2}}\epsilon^{-\frac{d-1}{2}}$. On the other hand, since $N_\epsilon(t-\epsilon) \leq N(t) \leq N_\epsilon(t+\epsilon)$, we can subtract $t^d|D|$ from each term, compare our estimate with $t^{d-1}\epsilon$, and conclude by setting $\epsilon = t^{-\frac{d-1}{d+1}}$ that

$$R(t) \lesssim t^{d-2+\frac{2}{d+1}}. \tag{2.4}$$

The estimate on $R_\epsilon(t)$ follows once we have good information about the rate of decay of $\widehat{\chi}_D$ at infinity. One can show by a fairly direct calculation in the case of the ball, and by a slightly more complicated argument in general, that if the boundary of D has everywhere nonvanishing Gaussian curvature, then

$$|\widehat{\chi}_D(\xi)| \lesssim |\xi|^{-1}|\xi|^{-\frac{d-1}{2}} \tag{2.5}$$

when $|\xi|$ is large. See, for example, [Stein93, Chapter VIII]. The factor $|\xi|^{-1}$ comes from reducing the integral to the boundary of D, while the remaining factor is the result of curvature. So how does (2.4) follow? By the discussion above, it is enough to show that $|R_\epsilon(t)| \lesssim t^{\frac{d-1}{2}}\epsilon^{-\frac{d-1}{2}}$. With (2.5) in hand, we see that

$$R_\epsilon(t) \lesssim t^d \textstyle\sum_{k\neq(0,\dots,0)} |tk|^{-1}|tk|^{-\frac{d-1}{2}}(1+|\epsilon k|)^{-N}$$

for any $N > 0$. Replacing sums by integrals, we see that this expression is $\lesssim t^{\frac{d-1}{2}}\epsilon^{-\frac{d-1}{2}}$ as desired.

How the curvature enters the picture in establishing the estimate (2.5) is easiest to see in two dimensions. Let D be an arbitrary convex set in the plane. Let e_θ denote a unit vector determined by the angle θ, and set

(2.6) $$S_\theta = \sup_{x \in D}(x \cdot e_\theta).$$

For small positive ϵ, define a region $A_D(\epsilon, \theta)$ via

(2.7) $$A_D(\epsilon, \theta) = \{x \in D : S_\theta - \epsilon < (x \cdot e_\theta) < S_\theta\}$$

(see Figure 3).

It is not hard to establish via an integration by parts argument[4] that

(2.8) $$|\hat{\chi}_D(re^{i\theta})| \lesssim |A_D(r^{-1}, \theta)| + |A_D(r^{-1}, \theta + \pi)|,$$

where the absolute value signs on the right-hand side denote area.

If the boundary of D has everywhere nonvanishing Gaussian curvature, then $A_D(r^{-1}, \theta)$ is a "lune" of width $\approx r^{-1}$ and length $\approx r^{-\frac{1}{2}}$, where the constants buried in the $\approx$ notation depend on the actual value of the curvature. It follows that $|A_D(r^{-1}, \theta)| \approx r^{-\frac{3}{2}}$, which, of course, implies (2.5) in two dimensions. In higher dimensions (2.5) does not hold in such full generality. However, it does essentially hold under the assumption of convexity and everywhere nonvanishing Gaussian curvature.

Indeed, after reducing to the boundary, we need to estimate the Fourier transform of the Lebesgue measure σ on a small piece of a smooth hypersurface S. Suppose that this hypersurface is convex and has finite order of contact with every tangent line. Let $T_x(S)$ denote the tangent plane to S at x, and define the "ball" $B(x, \delta)$ via

(2.9) $$B(x, \delta) = \{y \in S : dist(y, T_x(S)) \leq \delta\}.$$

J. Bruna, A. Nagel, and S. Wainger proved in this setting that

(2.10) $$|\hat{\sigma}(\xi)| \lesssim \sup_{x \in S} \left| B\left(x, \frac{1}{|\xi|}\right) \right|.$$

In the case when S has everywhere nonvanishing curvature, $B(x, \delta)$ is approximately a box of dimensions $\approx (\delta^{\frac{1}{2}}, \ldots, \delta^{\frac{1}{2}}, \delta)$, which implies (2.5) in view of (2.9) and the fact, mentioned above, that in computing $\hat{\chi}_D(\xi)$, we pick up another factor of $\frac{1}{|\xi|}$ in the process of integrating by parts to reduce the problem to the boundary.

"Arithmetic" Curvature

Let us think about the effect of curvature in this problem a bit more carefully. Choose a point on the boundary of the disc, and consider an outward normal at that point. As we expand the disc the curvature of the circle guarantees that almost all such normals miss the lattice points by a "significant" margin in a sense which can be made precise using Diophantine approximations. To put it simply,

$$\text{Curvature} \Rightarrow \text{Many different normals}$$
$$\Rightarrow \text{Few Lattice Points Are Encountered.}$$

Why do we explore this point of view? Let us consider, once again, the case of the unit square with sides parallel to the coordinate axes. As we noted above, the estimate $R(t) \lesssim t$ cannot be improved in this case because lack of curvature prevents the boundary of the cube from escaping from the integer lattice. However, we can actually take advantage of this complete lack of curvature by rotating the domain by a sufficiently irrational angle. The point here is that while the boundary of the unrotated square picks up lattice points by the bushel, the boundary of a properly rotated square picks up hardly any lattice points at all! In summary,

$$\text{No Curvature} \Rightarrow \text{Few Normals}$$
$$\overset{\text{irrational rotation}}{\Longrightarrow} \text{Few Lattice Points.}$$

Using a modification of the Poisson Summation argument given above, one can show that for almost every rotation of the square, or, more generally, any polygon, $R(t) \lesssim \log^\delta(t)$, provided that $\delta > 3$. Using a more sophisticated argument, Skriganov showed that the same result holds for $\delta > 1$. Results of a similar nature were obtained by B. Randol in the 1960s, Y. Colin de Verdière and M. Tarnopolska-Weiss in the 1970s, and others.

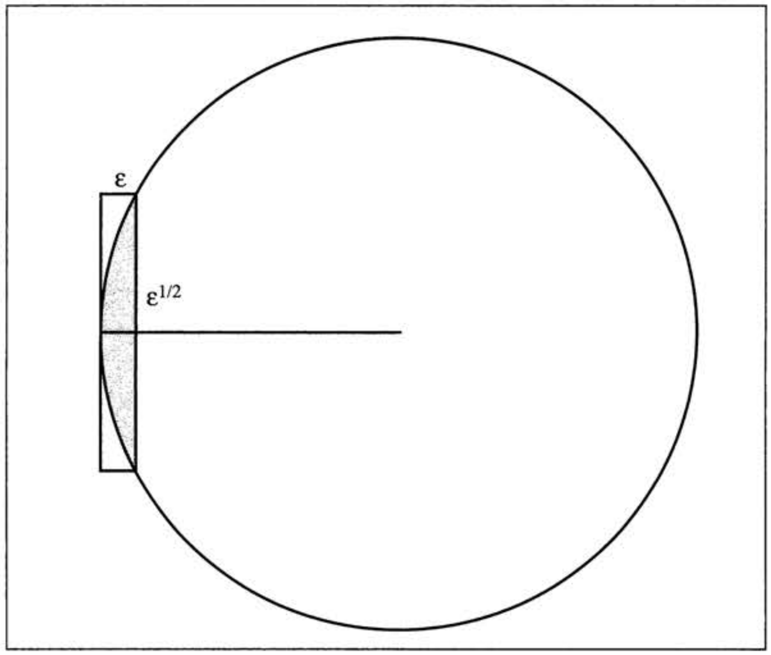

Figure 3.

Curvature Is Not Always Your Friend

In the previous examples the presence of curvature was always helpful in the sense that it improved the results in some well-defined way. In this

[4] *A beautiful and thorough description of this result and related issues appears in a paper by L. Brandolini, M. Rigoli, and G. Travaglini in* Revista Matemática Iberoamericana.

section, we shall see that curvature is not always helpful. Our first example will involve the standard Gaussian curvature in a way, and the second example will make use of the notion of "arithmetic" curvature from the preceding section. Roughly speaking, the idea is the following. Presence of curvature often leads to "cancellation" on the Fourier transform side, which leads to favorable results. However, if curvature is introduced in a suitable way on the Fourier transform side, the situation reverses, and curvature, which used to be our friend, becomes an enemy. This is the essence of the following examples.

Nikodým Set and a Fundamental Theorem of Calculus

The Lebesgue differentiation theorem says that if f is an integrable function on $\mathbb{R}^d$, then the average of this function over a cube Q centered at x converges to $f(x)$ for almost every x as Q shrinks to x. The problem becomes much more difficult, however, if we attempt to average f over more eccentric sets. Consider the following question. Let $\mathcal{R}$ be the collection of rectangles centered at the origin with arbitrary orientation. Is it true that

$$\lim_{\{diameter(R)\to 0;\ R\in\mathcal{R}\}} \frac{1}{|R|}\int_R f(x-y)\,dy = f(x) \tag{3.1}$$

for almost every x?

A. Zygmund observed that this question has a negative answer because O. Nikodým proved that there exists a subset N of the unit cube of full measure such that for every $x \in N$ there is a line $l(x)$ that intersects N only at the point x.

Indeed, choose a closed subset $F \subset N$ such that $|F| \geq 1-\epsilon$, where $\epsilon > 0$. It follows that

$$\liminf_{\{diameter(R)\to 0;\ R\in\mathcal{R}\}} \frac{1}{|R|}\int_R \chi_F(x-y)\,dy = 0, \tag{3.2}$$

which contradicts (3.1).

There is curvature in this problem in the sense that the rectangles in $\mathcal{R}$ have arbitrary orientations, so the underlying geometric object is a circle. It is not difficult to see that the above argument breaks down if we restrict the orientation of our rectangles to a finite number of directions, where the underlying geometric shape is a polygon. In fact, a positive result is known to hold in such a case. See [Stein93, Chapter X] and the references contained therein.

Projections and Trigonometric Polynomials

Let $T(x,y)$ be a trigonometric polynomial in two variables (the higher dimensional case is more difficult):

$$T(x,y) = \sum_{(n,m)\in\mathbb{Z}^2} c_{n,m}e^{i(nx+my)}, \tag{3.3}$$

where only finitely many coefficients $c_{n,m}$ are different from 0. Given a set Ω, define a projection P_Ω via

$$P_\Omega T(x,y) = \sum_{(n,m)\in\Omega} c_{n,m}e^{i(nx+my)}. \tag{3.4}$$

It is natural to measure to what extent P_Ω "distorts" polynomials $T(x,y)$. To that end, we say that P_Ω is bounded if there exists a constant C_Ω such that

$$\max_{x,y} |P_\Omega T(x,y)| \leq C_\Omega \max_{x,y} |T(x,y)| \tag{3.5}$$

for every polynomial T.

A beautiful result due to E. Belinsky says that if Ω is a strip of width Δ and slope λ, i.e.,

$$\Omega = \{(n,m)\in\mathbb{Z}^2 : |m-\lambda n| \leq \Delta\},$$
$$\lambda\in\mathbb{R},\quad \Delta > 0, \tag{3.6}$$

then P_Ω is bounded if and only if λ is rational. The argument we present can be found in [GLMP92], and the author is grateful to A. Podkorytov for pointing it out.

Recall that in the section on the distribution of lattice points inside convex domains, we argued in the context of rotated squares that the "arithmetic" curvature provided by the ubiquitous irrationality of rotations leads to very small error terms in that problem. We are about to see that things are completely reversed here. The case of rational λ is less interesting, so we treat only the irrational case. Using the pigeon-hole principle, or the Dirichlet principle as it is often called in this case, we can find an irreducible fraction $\frac{p}{q}$ such that

$$\left|\lambda - \frac{p}{q}\right| \leq \frac{1}{q^2}. \tag{3.7}$$

Let L be a straight line that passes through the points $(0,0)$ and (q,p). By the irreducibility of $\frac{p}{q}$, all integer points on L are of the form (kq,kp), $k\in\mathbb{Z}$. It follows that for some $N>0$,

$$\Omega\cap L = \{(kq,kp) : k\in\mathbb{Z},\ |k|\leq N\}. \tag{3.8}$$

We shall now demonstrate that

$$N \geq q\Delta. \tag{3.9}$$

Write $\lambda = \frac{p}{q} + \frac{\delta}{q^2}$, where $|\delta| < 1$. For $|k| \leq q\Delta$, $(kq,kp)\in\Omega\cap L$ when k satisfies the relation

$$|kp - \lambda kq| = \frac{|k\delta|}{q} \leq \frac{|k|}{q} \leq \Delta, \tag{3.10}$$

and (3.9) follows.

Now consider those polynomials whose coefficients $c_{n,m}$ are 0 for $(n,m)\notin L$. By the above, such polynomials T have projections of the form $P_\Omega T(x,y) = \sum_{\{k\in\mathbb{Z},\ |k|\leq N\}} a_k e^{ik(qx+py)}$.

A simple one-dimensional calculation that involves writing a trigonometric polynomial as a convolution with the Fejér kernel shows that (3.5) can hold only if $\log(N) \lesssim C_\Omega$. This gives

$$\log(q\Delta) \lesssim \log(N) \lesssim C_\Omega \tag{3.11}$$

by (3.9). This means that (3.5) cannot hold with a bounded constant, since q can be arbitrarily large.

Conclusion

The examples we have discussed follow the following simple pattern of ideas:

$$\text{Curvature} \overset{\text{Fourier transform}}{\Longrightarrow} \text{Cancellation} \Rightarrow \text{Unexpected Result.} \tag{4.1}$$

The very first example of this article, the Erdős Distance Problem, follows the pattern

$$\text{Curvature} \overset{\text{Combinatorics}}{\Longrightarrow} \text{Unexpected Result.} \tag{4.2}$$

However, an application of this result to the Fuglede conjecture puts it firmly into the framework of (4.1). Indeed, the main point in the proof that the ball is not spectral is to use the Erdős Distance Problem to show that the curvature of the boundary of the ball B_d implies that the property

$$\sum_{a \in A} |\widehat{\chi}_{B_d}(\xi - a)|^2 \equiv |B_d|^2 \tag{4.3}$$

for all $\xi \in \mathbb{R}^d$ cannot hold for any "reasonable" discrete set A. This means, in effect, that the curvature of the boundary of the ball is preventing cancellation from taking place! The word "cancellation" should be interpreted liberally, since we are summing positive terms. What we mean is that the terms need to be smaller than "expected" in order for (4.3) to hold, since each term is potentially close to 1.

In the case of the lattice points inside a disc, (4.1) takes the form

$$\text{Curvature} \underset{\text{Poisson Summation Formula}}{\overset{\text{Fourier transform}}{\Longrightarrow}} \text{Cancellation} \Rightarrow \text{Good Error Term,} \tag{4.4}$$

and in the case of the square we have

$$\text{No Curvature + Rotation} \underset{\text{Poisson Summation Formula}}{\overset{\text{Fourier transform}}{\Longrightarrow}} \text{Cancellation} \Rightarrow \text{Good Error Term.} \tag{4.5}$$

The notion of cancellation is quite classical here. The curvature causes the trigonometric integral of the form $\int_{\partial D} e^{-2\pi i x \cdot \xi}\, d\sigma(x)$ to be very small when ξ is very large, even though the integrand has constant modulus 1. This integral in turn is the key to obtaining a nontrivial, and often best possible, result.

Acknowledgments

The author thanks Chris Sogge for introducing him to the subject matter and teaching him many of its key techniques. The author also thanks the Department of Mathematics of the University of Iraklion, Crete, for technical support in the final stages of the preparation of this article.

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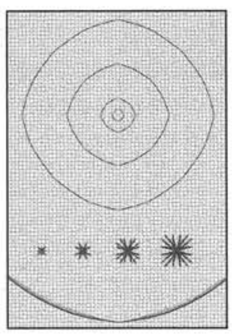
About the Cover



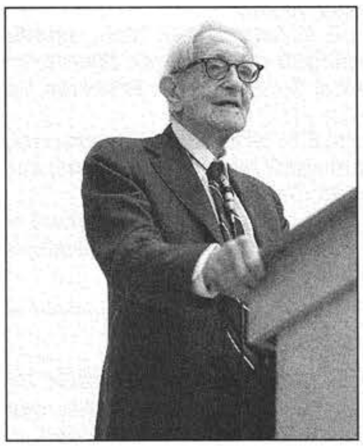
As the article by Alex Iosevich explains, curved paths have fewer lattice points on them than flat ones. But Vojtěch Jarník showed (*Math. Zeitschrift* **24** (1925), 500–518) that curvature alone will not guarantee the best estimates. He constructed an infinite sequence of curves C_N of length roughly N^3, with continuous radius of curvature bounded above by CN^3, containing roughly N^2 points of the integral lattice. The N-th curve interpolates the polygon constructed by starting at an arbitrary point of the lattice and following displacements, in order of their direction, parametrized by all primitive integral vectors whose coordinates have absolute value at most N. The cover illustration shows the first four of these polygons, as well as the corresponding sets of displacement vectors. (More information about Jarník's construction can be found in Chapter 2 of the book by Martin Huxley listed among Iosevich's references.)

The bottom of the illustration shows parts of several more of these polygons, scaled to equal diameters. Darker curves correspond to larger polygons. The picture suggests that the scaled polygons converge to a somewhat ragged limit curve.

—*Bill Casselman* (covers@ams.org)

Dirk Jan Struik (1894–2000)

Chandler Davis, Jim Tattersall, Joan Richards, and Tom Banchoff



Dirk Struik giving a talk at his own 100th birthday celebration, September 1994, Brown University. ***(Photographs by John Forasté.)***

Dirk Jan Struik was born in Rotterdam on September 30, 1894. He attended the Hogere Burger School from 1906 to 1911 and the University of Leiden from 1912 to 1917. He spent the next seven years at the Technische Hogeschool in Delft as an assistant mathematician to J. A. Schouten. In 1922, under the supervision of the geometer Willem van der Woude, Struik received his Ph.D. in mathematics from the University of Leiden. As the recipient of a Rockefeller Fellowship from 1924 to 1926, he studied at the University of Rome and at the University of Göttingen. He began his career in the United States as a lecturer in mathematics at the Massachusetts Institute of Technology (MIT) in the autumn of 1926. Except for a five-year period during the McCarthy era when he was accused of having engaged in subversive activities, Dirk taught at MIT until his retirement in 1960, when he became professor emeritus. He was a visiting mathematician at the Universidade Estadula de Campinas in Brazil, the University of Puerto Rico, the University of Utrecht, the University of Costa Rica, and on several occasions at the National University of Mexico. He was a fellow of the American Academy of Arts and Sciences and a corresponding member of the Royal Academy of Science of Amsterdam. In 1928 he was given a Lobachevskii citation from the University of Kazan and in 1989 was awarded the Kenneth O. May Prize for the History of Mathematics from the International Commission on the History of Mathematics. He died October 21, 2000, at his home in Belmont, Massachusetts.

—*Jim Tattersall*

Chandler Davis

Dirk Jan Struik and his wife, Ruth Ramler Struik, were the first research mathematicians I knew. In the 1930s, when I was in school, I knew them as friends of my parents. They encouraged me in mathematics and in social criticism. They remained my friends up till Ruth's death in 1993 and Dirk's in 2000. Their eldest daughter, Rebekka Struik, now a (retired) mathematician at the University of Colorado, has been my friend since our childhood.

Dirk had studied in the Netherlands and was especially influenced by the differential geometer J. A. Schouten in Delft and the physicist Paul Ehrenfest at Leiden. After his thesis Dirk produced significant research, much of it in collaboration with Schouten. Ruth did her doctoral thesis in 1919 under Gerhard Kowalewski and Georg Pick at Charles University in Prague. Pick is remembered

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by analysts for masterful contributions to interpolation of analytic functions, but Ruth's field was (and remained) axiomatics of affine geometry.

In 1924, at the suggestion of Tullio Levi-Civita, one of the leading experts in tensors, and Richard Courant, Dirk applied for and got a Rockefeller traveling fellowship—a boon, and one that was rare at that time. The Struiks' travels to Rome, Göttingen, and Paris were productive and exciting. The meetings with Vito Volterra and Jacques Hadamard made an especially profound impression on Dirk. Dirk's love for the history of mathematics was reawakened when Ruth and he wrote a joint article probing (but not solving) the question of whether A. L. Cauchy, when he was in Prague (1833–1836), might have met the Prague mathematician Bernard Bolzano [15].

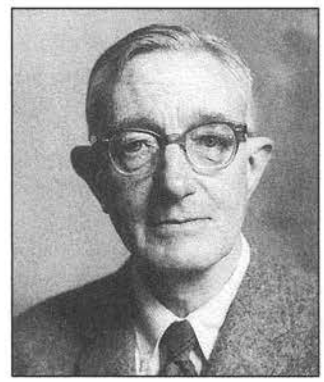
In Göttingen he and Norbert Wiener formed a personal and scientific friendship that was to last. Wiener successfully recommended Dirk for a faculty position in his own department at MIT, and Dirk remained there until retirement.

The study of tensor calculus had lively insiders practicing it in the early 1920s, and it had prestige among outsiders, both other mathematicians and the general public. General relativity was the motive. By the mid-1930s tensor calculus was no longer center stage. Differential geometry of manifolds was still studied for many motives, some of which were much more venerable. Dirk retained his love for the subject and spoke with enthusiasm not only about the lore but also about unsolved problems. He always preferred the tensor formulation. (To represent a matrix by a single unsubscripted letter seemed to him to be playing favorites. Why is this particular type of tensor singled out?) His preferred treatment, which I enjoyed thoroughly as a student and which is still accessible, especially in his *Lectures on Classical Differential Geometry* [9], retains a friendly appeal even in an era when discourse about manifolds has quite a different ring.

By the late 1930s his research had been redirected almost entirely to history of mathematics [2]. He had not kept up with developments in topology that made his classical approach to differential geometry and tensor analysis passé. It is doubtful that we should explain this redirection solely on the basis of his style of mathematics having become less fashionable: history of mathematics was, after all, even more unfashionable. It is doubtful that we should call this one more instance of aging mathematicians resorting to history when they lose the power to prove new theorems: if he had done history as a last resort, he most likely would not have had the power to write good history. I see two other causes. The first is Dirk's lifelong love of world culture, which opened other countries and other centuries for his exploration, even when he was in his twenties and mathematically most active. The second cause is Marxism.

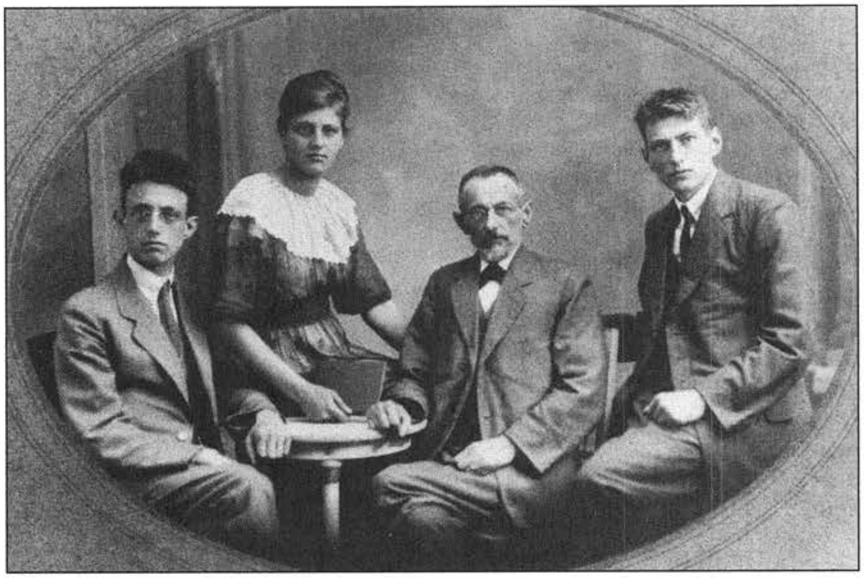
MIT yearbook, 1932.

He had been an active socialist since before the First World War. One of the attractions of the United States for him in 1927 was the relative freedom that it promised from punishment for his left-wing views, and for his wife America had always been the land to dream of. Another factor was Ruth's fragile health. In the U.S. he worked actively with the Marxist intellectual movement, which was then flowering. Dirk was one of the founders in 1936 of the Marxist quarterly *Science & Society*, which is still healthy today; it proclaims itself to be "the longest continuously published journal of Marxist scholarship in the world" and still lists Dirk J. Struik as an editor emeritus. In the first volume he contributed the first of several influential essays on the social sources of mathematics [4]. Fifty years after his 1936 essay he surveyed the fate of the field in the anniversary volume of *Science & Society* [11].



Above, Dirk and Ruth Struik, ca. 1958.

In the period 1947–60 many left-wing academics in the U.S. (though far from all) were harassed by government Red-hunters, the press, and university administrations. Dirk was annoyed to be called as a witness by the House Committee on Un-American Activities in 1949, but not surprised. Even he was a bit surprised in 1951 to be indicted under a rarely used state law for his part in the Samuel Adams School. The school had offered "workers' education", which was declared by the indictment to constitute "conspiring to teach and advocate" the overthrow "with force and violence" of the governments of the Commonwealth of Massachusetts and the United States of America. ("My," Bertrand Russell is reputed to have said of this, "that Struik must be a powerful man indeed!") He remained under indictment until 1955, when another state subversion indictment, the Steve Nelson case in Pennsylvania, was thrown out by the U.S. Supreme Court on the grounds that subversion was a federal, not a state, offense; this invalidated the Struik



Left to right: Dirk Struik, sister, father, and brother. Ca. 1910.

indictment, and the government never threatened action against Dirk again [13].

The MIT administration passed up the opportunity to punish him in 1949 for his failure to "clear" himself of the charge of Communism. In 1951 it put him on paid leave pending settlement of his felony indictment. In 1955 it returned him to his professorial position, where his duties continued until his retirement in 1960. It was conspicuous at the time how much better MIT responded than other U.S. universities in similar cases. True, the administration gave no spirited affirmation of support for freedom of thought or for Struik individually. Indeed, in 1955 the then president, James Killian, ungraciously censured him for failing to declare himself not a Communist. In 2000, in its press release on his death, the present administration recalled that censure without apology. It would have been in order instead, one would think, to claim credit for retaining a dissident on the faculty from 1949 to 1960. But what do you want? I never heard Dirk complain. The unusual defense of academic freedom that the administration had undemonstratively made he accepted undemonstratively. He valued highly his membership in the MIT community, and when, years later, the Dibner Institute for the History of Science and Technology was established there, he was an ever-friendly presence.

The field of history of mathematics has a wing of "internalists" (theorems are passed from generation to generation and new ones added), a mainstream (theorems are studied and made by people, who are much the same whatever the context), and a wing of social historians (theorems are produced in a social context, and understanding the context is part of understanding how they arise). Evidently Dirk Struik was in the latter wing, and I have said that his socialist commitment was an essential part of his taking up history of mathematics as a vocation. His orientation is plain in his research books and articles and in his *Concise History* [5], but these are used and respected by all historians of mathematics. When the International Commission on the History of Mathematics established a medal for achievement in the field, Struik was among the first awardees—not for achievement in one wing, but for contribution to the field as a whole.

I have been a lifelong disciple of Dirk Struik, and to me he was important not only for his mastery and intellectual grasp (for after all, I was working in other areas)—and not always for guidance (for I did not always accept his judgment; we had our disputes)—but as a stabilizer and a model for all radicals. He was a passionate advocate of ideas that were derided. Nevertheless, he maintained imperturbable good humor and unflinching honesty and made it look easy.

Jim Tattersall

Struik's father, Hendrik Jan, was a grammar school teacher and piqued his children's interest in mathematics at an early age by involving them in solving problems from the *Friends of Mathematics*, a magazine for mathematics teachers. His sister, Lena, became a teacher, and his brother, Anton, an engineer. At the Hogere Burger School, Struik's mathematics teacher, G. W. Ten Dam, encouraged him to pursue his studies at the University of Leiden. Struik matriculated at Leiden with the intention of becoming a high school mathematics teacher. There he studied mathematics with J. C. Kluyver, astronomy with Willem De Sitter, physics with Paul Ehrenfest, and history of mathematics with J. A. Vollgraf. After graduation he taught high school mathematics in Alkmaar for a brief period of time before beginning a productive association with Jan Schouten at the Technische Hogeschool in Delft. Struik's collaboration with Schouten led to his dissertation on Riemannian geometry [7].

In 1923 he and Saly Ruth Ramler were married. At a meeting of the Deutsche Mathematiker-Vereinigung in June of 1921, they had been introduced by Ehrenfest. Dirk and Ruth were married for seventy years.

In 1926, at the University of Rome, Struik solved a problem suggested by Levi-Civita involving properties of waves in canals with finite depth [6]. At the invitation of Ettore Bortolotti, Struik visited the Archiginnasio in Bologna and viewed sixteenth-century manuscripts of the Italian algebraists

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Scipio del Ferro and Niccolo Tartaglia. In Rome he gained admittance to the Vatican Library and did research in the history of mathematics in Italy during the Renaissance.

After a nine-month stay in Italy the Struiks migrated to Germany, arriving in Göttingen the day of Felix Klein's funeral. During his stay in Göttingen, Dirk attended the lectures of Hilbert and Courant and was instrumental in preparing Klein's lectures on the history of nineteenth- and early twentieth-century mathematics for publication. Norbert Wiener, on hearing that Struik's stipend would soon run out and that his academic future in the Netherlands seemed bleak, suggested that Struik come to MIT. When Samuel Stratton, then president of MIT, offered him a position, he accepted. Struik spent the summer of 1927 at the Bell Telephone Laboratories in New York working with Thornton C. Fry. Together they developed a new type of wave filter and obtained a patent for it. Dirk became a U.S. citizen in 1934; Ruth, in 1939. During the five-year hiatus from teaching at MIT in the 1950s, he edited the works of the Dutch mathematician Simon Stevin [10]. Later he wrote a popular account on the subject [8].

In the 1940s he and Norbert Wiener joined and began attending meetings of a local Sherlock Holmes society, the Speckled Band of Boston. In the 1970s Dirk became an active member in the Sherlockian group "Friends of Irene Adler". He was given the appellation "An Acute Reasoner". At their annual Christmas dinner at Harvard's Phoenix Club, Dirk invariably gave the toast to Dr. Moriarty, Holmes's archenemy. It was at just such a meeting that I was introduced to Struik and had the first of our many conversations about the history of mathematics. Several of our discussions involved his *A Concise History of Mathematics* [5] and *Yankee Science in the Making* [14], which he considered important because they shed light on the social and cultural atmosphere in which science is created. He was very proud of the time and effort he and Ruth put into researching *Yankee Science* [14]. They traveled to old factories in Rhode Island, the Slater Mill in Pawtucket, the Saugus Iron Works, the Lowell mills, and the Blackstone and Middlesex Canal sections in an effort to highlight the scientific and engineering activities of New Englanders in the first century of the Republic.

As a youth Struik honed his linguistic skills on novels by Mark Twain, James Fenimore Cooper, Jules Verne, and Captain Frederick Marryat. Later he became an ardent reader of detective fiction, in particular, works by A. E. W. Mason, J. S. Fletcher, and Arthur Conan Doyle. I visited him in Belmont on a semiregular basis mainly to discuss detective fiction and the history of mathematics. I was always in awe as to the sharpness of his mind and his inquisitiveness. He never failed to ask a few penetrating questions or to raise interesting points. Invariably he seemed to be excited about some correspondence he had just received or an aspect of the history of mathematics that I might find of interest. He never failed to suggest a book or article that I might enjoy reading. Once, after I had read Mason's *The House of the Arrow*, we had a lively discussion of the plot, albeit he had probably last read the book seventy years earlier.

With Ruth Struik, 1973.

During his stay in Delft, Struik assisted Schouten in reviewing mathematical papers for the *Revue Semestrielle* and the *Fortschritte*. Later, independent of Schouten, he reviewed for the *Zentralblatt*. In 1940 he shifted from the *Zentralblatt* to the *Mathematical Reviews*. He felt strongly that such timely reviews provided an important contribution to the mathematical community. It was a job he enjoyed very much and took very seriously. During the period from 1940 to 2000, he reviewed 875 articles for the *Mathematical Reviews*; the last appeared in March 2000, when he was 105. Until 1980 he reviewed mainly papers on tensors and differential geometry, many of them in Russian. After that time he preferred to review papers on the history of mathematics. He was fond of saying that he spent the first fifty years of his life doing mathematical research and looked forward to spending the second fifty doing research in the history of mathematics. His linguistic ability was phenomenal: he was fluent in Dutch, German, and English, and could read Latin, Greek, Italian, French, Russian, Rumanian, Portuguese, and Swedish. In 1969 his expertise was put to use when he translated and edited the seventy-five articles for *A Source Book in Mathematics* [12].

With daughter Rebekka, 1993.

At home, Belmont, MA, 1998.

Much of Struik's interest in the history of science stemmed from the challenge the field offered to the social responsibility of the scientist [1]. He may have begun research in the history of mathematics as a hobby, but he soon became interested in how society influences the development of mathematics. He was a witness and heavy contributor to the rise in prominence in the mathematical community and in academic potential of the history of mathematics [3]. His best advice to those embarking on a career in the subject was to know lots of mathematics and be persistent. Mainly because of its connection with education, Struik later became very interested in and supportive of ethnomathematics, the study of how mathematics has originated and developed under different cultures.

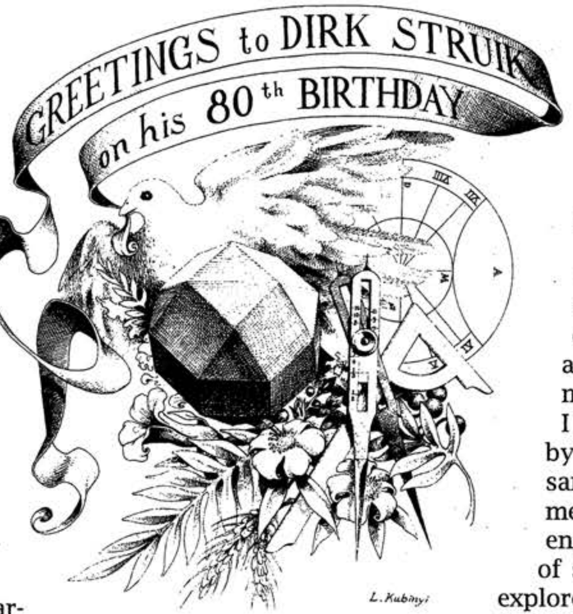
Dirk was a good friend, and I will miss his company very much. He was from a gentle and erudite European breed now vanishing from the American academic scene.

Joan Richards

I first met Dirk Struik in 1974. At the time I was a first-year graduate student in the history of science department at Harvard. "Dirk Struik is giving a course in the history of mathematics at MIT," my professor told me. "You should take it." It seemed like a good idea. I had long admired Struik's *Concise History of Mathematics* [5] and thought it would be interesting to meet the author. So twice a week over the course of that spring, I abandoned the familiar world of Harvard Square for a tiny room at MIT. There Struik exuberantly led me and perhaps ten MIT students through all of the history of mathematics: the relationship between algebra and geometry in ancient Greece, the development of the calculus in the seventeenth century, logarithms in the work of Simon Stevin, the tensor calculus of Tullio Levi-Civita. Struik was a mathematician, but the world he shared with us was filled with all kinds of people—merchants, travelers, philosophers, and gamblers. Struik was a fascinating teacher.

I considered myself especially privileged that spring, because I was acutely aware that about two decades of MIT students had been denied the experience of learning from Struik. I also believed that few would have it in the future; after all, he was almost eighty.

But here I was wrong. I as well as many others continued to encounter Struik in conferences, lectures, and seminars for decades thereafter. Over the years I realized that what made him so special was not so much that he was interesting, but that he was interested. I remember vividly a stifling summer conference at Vassar. Struik was there, sitting straight in the front row, though the mercury in a historic railroad thermometer on the wall hung stubbornly just below the point marked "Blood". At the time, Struik's age, like the temperature, was in the mid-90s, but he responded to each paper with sharp questions. In mine I struggled with eighteenth-century concepts of rigor in ways that were disturbing to many of the others at the conference. Struik, however, was unperturbed. "I'll have to look at Euler again," he said cheerfully, and he did. About a month later he called to give me a reference that he thought might be helpful in my thinking. Struik's historical interests focused on mathematics; he ushered me into that world at the very beginning of my academic career, and I have been fascinated by it ever since. At the same time, he became for me a model for ways to be engaged in a community of scholars who strive to explore that world together. I will always be grateful.



Drawing by L. Kubinyi to celebrate Dirk Struik's 80th birthday, 1974.

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Tom Banchoff

My first formal introduction to differential geometry of curves and surfaces came through Dirk Struik's excellent book *Lectures in Classical Differential Geometry* [9]. The hardcover version that I purchased in 1960 is featured on my geometry shelves, along with the Dover paperback edition that I still assign to my students. No matter what other text materials are used in introductory courses, this small and inexpensive volume remains the best resource for putting the subject into historical context. Only later in my career did I come to appreciate the thoroughness and care that the author had put into accumulating examples and exercises based on primary sources. As a graduate student I was sometimes frustrated when these references forced me to interpret geometry expressed in notations different

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from those in any modern book. Forty years later I appreciate this contribution to teaching literature even more, as I have become aware of the way Dirk Struik continued to contribute to a wide range of mathematical topics in their historical contexts. I look forward to introducing new generations of students and mathematicians to this classical text and to telling them about my interactions over these past years with its remarkable author.

It was when Dirk Struik was ninety-seven that I asked him casually during a visit about his plans for the inevitable hundredth birthday soon to come. He said that he would almost certainly spend it with his family, including several generations of descendants by that time. I had an immediate idea: "What about a lecture?", thinking about him sitting in the front row smiling while some distinguished geometer/historian held forth at an event in his honor. I should have known better. "A lecture?" he said. "Yes, I would love to give a lecture on my hundredth birthday." And so he did, at Brown University in front of a large audience consisting of about a third geometers, a third historians and coworkers in various causes, and the rest people intrigued by the idea of watching a hundred-year-old man giving his own centenary lecture. His presentation, "Mathematicians I Have Known"—including David Hilbert, Tullio Levi-Civita, John von Neumann, and Emmy Noether—rewarded all of us.[1] Afterwards many of us, including, of course, his family, gathered for dinner to share stories from all the areas his life had touched.

He was a good friend to many of us, and we will miss him even as we celebrate the good long time he was here with us.

Photograph by Donna Coveney/MIT.

1994, at age 100.

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Note: Photographs for this article are courtesy of Rebekka Struik and the Struik estate, Jim Tattersall, and the MIT Photo Service.

[1] *See also Dirk J. Struik, Some Mathematicians I Have Met, in* A Century of Mathematical Meetings *(Bettye Anne Case, ed.), Amer. Math. Soc., 1996; Allyn Jackson, Dirk Struik Celebrates His 100th,* Notices Amer. Math. Soc. *42 (1995), 43–45.*

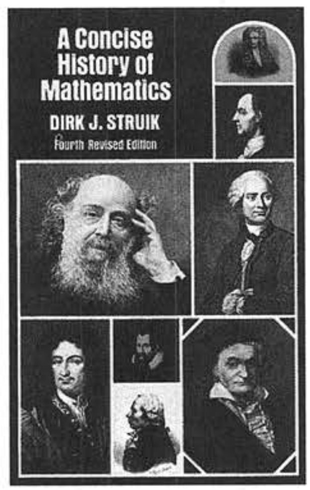
Book Review

Looking Back on a Bestseller: Dirk Struik's *A Concise History of Mathematics*

David E. Rowe

A Concise History of Mathematics
Dirk J. Struik
228 pages, $8.95
Fourth edition, September 1987
Dover Publications, ISBN 0486602559

Few books on the history of mathematics that were written over fifty years ago continue to attract many readers today, and certainly none has done so well as Dirk Struik's *A Concise History of Mathematics*, first published in 1948. This classic survey has gone through four editions and appeared in translation in at least eighteen different languages. Even its author had difficulty keeping up with the count, but whenever a new translation appeared, authorized or not, he tried to obtain a copy for his bookshelf. Clearly, *Concise History* not only gave the history of mathematics considerable visibility, it also helped promote a new kind of interest in the subject. Most standard histories before it had stressed the incremental growth of new knowledge, shorn for the most part from the social contexts out of which these results grew. Struik, on the other hand, emphasized the shifting social and political contexts that preconditioned these intellectual developments. At the same time, he sought to convey at least a glimpse of the rich diversity of mathematical ideas and cultures. For many who, like myself, went on to become professional historians of mathematics, this little gem was the book that first opened our eyes to an unsuspected world filled with the interplay of mathematical ideas,



institutions, and people.

Of course, not many people decide to take up history of mathematics as a career, so I don't want to make too much of Struik's impact on such a small subset of his readers. What about all the others in the broader audience he wanted to reach? What made this book such a success, and why has it retained so much of its freshness today? No doubt there were a number of circumstantial factors that help account for this, but beyond these I think the main reason had to do with the author's unusual qualifications and especially his character. Dirk Struik loved mathematics as well as history all his life, having acquired these passions from his father, a grammar school teacher in Rotterdam. When in 1989 Dirk was awarded the Kenneth O. May Medal for his contributions to the history of mathematics, he began his acceptance speech with a tribute to Hendrik Jan Struik:

> Vom Vater hab'ich die Statur
> Des Lebens ernstes Führen
> (J. W. Goethe, *Xenien VI*)

("From my father I have the stature/To lead an earnest life.") With regard to his father's intellectual passions, he liked to quote an even more famous line from Goethe's *Faust*: "Was du ererbt von deinen Vätern hast, erwirb es, um es zu

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besitzen." ("That which you have inherited from your fathers, acquire it so as to make it your own.") Dirk did, and consequently he knew an awful lot about both mathematics and history, clearly important qualifications for anyone who wants to become a reputable historian of mathematics.

Of course, that wasn't his life's goal; he first wanted to become a first-rate mathematician. But history of mathematics was such a natural interest, he couldn't help but pick up valuable insights along the way. A wonderful chance came in 1925 when he was a fellow of the Rockefeller Foundation in Göttingen. He arrived there in late June, just in time to attend Felix Klein's funeral. Soon afterward, Richard Courant asked if he would be interested in helping to edit Klein's unpublished lectures on the mathematics of the nineteenth century (*Vorlesungen über die Entwicklung der Mathematik im 19. Jahrhundert*). These were lectures that Klein delivered in his home during the war years, when only a few younger men were still in town (Emmy Noether attended regularly). Klein spoke and wrote about the world of mathematics he knew in vivid language, and these lectures give a highly personalized account of mathematical "high culture". A somewhat similar flavor animates the last chapters of Struik's more modest *Concise History*. Even some of the thematic elements in his account come straight out of Klein's lectures (the pivotal role of Gauss on the dividing line between the eighteenth and nineteenth centuries, the parallels between Gauss and Legendre, and the emphasis on Monge and the École Polytechnique as key modernizing factors for all of European mathematics).

One of Dirk's former students, Lorraine Daston, today a distinguished historian of science and codirector of the Max-Planck-Institut für Wissenschaftsgeschichte in Berlin, wrote of him that during her graduate school days he "seemed to her the closest approximation to omniscience in human form." Part of the secret to this, I think, stemmed from his uncanny linguistic abilities. Drawing on a reading knowledge of at least eight languages, Struik could move across nearly every major cultural divide. As he saw his book pass through so many translations, he took a keen interest in learning more about the mathematical traditions of the respective nations or regions associated with the language in question. His linguistic talents also bore fruit when he translated and edited several minor classics for his *Source Book in Mathematics* (1969).

Beyond these intellectual qualifications, Struik had a natural ability to communicate in a writing style that reflected the warmth of his personality. Never ponderous or pedantic, his work conveyed a clear sense of his resilient optimism, genuine humility, and a taste for light irony. And then there was his inquisitiveness, his truly insatiable appetite for knowledge. As Joan Richards so aptly expressed it, "what made him so special was not so much that he was interesting, but that he was interested." And he stayed that way all his life. So it is hardly surprising that the new editions and translations of his *Concise History* reflected an ongoing dialogue, as Struik kept abreast of new contributions and changing research trends.

I can think of no better way to illustrate his personality as a writer than by quoting from Struik's preface to the third revised edition of *Concise History*, which came out in 1966:

> The first edition of this book appeared in 1948. Since then the reception has been generous, both in this country and abroad, even if occasionally a Russian brow was raised for apparent neglect of Čebyšev, as Scotch or French brows may have been darkened because of apparent lack of respect to the memory of Gregory or Roberval. There have been several translations, and in some of them the translators have added material of special interest to their readers. Thus we find a section on Russian mathematics in the Ukrainian translation (Kiev, 1961) and in the Russian one (Moscow, 1964). I myself, when preparing a Dutch version of the book (Utrecht-Antwerp, 1965), added items of interest to Dutch readers.

Reading between the lines, one can easily sense Struik's low-key but evident excitement over the fact that his vision of mathematics as anchored in culture and evolving dialectically through time was beginning to resonate around the world. By this time the German translation of *Concise History* had already gone through three editions, and soon afterward Hans Wussing would establish a stronghold for both teaching and research on the history of mathematics at Leipzig's Karl Sudhoff Institute in the German Democratic Republic. Struik's *Concise History* was standard reading for the students there.

In his preface Struik went on to describe various updates and improvements that had been made, for example in the bibliographies, and how he had incorporated these into the new third English edition. He even told a little story about how it happened that the third edition contains a new treatment of Chinese mathematics:

> One day, one of my friends in Peking discovered a Chinese translation (Peking, 1956) which he forwarded to me. The translator of this edition, in his preface, praised the book but objected to its treatment of Chinese mathematics. Since I already had some misgivings,

> I rewrote the section on this subject. In this edition ancient Chinese mathematics now appears, as it should, as an integral part of medieval and premedieval mathematics, and not as a phenomenon outside of the main current of scientific development.

This anecdote speaks volumes about Struik's attitude toward his work. He knew he had embarked on a new adventure, and he was eager to see where it would lead him. In an article from 1942 entitled "On the Sociology of Mathematics", he even sketched a Marxist program aimed at studying mathematics along lines inspired by the work of the British Social Relations in Science Movement. Marxists have often been criticized as dogmatists (and not just during the McCarthy era), but no informed reader could possibly say this about Struik's approach in *Concise History*. Indeed, his book was an ongoing effort to present an overarching portrait of mathematical developments on a broad canvas of time and space. Its spirit was open-ended, without a trace of dogmatism, and its Marxist features were so attenuated that few could have guessed this guiding orientation unless they either knew the author personally or had read his other work.[1]

In the closing remarks of his preface to the third edition, Struik noted that his revised *Concise History* still ended around 1900, a long way from the year 1966. That would no longer do, and so he called for a concise history of mathematics in the spirit of his survey that would cover the period 1900 to 1950. After all, "the market teems with histories of twentieth-century physics." And while he admitted that the developments in physics were more spectacular, he was equally convinced that:

> the period that began with Poincaré, Hilbert, Lebesgue, Peano, Hardy and Levi-Civita offers a wealth of material for a fascinating history of mathematics, both in its own right and in relation to logic, physics, and engineering. Who of you, gentle readers, is going to take the initiative?

I remember my enchantment with Struik's book when I first read it as a graduate student, and I can also remember reading these words and fantasizing about what it might be like to "take the initiative" offered so seductively by its author. Luckily, I then had no idea of the Herculean efforts that would have been involved. Struik, after all, had spent his whole life acquiring the kinds of skills one needed. He could already read more languages as a teenager than I would ever learn; no one was going to fill his shoes.

Perhaps he came to realize many years later that the challenge he tossed out in 1966 was just a little daunting. So in 1987, still not yet ninety, he brought out the fourth edition of his *Concise History* with a new chapter on the first half of the twentieth century. This sketches various institutional changes that went hand in hand with the burgeoning intellectual developments of this period. Not surprisingly, Struik used Hilbert's problems from his speech at the International Congress of Mathematicians in Paris to convey a sense of the enterprise. He then turned to various special traditions: real variable theory in France; the impact of E. H. Moore's school at the University of Chicago on American mathematics; and the emergence of new research fields, including abstract algebra, set theory, and the foundations of mathematics. He surveyed all the leading mathematical centers—from Berkeley and Cambridge to Moscow and Lvov—including those he knew firsthand: Rome and Göttingen. Not surprisingly, he was at his best when writing about the work that excited him most in differential geometry and tensor analysis, a field that exploded in the wake of Einstein's general theory of relativity.

Despite its easy, flowing style, Struik's *Concise History of Mathematics* should not be mistaken as a book for beginners. Its principal audience was and remains broadly educated mathematicians and those with a serious interest in history of the exact sciences. My own experience suggests that most undergraduate students in mathematics are unable to appreciate this book unless they have already had a fair amount of mathematics, and usually they need a good course in the history of mathematics too. Young people with the requisite background can easily manage Struik's book, which can practically serve as a litmus test to determine whether they will find studying the history of mathematics exciting or not. Euclid was reputed to have told King Ptolemy that there were no "royal roads" to mathematical knowledge (though many over the centuries seem to have thought that Euclid's *Elements* provided the path of least resistance). The same is true, perhaps even more so, for the history of mathematics. But for those prepared to undertake this long and arduous journey, nothing is more indispensable than a good guidebook. Struik's *Concise History*—written with insight, perspective, and an intimate knowledge of and affection for the subject—is admirably designed to fulfill that purpose.

[1] *For an interesting comparative portrait of how Struik and two other Dutch mathematicians dealt with the interplay between political and mathematical ideas, see Gerard Alberts, On connecting socialism and mathematics: Dirk Struik, Jan Burgers, and Jan Tinbergen,* Historia Math. *21 (1994), 280–305.*

U.S. Hosts International Mathematical Olympiad

For the first time in twenty years the United States is serving as host for the International Mathematical Olympiad (IMO), the premier international mathematics competition for young people. In July 2001 about 500 high-school-age students from 83 countries will gather in Washington, DC, for the two-week event, which includes a full schedule of entertainment and cultural activities for the students. The IMO competition itself, consisting of six challenging questions requiring essay-format answers with proofs, will take place over two days, July 8 and 9, at George Mason University.

A Major International Event

First held in Romania in 1959, the IMO was originally a regional competition for countries in Eastern Europe. The United States first took part in 1974 and served as host for the competition in 1981, when the IMO was also held in Washington, DC. For many countries the IMO is the capstone of a series of national mathematics contests. In the U.S. these contests are known as the American Mathematics Competitions (AMC). About 400,000 students participate in the first round of the AMC. Subsequent rounds, including the U.S.A. Mathematical Olympiad (USAMO), yield a group of 24 to 30 students who participate in the four-week Mathematical Olympiad Summer Program, which prepares students for the IMO. Over the course of the summer program, 6 students are chosen for the IMO team. This year the summer program will be held at Georgetown University and will run from June 5 until the start of the IMO on July 3. Titu Andreescu, director of the AMC, will run the summer program and serve as team leader.

Some countries have less extensive preparation of their IMO teams; others have more. China, for example, trains its IMO team year-round. There is a long tradition of mathematics contests in certain countries, such as Romania and Hungary, and their teams tend to do very well in the IMO. About half of the 83 participating countries are in Europe or the former Soviet Union. Participation is also strong in Asia and in South America, but not in Africa and the Middle East, which together have just six teams participating: Iran, Israel, Kuwait, Morocco, South Africa, and Tunisia. Egypt and Zimbabwe are interested in future participation and may send observers to IMO 2001. In many countries the performance of the IMO teams is closely watched. John Kenelly of Clemson University, who serves as president of IMO 2001, noted that "it's on the front page of the newspapers who is number one."

This year's IMO is under the supervision of a nonprofit corporation called IMO 2001 USA, Inc., formed by twenty-one professional organizations (including the AMS). The host country for the IMO must pay the local expenses of the student contestants, the team leaders, and the deputy team leaders—a total of more than 650 individuals for IMO 2001. The budget for this year's Olympiad comes to around \$3 million. Walter Mientka of the University of Nebraska, director of IMO 2001, noted that in most countries the minister of education covers the tab and sometimes a science funding agency kicks in a portion. For IMO 2001, around half the funding was provided by the U.S. government, and the rest had to be raised through private sources. "We're the richest country in the world, so you'd think it would be easy to raise the \$3 million," Mientka said. But it wasn't. In fact, planning for IMO 2001 reached a crisis last year when fundraising efforts fell short. Kenelly, who has had experience in fundraising, was brought in to help. On a plane trip he happened to be seated next to the wife of Trent Lott, majority leader of the Senate. This chance encounter led to a meeting with Senator Lott, who provided much needed help at a crucial time. Funding for IMO 2001 is now secure, with major corporate sponsorship from Texas Instruments, Wolfram Research, and the Akamai Foundation. The Clay Mathematics Institute is hosting the closing ceremonies and banquet.

A Logistical Nightmare

The IMO is something of a logistical nightmare. One source of complications is the international nature of the event. Some of the teams scheduled to participate in IMO 2001 come from countries, such as Cuba, with which the U.S. has no diplomatic relations, so obtaining visas for the team members and leaders is not an easy task. "It would be very embarrassing if there were countries that deserved to be here and some glitch [concerning visas] turned them back," Mientka noted. IMO 2001 has engaged a visa attorney in Washington, DC, to handle such matters. To get around language barriers, as well as to ensure the safety and well-being of the teen-age contestants, the IMO has assembled a group of 83 language guides, one for each IMO team. Each guide is fluent in the language of the team to which he or she is assigned. The guides will be housed together with the students in dormitories on the campus of George Mason University.

Another reason the IMO is so complex is that the preparation, proctoring, and grading of the examination all take place during the two-week event. The examination is prepared by the IMO jury, which consists of the team leaders from all 83 participating countries. The process began last November, when each team leader was invited to propose up to six problems (the host country is not allowed to propose problems in order to avoid a "home-team advantage"). This initial list contains on the order of one hundred problems. By the time the jury arrives in Washington on June 30, the Problem Selection Committee, chaired by Cecil Rousseau of the University of Memphis, will have produced a "short list" of thirty problems.

Over the next five days in sessions moderated by Ronald Graham of the University of California, San Diego, the jury will narrow the list to six problems to be included on the examination. There will also be break-out sessions organized by language to ensure that all the team leaders understand the problems precisely. With 83 individuals using parliamentary procedure to prepare a six-problem examination, there is a certain amount of chaos. "It's a difficult and awkward process," acknowledged Daniel Ullman of George Washington University, who serves as the Washington, DC, coordinator for the IMO. "But the goal is not just to write a good exam but to make every country feel it is included in the process." The problems must be new and original and must not have been solved by the students, and the team leaders are supposed to speak up when they know their students have seen a problem. The prestige accorded to the winning team, as well as more tangible rewards like college scholarships, can create overwhelming pressure on the leaders to give their team an advantage. At a past IMO a team was disqualified after it was discovered that before the examination the team knew the solution to one of the problems. Balancing the temptation to cheat is the pride the team leaders take in formulating new, original problems. "It would be embarrassing [for a team leader] to admit to copying a problem from somewhere else," Ullman pointed out.

Once the six examination problems are assembled, together with their official solutions, everything is translated into the six official languages of the IMO: Chinese, English, French, German, Russian, and Spanish. Leaders of teams that do not speak one of these languages then translate the problems into their own languages; altogether, the problems appear in abut forty different languages. All of the translations are posted for inspection by jury members. During the problem selection phase and throughout the examination itself, the team leaders are carefully sequestered from the contestants. While the students are housed at George Mason University, the team leaders stay in a Washington, DC, hotel whose location is not disclosed to the students. During the IMO opening ceremonies, which will take place in a performance hall at George Mason on the Fourth of July, the team leaders must remain on a balcony separate from the students. In years past it was possible to isolate the two groups, but today, with the availability of e-mail and cell phones, it's harder to prevent communication between the teams and their leaders.

Mathematics in a Basketball Arena

The examination itself will take place in two $4\frac{1}{2}$-hour sessions on July 8 and 9 in the Patriot Center, the basketball arena of George Mason University. The entire floor of the arena, as well as the entrance forums, will be taken up with tables where the students will sit and forty volunteer "invigilators" will administer the examination. Each student will be given an envelope containing the problems in up to two languages of the student's choice. During the first half hour students can ask questions about the problems. The invigilators fax the questions to the team leaders, who remain at the hotel and who can fax back replies. Sometimes mistranslations surface during the examination, and corrected translations must be distributed to all students who had requested the problems in that language.

The papers are graded in a two-step process that stretches over two days. First the team leaders and deputy team leaders grade the papers of their own teams. They then defend their scoring before two IMO "coordinators", mathematicians who volunteered for the task and have undergone a two-day orientation on the grading rubric for the examination. There are a total of forty-eight coordinators, eight for each problem: four pairs work in parallel to coordinate the grading of one problem. "Some leaders can be very aggressive" during the coordination, Mientka remarked. "And the students are so bright that their solutions might not be the same as the official solution." Therefore, the coordinators have to be flexible and savvy enough to spot legitimate alternative solutions, as well as firm enough to rebuff efforts to inflate students' grades. A dispute that cannot be resolved in the twenty minutes allotted for each coordination session will be turned over to the chief coordinator, Cecil Rousseau of the University of Memphis, and his assistant, Kiran

Kedlaya of the University of California, Berkeley. The final decisions are made in a meeting of the full IMO jury.

At the IMO in Sigtuna, Sweden, in 1991, one of the members of the U.S. team, Lenhard Ng, wrote a two-page solution that could not be coordinated in the allotted time. A team of coordinators spent several hours scrutinizing Ng's solution, trying to determine its correctness. All of the solutions of all the other students in the competition had been scored and recorded, except Ng's solution to this one problem. "The whole place was waiting for the verdict," recalled Ullman, who was serving as deputy team leader. He and team leader Rousseau had asked for a perfect score of 7 points for this solution, but in the end the coordinators gave Ng only 3 points. Ng ended up with a silver medal in the competition and, like many former members of U.S. teams for the IMO, has gone on to distinction in mathematics. Ng received his Ph.D. from the Massachusetts Institute of Technology this year and was recently given the prestigious AIM Five-Year Fellowship from the American Institute of Mathematics.

By Wednesday evening, July 11, the jury will have decided which students will receive IMO medals. The medals are distributed in such a way that about one-twelfth of the students will receive gold medals; about one-sixth, silver medals; and about one-fourth, bronze medals. Altogether, around half the students will receive medals. Officially, there are only individual scores on the IMO, no team scores. However, in news reports about the Olympiad it is common practice to rank the countries' performance by totaling the team scores for each country. The U.S. is usually among the top contenders and has placed among the top five countries in all but four of the competitions in which it has participated.

A Cultural Exchange

While the examination is being prepared and graded, the 500 teen-age contestants keep busy with a variety of activities planned especially for them. "The IMO is much more than a mathematics contest," remarked Ullman, who has been closely involved in planning local activities for the students. "It's a cultural exchange among the top talented mathematics students internationally." IMO activities have traditionally showcased the culture of the host country but have involved little mathematics. "I have always felt the IMO needed more of a mathematics component," Ullman noted, "and we are doing some of that." Students will have the opportunity to see the BBC television program about Fermat's Last Theorem, the film showing the sphere being turned inside out, and the film *Not Knot*, which features a ride through the world of hyperbolic geometry. The day before the first part of the examination, a selection of mathematically based games, toys, and puzzles will be available for the students, and the calculating wizard Arthur Benjamin of Harvey Mudd College will give a performance.

One of the aims of the IMO 2001 organizers is to display the multiculturalism of the U.S. The opening ceremonies on the Fourth of July will feature a number of cultural performances, such as clogging, Native American hoop dancing, and gospel singing. Later that day the group will take a boat ride on the Potomac River and watch the fireworks display on Constitution Mall. During the rest of the IMO there will be a visit to the Air and Space Museum, trips to the National Zoo and to a large amusement park, and an all-day excursion to Baltimore to visit the National Aquarium and the Maryland Science Center. Just how much entertainment to schedule, especially close to the examination, is a difficult call. "The kids do get nervous," Ullman noted. "There's a lot of pressure, especially with a team that has a chance to do well. If you don't do well, you disappoint a whole country. So it's tough."

After the examination students will pay visits to their individual countries' embassies. Last year when the IMO was held in South Korea, President Kim Dae Jung had the entire IMO contingent as guests at his residence. Ullman said that the idea of having the IMO 2001 group visit the White House was dropped because it seemed so complicated and uncertain. There is still hope, though, that some high officials from the U.S. government will turn out for the opening or closing ceremonies.

The Clay Mathematics Institute (CMI) is organizing the IMO closing ceremonies and banquet, which according to CMI president Arthur Jaffe will provide an "elegant and uplifting" finale. Students will receive their medals at the closing ceremonies on July 13, to be held in the concert hall of the John F. Kennedy Center for the Performing Arts. One of the highlights will be inspirational talks by CMI advisory board members Andrew Wiles and Edward Witten. (CMI is also holding its own annual meeting in conjunction with this event and will present its annual research award.) That evening the closing banquet for the Olympiad will take place at the National Building Museum, one of the most spectacular dining halls in Washington and the site of many presidential dinners. About one thousand people will attend the banquet.

All of the IMO organizers have been working hard to make IMO 2001 an event that shows off the best of the United States. As Kenelly put it, "We will be able to stand up, stick our chests out, and be proud of being U.S. mathematicians."

—Allyn Jackson

For further information on IMO2001, consult the Web site `http://imo2001.usa.unl.edu/`.

The Mathematician's *Proof*

Reviewed by Mark Saul

Right you are—if you think you are.
—*Luigi Pirandello*

Proof
A play by David Auburn
Directed by Daniel Sullivan
Walter Kerr Theatre
New York, NY

Mathematicians are rarely seen on the Broadway stage, and mathematics itself even less often. So it is some cause for celebration that David Auburn's play *Proof*, having been on Broadway for several months, has just won a Pulitzer Prize. The piece gives us a new look at the role mathematics plays in all our lives.

Why are mathematicians so often perceived by the general public as immature? The image of the mathematician is, too often, that of a nerd, a social misfit, a person obsessed with his (usually not her!) own insights, one who has not yet learned to take notice of those with other interests. The elite, the aloof, the initiated—who would care to think of them as anything more than cases of arrested development?

Like all stereotypes, this view is of course incorrect. But like all stereotypes, it takes its origin from wisps of reality. For the dialogues of mathematicians must seem, to those who don't care to look deeper, like childhood fantasies. Why this obsession for proof, sometimes of statements that would pass as obvious in any other context? Why fret about the possibility of astronomically large counterexamples to a conjecture that is true for the first billion cases? These concerns are dangerously close, in the public mind, to the child's invention of an imaginary companion or to nighttime fears of a monster in the closet.

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For another view of this play, see Notices, *October 2000, pp. 1082-1084.*

So much for misconception. There is also some factual basis for the comparison. In many ways, mathematics is a young man's profession (the gender-specific language is used consciously here). Gauss is said to have remarked that his best ideas had occurred to him by the time he was nineteen— this from the man whose credo was *pauca sed matura* (few but ripe).

It is the ripeness, the bringing to fruition of callow genius, that the public does not usually appreciate. We have the examples of Hadamard and Ahlfors, of Mac Lane and Gelfand, and numerous others whose energy and creativity endured well into their eighth or ninth decade. We have great expositions of mathematics in which the ideas are given the polish of long use. Perhaps most important, we have the common but unseen phenomenon of the mathematician as teacher, leading a new generation through past discoveries and towards new ones. This last effort requires a genius different from that of mathematics itself, a genius that might be more appreciated by the public were it more appreciated by the agents themselves.

All this aside, the image of the mathematician as child is alive and well on Broadway. David Auburn's play *Proof* is about four characters, three of whom are mathematicians (and the fourth a financial analyst). The characters often appear immature and, worse, insane. And yet the evening is delightful, fascinating, and engaging, yielding insight into the relationship between the reality of the mathematician and that of the public.

In some sense, reality is the subject of all of theatre. At its best, theatre confronts a real audience—who have come in the rain and the traffic to see living actors on a living stage—with the imagination of the author, director, or performer. A good production challenges those seated in the theatre to try to distinguish between the art before them and the world behind. This contrast has long been a part of the dramatist's art.

So the theatre is a good setting to explore the relationship between mathematics and reality. Now *Proof* explores much more than that, and many audiences will see something completely different in the touching story of a young woman's struggle for recognition, for identity, for separation from the mad genius of her father. The interesting point, for a mathematical audience, is the role played by mathematics. For the author might have chosen any number of scientific endeavors as his metaphor. Indeed, the association of genius with insanity is perhaps stronger in the public view of the natural sciences than any such association with mathematics.

So why mathematics? Because of the abstract nature of mathematical results, which renders them invisible from outside the profession. Indeed, the characters in the play are at times seen talking to ghosts, a good metaphor for the appearance of mathematics to the outsider. What could be less tangible than mathematics?

Well, emotions can be less tangible. Sometimes our feelings are difficult to discern, even as we are feeling them, and certainly so for someone not experiencing these same emotions. The dramatist's art maneuvers the audience into feeling the emotions being enacted on stage, and in this particular drama the medium is the mathematics.

On stage we have a young woman, untutored yet brilliant, emotionally fragile yet the sole support of her mentally ill father. We have the father, once a light of the University of Chicago, a noble mind here o'erthrown, whose mathematics has deteriorated into scribbles. (Paradoxically, the general audience can comprehend the meaning of the scribbles much more quickly than they might any of the character's "real" work. The theatre is not a good place to learn mathematics.) We have a younger, more typical mathematician, worried about publication, promotion, and tenure.

And we have the financier from New York, the mathematician's other daughter. Paying the bills, building a family and career, earning a living, she is supremely practical in her contribution to the dialogue. A lot of the play's wit rests on the responses to her remarks by the more mathematical characters. The application of cold logic to the ambiguities of natural language and of natural relationships can render the latter absurd and reveal the complexity of these commonplace phenomena. The effect is like that of a book about nonstandard analysis on those used to the classical exposition: one begins to think that those epsilons and deltas are the more intuitive way to think of the subject and that the surreal numbers are what is contrived.

Indeed, it is this sort of reversal of reality and fantasy, of the intuitive and the contrived, that is the most interesting mathematical aspect of the play. We never get to see the actual proof—probably something in number theory—that is the bone of contention. The title refers to the mathematical proof, but also to the question of proving authorship of a proof; a few twists of plot make this more difficult than it sounds. And it also refers to the proof that we all require daily of the stability of reality and of personal relationships.

This is probably what the play was meant to explore. But the vehicle for exploration—mathematics—brings yet another meaning. In an ironic twist, it is the mathematics that renders visible the characters' emotions, as the bandages serve to turn the Invisible Man into the likeness of Claude Rains.

Is mathematics real? This question is foolish if asked of a mathematician or of someone whose daily experience is close to mathematics. But the general public finds the imaginary numbers, the abstractions of abstractions of metaphors built on metaphor, the structures based on structures which are based on yet other structures all very hard to swallow. The triumph of this play is to bring another answer to the question. Mathematics for the mathematician is very, very real. The search for accomplishment, for recognition, for connection with others doing similar work is easily as powerful a source of motivation as a more dignified but colder passion for discovery of the truth—perhaps more powerful.

So in this play mathematics is certainly real, as real as the characters and their emotions and the theatre itself. For it is not at all a two-hour parody of mathematics and mathematicians that the audience, mathematical or general, comes away with. It is a deep exploration of the characters' relationships, their self-definition, their struggle for self-realization that is the real subject of the drama.

For the mathematics, it doesn't really matter who wrote the proof discovered in the play. But for the characters involved this is all that matters. For the lay audience uninvolved in mathematics, and even for the mathematician observing (for there is really no mathematics here), it is the resolution of this question and not of any mathematical question that drives the drama, and it is the feelings surrounding this question that provide the deeper experience that we take away from the evening.

A mathematical audience will recognize this. They will see also the immature colleague, the eccentric elder, the fragile young student. Perhaps they will be a bit annoyed at this incomplete but all-too-common picture of the field, but still enjoy the counterpoint between logic and daily life. And most important, they will come away with a deeper appreciation of the role that mathematics plays in their own lives and in those of others.

Mathematics People

2001-2002 AMS Centennial Fellowships Awarded

The AMS has awarded four Centennial Fellowships for 2001-2002. The recipients are IVAN DIMITROV, RAVI VAKIL, JIAHONG WU, and MEIJUN ZHU. The amount of the fellowship is $40,000, with an additional expense allowance of $1,600.

Ivan Dimitrov

Ivan Dimitrov received his Ph.D. in 1998 from the University of California, Riverside, under the supervision of Ivan Penkov. Since then Dimitrov has been a Hedrick Assistant Professor at the University of California, Los Angeles. He also visited the Max-Planck-Institut für Mathematik in Bonn (summer 1999). During the 2001-02 academic year he will spend a semester at Yale University and a semester at the Mathematical Sciences Research Institute in Berkeley.

Ivan Dimitrov

Dimitrov's research area is representation theory of Lie algebras and Lie superalgebras. Among the problems he has worked on are the algebraic and geometric aspects of representations of direct limit Lie algebras and classification of weight representations of Lie superalgebras. His current research projects are centered on various extensions of the theory of Harish-Chandra modules to complex Lie algebras and real Lie superalgebras.

He plans to use part of the Centennial Fellowship to visit Yale University.

Ravi Vakil

Ravi Vakil received his Ph.D. in 1997 from Harvard University under the direction of Joe Harris. Vakil was an instructor at Princeton University (1997-98) and is currently a C.L.E. Moore Instructor at the Massachusetts Institute of Technology (1998-2001).

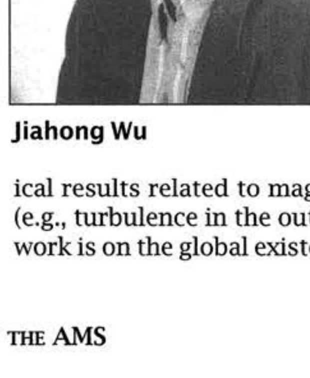
Ravi Vakil

Vakil's research is in the field of algebraic geometry. His main work to date has been on the geometry of algebraic curves and maps of algebraic curves, as well as the intersection theory of moduli spaces, especially of curves and stable maps. His current interests involve the interactions of algebraic geometry with nearby fields, including enumerative geometry, mathematical physics, number theory, and combinatorics.

He plans to use the Centennial Fellowship to visit the Mathematical Sciences Research Institute in Berkeley as well as Stanford University, where he will take up an assistant professorship.

Jiahong Wu

Jiahong Wu received his Ph.D. in 1996 from the University of Chicago under the supervision of Peter Constantin. After a year at the Institute for Advanced Study, he spent three years at the University of Texas at Austin as an instructor. In the fall of 2000 he moved to Oklahoma State University, where he is currently an assistantprofessor.



Jiahong Wu

Wu's research has been in nonlinear partial differential equations, especially those arising in the study of fluid mechanics. His work includes the study of zero-dissipation limits for various equations arising in the description of physical systems and analytical results related to magneto-hydrodynamic turbulence (e.g., turbulence in the outer layers of the sun). His recent work is on the global existence of smooth solutions for the

2D quasi-geostrophic equation, an evolution equation that describes the large-scale motion of the atmosphere and ocean in certain regimes, the zero viscosity limit of the classical Navier-Stokes equations in bounded domains, and several initial-boundary-value problems for model equations in nonlinear, dispersive media.

He plans to use the Centennial Fellowship for visits to the University of Chicago and the University of Texas at Austin.

Meijun Zhu

Meijun Zhu received his Ph.D. from Rutgers University in 1996 under the direction of Yan Yan Li. Zhu was a postdoctoral fellow at the University of British Columbia and at the Pacific Institute for the Mathematical Sciences (1996–98), and a postdoctoral fellow at McMaster University (1998–99). Since 1999 he has been an assistant professor at the University of Oklahoma.


Meijun Zhu

Zhu's research area is partial differential equations. He has worked mainly on nonlinear elliptic equations involving critical Sobolev exponents, curvature equations, and geometric inequalities. Recently he has been working on sharp Sobolev inequalities and various isoperimetric inequalities on Riemannian manifolds. He plans to use the Centennial Fellowship to visit Princeton University.

Please note: Information about the competition for the 2002–2003 AMS Centennial Fellowships will be published in the "Mathematics Opportunities" section of an upcoming issue of the *Notices*.

—Allyn Jackson

Kuranishi Receives 2000 Bergman Prize

MASATAKE KURANISHI has been awarded the Stefan Bergman Prize for 2000. The prize, established in 1988, recognizes mathematical accomplishments in the areas of research in which Stefan Bergman worked. The amount of the 2000 Bergman Prize is $26,000.

The previous Bergman Prize winners are: David W. Catlin (1989), Steven R. Bell and Ewa Ligocka (1991), Charles Fefferman (1992), Yum Tong Siu (1993), Jon Erik Fornæss (1994), Harold P. Boas and Emil J. Straube (1995), David E. Barrett and Michael Christ (1997), and John P. D'Angelo (1999). On the selection committee for the 2000 prize were Frederick Gehring, J. J. Kohn (chair), and Yum Tong Siu.

What follows is the citation prepared by the committee, a brief biographical sketch, and some background about the Bergman prize.


Masatake Kuranishi

Citation

The Bergman Prize was awarded to Professor Masatake Kuranishi of Columbia University for his numerous fundamental contributions to the theory of complex manifolds and Cauchy-Riemann structures.

Of his voluminous work we highlight two results: one from complex manifold theory on locally complete deformation of compact complex manifolds, and one from Cauchy-Riemann structures on the local embedding problem.

His result on locally complete deformation of compact complex manifolds is one of the pivotal results in the long history of the study of deformation of complex structures.

Deformation theory has its origin in the work of Riemann, which, for a compact Riemann surface of genus at least two, determined the number of complex deformation parameters to be three times its genus minus three.

In the late 1950s Kodaira and Spencer pioneered the study of the local moduli of compact complex manifolds by the methods of elliptic systems of partial differential equations. The problem was to prove the existence of a locally complete deformation of any compact complex manifold. A locally complete deformation means a local holomorphic deformation such that any other local holomorphic deformation can be obtained as a pullback of it. Kodaira, Spencer, and Nirenberg proved its existence under the additional assumption of the vanishing of the second cohomology group of the tangent bundle. In such a case the local moduli space is regular.

In 1962 Kuranishi constructed a locally complete holomorphic deformation of any compact complex manifold. His local moduli space is in general a complex-analytic set that may have singularities. His deformation is also locally complete at points of the parameter space sufficiently near the reference point. Kuranishi's work is of great fundamental importance in the theory of holomorphic deformation. His work, building upon that of Kodaira-Spencer, ushered in the development of local deformation theory in the following two decades in which the work of a long list of mathematicians, Douady, Grauert, Palamodov, Forster, Knorr, Tyurina, Bingener, and many others, completed the theory of semi-universal deformation of analytic objects. A semi-universal deformation allows nilpotent elements in the structure sheaf of the local moduli space and requires that the tangent space of the moduli space at the reference point agrees with the space of first-order infinitesimal deformations, which in the case of a compact complex manifold is the first cohomology group of the tangent bundle.

Kuranishi's result on the local embedding problem of Cauchy-Riemann structures concerns the realization of abstract real submanifolds endowed with some partial complex structures called Cauchy-Riemann structures.

For a local smooth real submanifold in complex Euclidean space, the tangent space inherits the complex structure of the ambient space, and a subspace of it is a complex vector space. When the dimension of the maximum complex vector subspace of the tangent space is constant, the local smooth real submanifold is a Cauchy-Riemann manifold (or CR manifold). The restrictions to it of local holomorphic functions on the ambient space are the CR functions. When the local smooth real submanifold is a real hypersurface, it is said to be strongly pseudoconvex at a point if after a local biholomorphic coordinate change it becomes strictly convex. Strong pseudoconvexity is equivalent to the complex Hessian of its defining function being positive or negative definite when restricted to the maximum complex vector space of its tangent space. This notion of strong pseudoconvexity is also defined for the higher codimension case, using the positivity of the so-called Levi form, which is the generalization of the complex Hessian of the defining function of the hypersurface case.

The Cauchy-Riemann equations, which define CR functions on a CR manifold, form a very important class of partial differential equations. A CR structure can be defined on an abstract smooth real manifold by conditions concerning a subbundle of its tangent bundle having a complex structure. More precisely, a CR manifold is a real manifold whose complexified tangent bundle contains an integrable subbundle whose intersection with its complex conjugate bundle is the zero section. A fundamental question is: Under what conditions can an abstract CR manifold be locally embedded in a complex Euclidean space? Or, equivalently, are there enough local CR functions on it to make such an embedding possible?

Hans Lewy in 1957 constructed the first example of a smooth linear partial differential equation without nonconstant solution, which geometrically can be interpreted as the nonexistence of nonconstant CR functions in some CR manifold.

Kuranishi, in his trailblazing series of three papers in 1982, proved the local embedding theorem for abstract CR manifolds of real dimension at least nine under the assumption of strong pseudoconvexity. For the case of real dimension three there are counterexamples, for example, Nirenberg's strongly pseudoconvex CR threefold without nonconstant CR functions. After Kuranishi's work the case of real dimension seven was verified in the work of Akahori, Catlin, Webster, and others. The case of real dimension five, which is conjectured to be true, is still an open problem.

Kuranishi's work on the local embedding of CR manifolds is a formidable tour de force. He starts out by choosing a suitable smooth non-CR embedding and employs an ingenious approximation scheme to modify the embedding in an infinite sequence of steps in which he skillfully controls the estimates of the CR Neumann operator by Moser's method.

In his recent work, Kuranishi develops a new approach to describing CR structures by frame bundles and Cartan connections to put in better perspective the local embedding problem and the techniques of its solution.

The impact of Kuranishi's work on complex manifolds and Cauchy-Riemann structures has been deep and far-reaching.

Biography

Masatake Kuranishi was born on July 19, 1924, in Tokyo. He received his Ph.D. in 1952 fom Nagoya University, where he became a lecturer (1951–52), associate professor (1952–58), and professor (1958–61). Between 1956 and 1961 he also held visiting positions at the University of Chicago, the Massachusetts Institute of Technology, and Princeton University. In the summer of 1961 he assumed his present position as professor of mathematics at Columbia University. He was a fellow of the Guggenheim Foundation in 1975.

About the Prize

The Bergman Prize honors the memory of Stefan Bergman, best known for his research in several complex variables as well as the Bergman projection and the Bergman kernel function, which bear his name. A native of Poland, he taught at Stanford University for many years and died in 1977 at the age of 82. He was an AMS member for thirty-five years. When his wife died, the terms of her will stipulated that funds should go toward a special prize in her husband's honor.

The AMS was asked by Wells Fargo Bank of California, the managers of the Bergman Trust, to assemble a committee to select recipients of the prize. In addition, the Society assisted Wells Fargo in interpreting the terms of the will to assure sufficient breadth in the mathematical areas in which the prize may be given. Awards are made every year, in the case of a single recipient, or every other year, in the case of two joint recipients, who share the prize funds over two consecutive years. The Bergman Prize is given in the following areas: (1) the theory of the kernel function and its applications in real and complex analysis and (2) function-theoretic methods in the theory of partial differential equations of elliptic type with attention to Bergman's operator method.

—Allyn Jackson

Yao Receives Turing Award

The Association for Computing Machinery (ACM) has given its Turing Award for 2001 to Andrew Yao of Princeton University. He received the award in recognition of his fundamental contributions to the theory of computation, including the complexity-based theory of pseudorandom number generation, cryptography, and communication complexity.

The award, named for Alan Turing, includes a $25,000 prize and is given for technical contributions "of lasting and major technical importance to the computer field."

—From an ACM announcement

Arnol'd Receives 2001 Heineman Prize

VLADIMIR I. ARNOL'D of the Steklov Institute of Mathematics, Russia, has been awarded the 2001 Dannie Heineman Prize for Mathematical Physics for his contributions to the understanding of dynamics and of singularities of maps, with profound consequences for mechanics, astrophysics, statistical mechanics, hydrodynamics, and optics. The prize carries a cash award of $7,500 and is presented in recognition of outstanding publications in the field of mathematical physics.

The Heineman Prize was established in 1959 by the Heineman Foundation for Research, Educational, Charitable, and Scientific Purposes, Inc., and is administered jointly by the American Physical Society (APS) and the American Institute of Physics (AIP). The prize is presented annually.

—From an APS announcement

Dongarra Elected to NAE

The National Academy of Engineering (NAE) has announced the election of seventy-four members and eight foreign associates. One mathematical scientist was elected, JACK J. DONGARRA of the University of Tennessee, Knoxville. Dongarra was elected for his contributions to numerical software, parallel and distributed computation, and problem-solving environments.

—From an NAE announcement

Kenyon Receives Rollo Davidson Prize

The trustees of the Rollo Davidson Trust have awarded the Rollo Davidson Prize for 2001 to RICHARD KENYON of the Université de Paris-Sud. Kenyon received the prize in recognition of his achievements in the study of discrete lattice systems, for his proof of the scaling limit and conformal invariance of domino tilings and the uniform spanning tree in two dimensions.

The prize was established to commemorate the life and work of Rollo Davidson and is awarded to young scientists of outstanding promise and achievements for work in probability, statistics, and related areas.

—From a Rollo Davidson Trust announcement

Golubitsky and Stewart Receive Sunyer i Balaguer Prize

The Institut d'Estudis Catalans has awarded the 2001 Ferran Sunyer i Balaguer Prize jointly to MARTIN GOLUBITSKY of the University of Houston and IAN STEWART of the University of Warwick, England, for their monograph *The Symmetry Perspective: From Equilibrium to Chaos in Phase Space and Physical Space*. The prize consists of 10,000 euros (about US$9,000). According to the terms of the prize, the monograph will be published in the Birkhäuser series Progress in Mathematics.

The Ferran Sunyer i Balaguer Prize is awarded each year for a mathematical monograph of an expository nature presenting the latest developments in an active area of mathematics research in which the author has made important contributions.

—From an Institut d'Estudis Catalans announcement

2001 Sloan Fellows Announced

The Alfred P. Sloan Foundation has announced the names of 104 outstanding young scientists and economists who have been selected to receive Sloan Research Fellowships. Grants of $40,000 for a two-year period are administered by each fellow's institution. Once chosen, fellows are free to pursue whatever lines of inquiry most interest them, and they are permitted to employ fellowship funds in a wide variety of ways to further their research aims.

More than four hundred nominations for the 2001 awards were reviewed by a committee of distinguished scientists. The mathematicians on the committee were: George C. Papanicolaou, Stanford University; Peter Sarnak, Princeton University; and Ronald J. Stern, University of California, Irvine.

The 2001 Sloan Fellows in mathematics are: YURI BEREST, Cornell University; HUBERT L. BRAY, Massachusetts Institute of Technology; JARED C. BRONSKI, University of Illinois at Urbana-Champaign; DAVID CAI, University of North Carolina; EMMANUEL J. CANDES, California Institute of Technology; BRIAN CONRAD, University of Michigan; ANDREA GOLDSMITH, Stanford University; DMITRY JAKOBSON, McGill University; ALEXANDER KISILEV, University of Chicago; DMITRY KLEINBOCK, Brandeis University; ALLEN KNUTSON, University of California, Berkeley; AI-KO LIU, University of California, Berkeley; NADER MASMOUDI, New York University; ALEXANDER POLISHCHUK, Boston University; WILHELM SCHLAG, Princeton University; DIMITRI SHLYAKHTENKO, University of California, Los Angeles; CHRISTOPHER M. SKINNER, University of Michigan; KONSTANTINA TRIVISA, University of Maryland; CATHERINE HUAFEI YAN, Texas A&M University; and JIU-KANG YU, University of Maryland.

—Alfred P. Sloan Foundation announcement

NSF Graduate Research Fellowships Announced

The National Science Foundation (NSF) has awarded its Graduate Research Fellowships for fiscal year 2001. This program supports students pursuing doctoral study in all areas of science and engineering and provides a stipend of $18,000 per year for three years of full-time graduate study. Listed below are the names of the awardees in the mathematical sciences for 2001, followed by their undergraduate institutions (in parentheses) and the institutions at which they plan to pursue graduate work.

SAMI H. ASSAF (University of Notre Dame), University of California, Berkeley; ANDREA K. BARREIRO (Rensselaer Polytechnic Institute), New York University; MACIEJ F. BONI (Princeton University), Cornell University; JY-YING J. CHEN (Stanford University), Harvard University; MICHAEL J. COLSHER (Duke University), New York University; EDGARDO S. CUREG (University of the Philippines), University of South Florida; MICHELLE C. DUNN (Harvard University), Carnegie Mellon University; NICHOLAS K. ERIKSSON (Massachusetts Institute of Technology), University of California, Berkeley; JOHANNA N. Y. FRANKLIN (Carnegie Mellon University), University of California, Berkeley; MATTHEW T. GEALY (University of Chicago), Massachusetts Institute of Technology; PHILIP T. GRESSMAN (Washington University), Massachusetts Institute of Technology; JAIME J. HALETKY (Rensselaer Polytechnic Institute), University of California, Berkeley; DION K. HARMON (Cornell University), Massachusetts Institute of Technology; RICHARD C. HAYNES (Williams College), Harvard University; CHRISTOPHER J. HILLAR (Yale University), University of California, Berkeley; JAMES KELLEY (Pennsylvania State University), University of California, Berkeley; PETER S. KIM (Massachusetts Institute of Technology), University of Chicago; SARAH C. KOCH (Rensselaer Polytechnic Institute), Brown University; FUMEI LAM (University of California, Berkeley), Massachusetts Institute of Technology; JOHANN K. LEIDA (University of St. Thomas, MN), Massachusetts Institute of Technology; CARL A. MILLER (Duke University), Harvard University; MANISH M. PATNAIK (Massachusetts Institute of Technology), University of Chicago; SAMUEL D. PAYNE (Princeton University), University of California, Berkeley; ALEXANDER PEKKER (Stanford University), Harvard University; MICHAEL M. SCHEIN (California Institute of Technology), Princeton University; SUZANNE S. SINDI (California State University, Fullerton), Cornell University; SETH M. SULLIVANT (University of California, Berkeley), Massachusetts Institute of Technology; JOAQUIN T. THOMAS (Yale University), University of Cambridge, England; JUSTIN L. TUMLINSON (Northern Arizona University), Massachusetts Institute of Technology; BART VAN STEIRTEGHEM (Free University of Brussels), Columbia University; and XIAOHUI WANG (Nanjing University, China), University of North Carolina, Chapel Hill.

Editor's note: The institutions of graduate study listed here are from the students' original applications. In some cases students will have switched institutions by the time the fellowship tenure begins.

—From an NSF announcement

Guggenheim Fellowships Awarded

The John Simon Guggenheim Memorial Foundation has announced the names of 183 artists, scholars, and scientists who were selected as Guggenheim Fellows from more than 2,700 applicants in the 2001 competition. The awards totaled $6,588,000. Guggenheim Fellows are appointed on the basis of distinguished achievement in the past and exceptional promise for future accomplishment.

Following are the names of the awardees who work in the mathematical sciences, together with their affiliations and areas of research interest. MICHAEL C. FERRIS, University of Wisconsin, Madison: Optimization for medical applications; ARTHUR J. KRENER, University of California, Davis: Normal forms and bifurcations of control systems; FREYDOON SHAHIDI, Purdue University: New instances of functoriality; KAREN K. UHLENBECK, University of Texas, Austin: A geometric approach to soliton and wave equations; GUNTHER UHLMANN, University of Washington: Inverse boundary problems; RUTH J. WILLIAMS, University of California, San Diego: Mathematical theory for stochastic networks.

—From a Guggenheim Foundation news release

Fulbright Awards Announced

The J. William Fulbright Foundation and the United States Information Agency have announced the names of the recipients of the Fulbright Foreign Scholarships for 2000–2001. Following are the U.S. scholars in the mathematical sciences who have been awarded Fulbright scholarships to lecture or conduct research, together with their home institutions and the geographical areas in which they plan to use the awards.

DER-CHEN E. CHANG, Georgetown University: Taiwan; UDAYAN B. DARJI, University of Louisville: Hungary; SABER N. ELAYDI, Trinity University, Texas: West Bank; THOMAS E. GILSDORF, University of North Dakota: Mexico; ANDRZEJ S. GUTEK, Tennessee Technological University: Cameroon; DAVID W. HENDERSON, Cornell University: Latvia; CONSTANTINE K. KLIORYS, Gannon University: Lithuania; WELDON A. LODWICK, University of Colorado, Denver: Portugal; JAMES H. MATIS, Texas A&M University, College Station: India.

—From a Fulbright Foundation announcement

2001 Intel Science Talent Search Winners Announced

Two students working in mathematics have been awarded an Intel Science Talent Search scholarship for 2001. GABRIEL D. CARROLL, eighteen years old and a student at Oakland Technical High School in Oakland, California, was awarded third place and a $50,000 scholarship for his project "Homology of Narrow Partially Ordered Sets (Posets)", in which he studied partial orders by investigating the shape of a related geometric space. Carroll is first in his class and is president of the school's math club. He has won numerous mathematics awards, including a gold medal in 1998 and a silver medal in 1999 at the International Mathematical Olympiad.

Fourth place honors, plus a $25,000 scholarship, went to 17-year-old Alan Mark Dunn of Potomac, Maryland, a student at Montgomery Blair High School, for his computer science project "Optimization of Advanced Encryption Standard Candidate Algorithms for the Macintosh G4". Dunn used two different strategies to optimize five algorithms. Each strategy was successful to some degree, increasing the speed of most algorithms by 200% to 400%. Dunn is a coauthor of a paper for the 15th European Meeting on Cybernetics and Systems Research.

The Intel Science Talent Search is the oldest and most respected high school science scholarship competition in the United States. Five previous winners have gone on to receive Nobel Prizes. The total value of the Intel awards is $1.25 million. The forty finalists received awards ranging from $5,000 to $100,000.

—From an Intel Corporation announcement

Deaths

Thomas Albert Beiter, of Mansfield, OH, died on February 8, 2001. Born on January 21, 1947, he was a member of the Society for 8 years.

Philippe M. A. Benilan, of the Université de Franche-Comte, died on February 17, 2001. Born on October 6, 1940, he was a member of the Society for 11 years.

Winifred K. Burroughs, of West Grove, PA, died on March 9, 2001. Born on November 15, 1919, she was a member of the Society for 54 years.

Leonard Carlitz, of Palo Alto, CA, died on September 17, 1999. Born in December 1907, he was a member of the Society for 72 years.

Ben Fitzpatrick Jr., of Waverly, AL, died on November 11, 2000. Born on September 28, 1932, he was a member of the Society for 44 years.

C. R. Kossack, of North Haven, CT, died on March 22, 2001. Born on May 16, 1906, he was a member of the Society for 53 years.

Wendell D. Lindstrom, professor emeritus, Kenyon College, OH, died on December 8, 1999. Born on February 7, 1927, he was a member of the Society for 46 years.

Wilbur T. McKinney, of San Diego, CA, died on February 7, 2001. Born on August 25, 1910, he was a member of the Society for 43 years.

Crispin St. J. A. Nash-Williams, emeritus professor, University of Reading, England, died on January 20, 2001. Born on December 19, 1932, he was a member of the Society for 30 years.

Robert A. Rankin, professor emeritus, University of Glasgow, died on January 27, 2001. Born on October 27, 1915, he was a member of the Society for 54 years.

David Rosenblatt, of Washington, DC, died on March 10, 2001. Born on September 7, 1919, he was a member of the Society for 44 years.

Ahmad Hani Shamsuddin, of American University of Beirut, Lebanon, died on April 5, 2001. Born on December 28, 1951, he was a member of the Society for 8 years.

Robert Simon, vice president, Leasing Tech. International, Darien, CT, died on February 11, 2001. Born on December 25, 1919, he was a member of the Society for 49 years.

James R. Smith, of Appalachian State University, Boone, NC, died on December 16, 2000. Born on June 6, 1942, he was a member of the Society for 31 years.

Victor R. Staknis, retired, Northeastern University, died on January 18, 2001. Born on June 14, 1920, he was a member of the Society for 48 years.

Indulis Strazdins, of Riga Technical University, Latvia, died on April 3, 2001. Born on March 31, 1934, he was a member of the Society for 24 years.

Ernst-Jochen Thiele, professor emeritus, Technische Universität Berlin, died on February 22, 2001. Born on September 9, 1928, he was a member of the Society for 39 years.

Clifford A. Truesdell III, professor emeritus, Johns Hopkins University, died on January 14, 2000. Born on February 18, 1919, he was a member of the Society for 22 years.

Arthur G. Walker, of West Sussex, England, died on March 31, 2001. Born on July 17, 1909, he was a member of the Society for 54 years.

Charles H. Wheeler, of Richmond, VA, died on September 16, 2000. Born on October 30, 1904, he was a member of the Society for 68 years.

Helmut W. Wielandt, professor emeritus, Universität Tübingen, died on February 14, 2001. Born on December 19, 1910, he was a member of the Society for 40 years.

J. W. Zimmer, of Severna Park, MD, died in August 2000. Born on September 18, 1909, he was a member of the Society for 61 years.

Mathematics Opportunities

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, 2001**. Applications must be submitted via FastLane on the World Wide Web. Go to `http://www.fastlane.nsf.gov/` and click on "Postdoctoral Fellowships". Information can be found there for the Mathematical Sciences Postdoctoral Research Fellowships as well as other NSF fellowship opportunities. For more information contact the DMS by telephone, 703-306-1870, or by e-mail: `msprf@nsf.gov`.

—From an NSF announcement

Call for VIGRE Proposals

The Division of Mathematical Sciences (DMS) of the National Science Foundation has announced a new competition for Grants for Vertical Integration of Research and Education in the Mathematical Sciences, known as VIGRE grants.

VIGRE grants are designed to allow departments in the mathematical sciences to carry out innovative educational programs in which research and education are integrated and in which undergraduates, graduate students, postdoctoral fellows, and faculty are mutually supportive. The goals of VIGRE are: (1) to prepare undergraduate students, graduate students, and postdoctoral fellows for the broad range of opportunities available to individuals with training in the mathematical sciences; and (2) to encourage departments in the mathematical sciences to initiate or improve education activities that lend themselves to integration with research, especially activities that promote the interaction of scholars across boundaries of academic age and departmental standing.

The deadline for proposals for the new competition is **July 17, 2001**. At present the DMS funds about thirty VIGRE grants. The number of grants to be awarded in the new competition will be determined based on the quality of proposals received. For further information consult the DMS Web site, `http://www.nsf.gov/mps/dms/`.

—Allyn Jackson

Travel Grants Available for ICM

The International Mathematical Union (IMU) will award grants to young mathematicians to cover travel expenses to the International Congress of Mathematicians (ICM), to be held in Beijing, China, August 20-28, 2002. The grants are intended for young mathematicians from developing countries that are not necessarily members of the IMU. (Mathematicians from Eastern European countries are not eligible for this program but will be considered directly by the local organizing committee of the ICM.) Applicants must be under 35 years of age at the time of the congress and should have done research work at the postdoctoral level.

The deadline for receipt of applications is **January 31, 2002**. More information about the grants and the congress can be obtained at the IMU Web site, `http://elib.zib.de/IMU/`, or by contacting Phillip A. Griffiths, Secretary, IMU, Institute for Advanced Study, Einstein Drive, Princeton, NJ 08540; telephone 609-734-8200; fax 609-683-7605; e-mail: `imu@ias.edu`.

—From an IMU announcement

Call for Nominations for National Medal of Science

The President's Committee on the National Medal of Science is calling for nominations for the 2002 medal. The National Medal of Science is awarded to individuals in recognition of outstanding contributions to knowledge in the fields of mathematical, physical, biological, engineering, and social and behavioral sciences.

The deadline for nominations for the 2002 award is **June 30, 2001**. Further information, guidelines, and instructions for submitting nominations electronically can be found on the Web site of the National Science Foundation (NSF) at `http://www.nsf.gov/nsb/awards/nms/start.htm`.

—From an NSF announcement

Call for Nominations for Sloan Fellowships

Nominations for candidates for Sloan Research Fellowships, sponsored by the Alfred P. Sloan Foundation, are due by **September 15, 2001**. A candidate must be a member of the regular faculty at a college or university in the United States or Canada and must be at an early stage in his or her research career. For information write to: Sloan Research Fellowships, Alfred P. Sloan Foundation, 630 Fifth Avenue, Suite 2550, New York, NY 10111; or consult the foundation's Web page `http://www.sloan.org/`.

—From a Sloan Foundation announcement

2002–03 Fulbright Awards for U.S. Faculty and Professionals

The Fulbright Scholar Program offers opportunities for lecturing or advanced research in nearly 140 countries to college and university faculty and professionals outside academe. U.S. citizenship and a Ph.D. or comparable professional experience are required. For lecturing awards, university or college teaching experience is expected. Foreign language skills are needed in some countries, but most lecturing assignments are in English. The terms of the awards vary from two months to one academic year, sometimes longer. The deadline is: **August 1, 2001**, for lecturing and research grants in the academic year 2002–03.

For further information contact the Council for International Exchange of Scholars (CIES), 3007 Tilden Street, NW, Suite 5L, Washington, DC 20008-3009; telephone 202-686-7877; World Wide Web `http://www.cies.org/cies/pr_competit_02.htm`. Online application materials are available at `http://www.cies.org/`.

—From a CIES announcement

NSF CAREER Program Guidelines Available

The guidelines for the Faculty Early Career Development (CAREER) Program of the National Science Foundation (NSF) are now available on the World Wide Web. The announcement number is NSF 01-84. Information is available at `http://www.nsf.gov/cgi-bin/getpub?nsf0184/`. Proposals must be submitted electronically. The deadline is **July 26, 2001**.

The CAREER program supports junior faculty who combine strong research activity with a genuine and substantive involvement in education. For the FY2002 competition, the minimum award size is $300,000 in total. The award duration for all CAREER awards is five years.

NSF will select from the most meritorious awardees supported by the CAREER program the nominees for Presidential Early Career Awards for Scientists and Engineers (PECASE). Beginning with the FY2001 competition, the PECASE award is an entirely honorary award for all NSF recipients and does not provide additional funds.

Last year the NSF's Division of Mathematical Sciences responded to the high quality of the proposals in the competition by increasing the number of its CAREER awards to about twelve (a significant increase from prior years). In the upcoming competition the Division plans to continue to increase funding available for the very high-quality proposals received.

—From an NSF announcement

For Your Information

Proof Playwright Wins Pulitzer

DAVID AUBURN, author of the Broadway hit *Proof*, won the 2001 Pulitzer Prize for drama. The play has four characters, three of whom are mathematicians, and the plot centers on a mystery about the author of a certain mathematical proof. The play opened to wide acclaim in New York City in May 2000 and moved to Broadway in October of that year. A review appeared in the October 2000 issue of the *Notices*, pages 1082–84. To mark the awarding of the Pulitzer, this issue of the *Notices* carries a new review (pages 596-597).

David Auburn, 31 years old, lives in Williamstown, Massachusetts. He is the recipient of a number of awards, including a Guggenheim Fellowship. He is a graduate of the playwrighting program at the Juilliard School.

—*Allyn Jackson*

Call for Mathematician Mentors

Making Mathematics is a National Science Foundation-funded program that pairs mathematicians with secondary students and teachers to work on research-like problems in mathematics.

This program stems from years of work in schools, in which students get involved with mathematics projects that provide genuine research experiences. Making Mathematics is based on the belief that, while frontline mathematical research problems are out of reach for non-specialists, the methods used by research mathematicians are accessible to almost all young people. Developing the habits of mind used by working scientists and mathematicians is of immense and lasting value to all students, no matter what they do with their lives.

This kind of work is unfamiliar to many students and teachers. That is why the involvement of mathematicians as online mentors to students and their teachers is essential to the program. A mentor's role is to help students and teachers ask themselves the right questions, point them to available resources, help them build their mathematical background when necessary, and help them navigate their path through the problem-solving and research process.

Making Mathematics is seeking mathematicians—college and university faculty, mathematically educated professionals involved in various technical/professional fields, and mathematics graduate students—to apply to become mentors. Mentors exchange e-mail with students and/or teachers approximately once a week for a span of approximately 3 to 6 months and assist with the process of conducting mathematics research. The project supports a mentor training program as well as materials and resources to help mentors acclimate to online mathematical communication with teachers and students.

There are many ways mathematicians can contribute to K-12 education, but working with an eager student on a mathematical problem of substance is one of the most rewarding and important. The project Web site and materials are designed, maintained, and facilitated by staff from the Center for Mathematics Education at Education Development Center, Inc. For more information visit `http://www2.edc.org/makingmath/`, send e-mail to `dmrs@edc.org`, or contact Jean Benson, Making Mathematics, Education Development Center, Inc., 55 Chapel Street, Newton, MA 02458; telephone 617-969-7100.

—*Educational Development Center announcement*

45th Reunion Conference for Ross Program

On July 27-29, 2001, a reunion conference celebrating the 45th year of the Ross Summer Mathematics Program will be held at the Ohio State University. The program, begun by Arnold E. Ross in 1957, brings together some of the most mathematically talented students in the U.S. for eight intensive weeks of mathematical discovery. The conference will be a time for friends of Ross, now 94 years old, and alumni of his program to renew contact and to celebrate the ongoing mission of the Ross Program.

The conference will feature scientific lectures on a variety of topics, some of them geared to current participants in the Ross Program. Capping the conference will be a banquet sponsored by the Clay Mathematics Institute, which has worked in partnership with the Ross Program for the past two years.

More information about the Ross Reunion Conference is available on the Web site http://www.math.ohio-state.edu/ross/rossconf2001.html.

—Allyn Jackson

Undergraduate Paper Competitions in *Cryptologia*

Two undergraduate paper competitions have been announced, each with a $300 cash prize and publication in *Cryptologia*, a refereed journal. Both the Annual Undergraduate Paper Competition in Cryptology and the Annual Greg Mellen Memorial Cryptology Scholarship Prize are sponsored by *Cryptologia* to encourage the study of all aspects of cryptology in the undergraduate curricula.

The topics of the papers may be in any area of cryptology—technical, historical, and literary subjects. Papers must be no more than 20 typewritten pages in length, double spaced, and fully referenced. Four copies must be submitted. Authors should keep one copy. Papers are to be original works that have not been published previously.

The closing date for both competitions is **December 31** for the year of entry. The winner(s) will be announced on April 1, with publication of the winning paper in a later issue of *Cryptologia*. Papers will be judged by the editors of *Cryptologia*. The address for further information or to make submissions is: *Cryptologia*, Department of Mathematical Sciences, United States Military Academy, West Point, NY 10996; e-mail: Cryptologia@usma.edu; World Wide Web: http://www.dean.usma.edu/math/resource/pubs/crypto/index.htm.

—From a Cryptologia *announcement*

Volunteers Sought for AWM Essay Contest

To increase awareness of women's contributions to the mathematical sciences, the Association for Women in Mathematics (AWM) is sponsoring a student essay contest. Contestants will write biographical essays of contemporary women mathematicians and statisticians in academic, industrial, and government careers. The essays will be based on personal interviews conducted by the contestants with professional women in the mathematical sciences.

The contest is open to students in the following categories: middle school, high school, undergraduate, and graduate. At least one winning entry will be chosen from each category. Winners will receive a prize, and their essays will be published online at the AWM Web site. A grand prize winner will have his or her entry published in the AWM newsletter as well. The deadline for entries is **November 1, 2001**.

The AWM is seeking women mathematicians to volunteer to be interviewed for these essays. For more information see the AWM Web site, http://www.awm-math.org/biographies/contest.html, or send e-mail to the contest organizer, Victoria Howle, at vehowle@sandia.gov.

—From an AWM announcement

Corrections

The April 2001 issue of the *Notices* carried an announcement about the 2001 Satter Prize. The announcement misstated the amount of the prize; the correct amount is $4,000.

In the announcement in the April 2001 issue of the award of the 2001 Veblen Prize to Jeff Cheeger, Yakov Eliashberg, and Michael J. Hopkins, the response from Cheeger was not faithfully reproduced from the version distributed on January 11, 2001, at the prize ceremony at the Joint Mathematics Meetings in New Orleans. In particular, in the third paragraph "the splitting theorem and volume cone imply the metric cone theorem" should have read "the splitting theorem and volume cone implies metric cone theorem"; in the fourth paragraph "conjectures of Anderson's and mine" should have read "conjectures of Anderson and myself"; and in the fifth paragraph "one could do index theory L_2-cohomology on singular spaces" should have read "one could do index theory for L_2-cohomology on singular spaces."

Inside the AMS

"Mathematical Moments" Program Launched

The AMS Public Awareness Office has created a series of one-page flyers called "Mathematical Moments" which describe important uses of mathematics in science, technology, and human culture. Each "Mathematical Moments" flyer focuses on a single topic, such as aircraft design, fractals, heart modeling, the Internet, music, or weather prediction. The flyers are illustrated with colorful graphics and supply references for more in-depth treatment of the topics described.

The "Mathematical Moments" provide a handy, eye-catching, and concise way to reach such audiences as elected officials, precollege students, and school teachers and administrators. Paper copies of "Mathematical Moments" have been distributed to the approximately 500 chairs of mathematics departments that are institutional members of the Society. The flyers may also be downloaded from the Web site `http://www.ams.org/ams/mathmoments.html`. Feedback about the flyers is welcome and may be directed to the AMS Public Awareness Officers, Mike Breen and Annette Emerson (e-mail: `pa-office@ams.org`).

—Allyn Jackson

AMS Receives Grant for Students to Attend "Math in Moscow"

The AMS has received a grant from the National Science Foundation that will support the participation of ten U.S. undergraduate students per year in the "Math in Moscow" program. Held at the Independent University of Moscow, the semester-long program draws on the Russian tradition of teaching mathematics, emphasizing a creative approach and in-depth understanding. The teachers in the program have significant connections with contemporary research topics, and most are internationally recognized mathematicians.

The fellowships supported by the grant offer a standard award to be applied toward tuition, travel, and living expenses. The AMS has assembled a committee to screen applicants for the fellowships. For further information, including instructions on applying, visit the Web site `http://www.ams.org/careers-edu/mimoscow.html`, or write to: Professional Services Department, AMS, 201 Charles Street, Providence, RI 02904.

Further information about "Math in Moscow" is available on the Web at `http://www.mccme.ru/mathinmoscow/`, or by writing to: Math in Moscow, P.O. Box 524, Wynnewood, PA 19096.

—Allyn Jackson

Joint Testimony by Society Presidents

On March 21, 2001, AMS president Hyman Bass, together with three other scientific organization officials, gave testimony before the House Subcommittee on Veterans Affairs, Housing and Urban Development, and Independent Agencies. This subcommittee is responsible for appropriations for the National Science Foundation (NSF).

Joining Bass in the presentation were George Trilling, president of the American Physical Society; Mary J. C. Hendrix, president of the Federation of American Societies for Experimental Biology; and Eli M. Pearce, president-elect of the American Chemical Society. This testimony was presented at a crucial time, when the scientific community had learned that the Bush administration planned to request only a 1.3 percent increase for the NSF for fiscal year 2002. In Congress there is widespread support for the NSF, so this increase may be enlarged as the budget moves through Congress. The testimony by the four presidents called on the subcommittee to provide the NSF with a 15 percent increase in fiscal 2002.

Bass's portion of the testimony was as follows.

"Mr. Chairman, Mr. Mollohan, and members of the Subcommittee, research supported by the National Science Foundation has had a monumental impact. The NSF investment has enabled the U.S. to build a scientific infrastructure second to none, facilitated revolutionary research that pushes the frontiers of knowledge, and laid the groundwork for innovation that has resulted in a vibrant economy and a superior quality of life. Many new products, procedures, and methods have accrued from the NSF investment in basic research—research performed over many years and not always predetermined toward a specific application. Society, unaware for the most part how basic research impacts daily life, enjoys many benefits from NSF investments. I would like to highlight a few examples.

"Mary Hendrix just presented four brief case stories about NSF-supported research in medicine and disease. Let me add one more that illustrates the role of mathematics in this arena. Every year tens of thousands of people in the U.S. receive artificial heart valve implants. NSF currently supports a group of mathematicians studying unsteady fluid flows driven by dynamic boundaries. The heart valve is an excellent example of such a boundary. The results of this kind of mathematics research have had a dramatic impact on heart valve design and functionality.

"Lighter replacements for structural steel, such as strong and resilient plastics, are also the result of research supported by NSF, in this case in the area of chemical engineering. In less than a minute, two or more reactive chemicals can now be mixed, molded, and cured. The result is molded plastic that reduces automobile repair and insurance costs and reduces fuel consumption. Public benefits accrue from reduced air pollution as well.

"Let me turn to Web searching and surfing, which have become as commonplace as driving a car. Today's Web browsers and search engines grew out of NSF-supported research. Mosaic, software developed by a University of Illinois student, is the basis for Internet Explorer and Netscape. The search engines Excite and Infoseek owe their origins to the NSF, as does Thomas, the search engine used by the Library of Congress.

"Bar codes—those ubiquitous symbols stamped on everything from packages and magazines to store tags and grocery items—provide another example of benefits from NSF-supported research. In the 1970s NSF helped fund research to improve the accuracy of bar code scanners. Later in the 1990s NSF supported efforts that eventually led to a new type of bar code reader that can operate under adverse and messy conditions. Continuing research is focused on developing two-dimensional bar codes that will allow more information to be represented in a very compact form. I think it safe to say that almost every citizen in the U.S., perhaps even the world, has been affected by this research.

"I would be remiss if I didn't mention the contribution that NSF makes to science and mathematics education, an area that is critical to our nation's future. Trained as a mathematician who has spent the bulk of his career in mathematical research, I personally have pursued research in the teaching and learning of mathematics for the past decade.

"We must improve student learning in mathematics and science if our population is to participate fully in our country's technological growth and development. The NSF funds centers for learning and teaching that provide a mix of research, teacher education, and leadership development. These centers promote innovative professional development opportunities for in-service and pre-service teachers. Along with the Department of Education, the NSF also supports research in learning processes in mathematics, science and reading, an effort to identify ways of improving student learning. Finally, NSF supports educationally innovative projects in undergraduate education and is the lead federal agency supporting graduate research assistants in the physical sciences and mathematics.

"The work of NSF plays a critical role in the vitality of our country, in research and education. A future that will provide the opportunities and discoveries that will measure up to the successes of the last fifty years will require a continuing chain of discoveries in mathematics and science and a population better educated in mathematics and science. The health of the National Science Foundation is central to that success."

The complete testimony of all four participants is available on the Web at `http://www.ams.org/government/statehb301.html`.

—Allyn Jackson

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.

Information for *Notices* Authors

The *Notices* welcomes unsolicited articles for consideration for publication, as well as proposals for such articles. The following provides general guidelines for writing *Notices* articles and preparing them for submission.

***Notices* readership.** The *Notices* goes to about 30,000 subscribers worldwide, of whom about 20,000 are in North America. Approximately 8,000 of the 20,000 in North America are graduate students who have completed at least one year of graduate school. All readers may be assumed to be interested in mathematics research, but they are not all active researchers.

***Notices* feature articles.** Feature articles may address mathematics, mathematical news and developments, mathematics history, issues affecting the profession, mathematics education at any level, the AMS and its activities, and other such topics of interest to *Notices* readers. Each article is expected to have a large target audience of readers, perhaps 5,000 of the 30,000 subscribers. Authors must therefore write their articles for non-experts rather than for experts or would-be experts. In particular, the mathematics articles in the *Notices* are expository. The language of the *Notices* is English.

Most feature articles, including those on mathematics, are expected to be of long-term value and should be written as such. Ideally each article should put its topic in a context, providing some history and other orientation for the reader and, as necessary, relating the subject matter to things that readers are likely to understand. In most cases, articles should progress to dealing with contemporary matters, not giving only historical material. The articles that are received the best by readers tend to relate different areas of mathematics to each other.

By design the *Notices* is partly magazine and partly journal, and authors' expository styles should take this into account. For example, many readers want to understand the mathematics articles without undue effort and without consulting other sources.

Mathematics feature articles in the *Notices* are normally six to nine pages, sometimes a little longer. Shorter articles are more likely to be read fully than are longer articles. The first page is 400 or 500 words, and subsequent pages are about 800 words. From this one should subtract an allowance for figures, photos, and other illustrations,

Where To Find It

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

and an appropriate allowance for any displayed equations and any bibliography.

Form of articles. Except with very short articles, authors are encouraged to use section headings and subsection headings to help orient readers. Normally there is no section heading at the beginning of an article. Despite the encouraged use of internal headings, the assigning of numbers to sections and subsections is not permitted in any article.

The bibliography should be kept short. In the case of mathematics articles, bibliographies are normally limited to about ten items and should consist primarily of entries like books in which one may do further reading. To help readers who might want lists of recent literature, an author might include a small number of recent publications with good bibliographies.

Editing process. Most articles that are destined to be accepted undergo an intensive editing process. The purposes of this process are to ensure that the target audience is as large as practicable, that the content of the article is clear and unambiguous, and that the article is relatively easy to read. Usually it is the members of the editorial board who are involved in this process. Sometimes outside referees are consulted.

Preparation of articles for submission. The preferred form for submitted articles is as electronic files. Authors who cannot send articles electronically may send the articles by fax or by postal mail.

Articles with a significant number of mathematical symbols are best prepared in TeX, LaTeX, or AMS-TeX. There are no special style files for the *Notices* because TeX code gets converted to something else during the production process. Since the *Notices* is set in narrow columns, keeping displayed formulas relatively short helps to minimize adjustments during the production process; avoiding nonstandard supplementary files and complex sequences of TeX definitions also helps. For the handling of figures and other illustrations, please consult the editor.

Articles without a significant number of mathematical symbols may be prepared as text files or in Microsoft Word. In the case of files prepared in Microsoft Word, it is advisable to send both the file and a fax of a printout.

Upcoming Deadlines

June 30, 2001: Nominations for the 2002 National Medal of Science. See "Mathematics Opportunities" in this issue.

July 26, 2001: Proposals for Faculty Early Career Development (CAREER) Program, NSF. See "Mathematics Opportunities" in this issue.

July 30, 2001: VIGRE program, NSF. See "Mathematics Opportunities" in this issue.

August 1, 2001: Applications for Fulbright Scholar lecturing and research grants. See "Mathematics Opportunities" in this issue.

August 15, 2001: Applications for the third competition for NRC Research Associateships. See http://www4.nationalacademies.org/osep/rap/, 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; e-mail: rap@nas.edu.

September 1, 2001: Applications for AWM Workshops for Women Graduate Students and Postdocs. See http://www.awm-math.org/, or contact Workshop Selection Committee, Association for Women in Mathematics, 4114 Computer & Space Sciences Building, University of Maryland, College Park, MD 20742-2461; telephone 301-405-7892; e-mail: awm@math.umd.edu.

September 15, 2001: Nominations for Alfred P. Sloan Research Fellowships. See "Mathematics Opportunities" in this issue.

October 1, 2001: Nominations for the Louise Hay and Alice T. Schafer awards of the AWM. Call the AWM at 301-405-7892 or send e-mail to awm@math.umd.edu.

October 1, 2001: Nominations for the Emanuel and Carol Parzen Prize. Submit nominations to J. H. Matis, Department of Statistics, Texas A&M University, College Station, TX 77873-3143.

October 1, 2001: Applications for NSF/AWM Travel Grants for Women. See http://www.awm-math.org/travelgrants.html; telephone 301-405-7892; e-mail: awm@math.umd.edu.

October 17, 2001: Applications for NSF Postdoctoral Research Fellowships. See "Mathematics Opportunities" in this issue.

December 31, 2001: Submissions for undergraduate paper contest in *Cryptologia*. See "For Your Information" in this issue.

January 31, 2002: Applications for travel grants for ICM 2002. See "Mathematics Opportunities" in this issue.

New Journals for 2000

Below is a list of mathematical journals appearing for the first time in 2000, as compiled by *Mathematical Reviews*. This list, as well as the listings for new journals for other years, can be found on the Web at http://www.ams.org/mathweb/mi-newjs.html.

Journal of Inequalities in Pure and Applied Mathematics, 1443-5756, Victoria University.

Book List

*The **Book List** highlights books that have mathematical themes and hold appeal for a wide audience, including mathematicians, students, and a significant portion of the general public. When a book has been reviewed in the* Notices, *a reference is given to the review. Generally the list will contain only books published within the last two years, though exceptions may be made in cases where current events (e.g., the death of a prominent mathematician, coverage of a certain piece of mathematics in the news) warrant drawing readers' attention to older books. Suggestions for books to include on the list may be sent to the managing editor, e-mail:* notices@ams.org.

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

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

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

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

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

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

* *A Concise History of Mathematics*, by Dirk J. Struik. Dover Publications, 1987. ISBN 0-486-60255-9. (Reviewed in this issue.)

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

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

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

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

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

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

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

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

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

Excursions into Mathematics: Millennium Edition, by Anatole Beck, Michael N. Cleicher, and Donald W. Crowe. A K Peters, 2000. ISBN 1-56881-115-2.

Exploring Randomness, Gregory J. Chaitin. Springer, December 2000. ISBN 1-85233-417-7.

The Fermat Diary, by C. J. Mozzochi. AMS, October 2000. ISBN 0-8218-2670-0.

Finite vs. Infinite, Contributions to an Eternal Dilemma, Cristian S. Calude and Gheorghe Paun, editors. Springer, 2000. ISBN 1-85233-251-4.

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

The Game's Afoot! Game Theory in Myth and Paradox, by Alexander Mehlmann. AMS, April 2000. ISBN 0-8218-2121-0.

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

Gödel: A Life of Logic, by John L. Casti and Werner DePauli. Perseus, August 2000. ISBN 0-738-20274-6.

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

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

* *How to Solve It: Modern Heuristics*, by Zbigniew Michalewicz and David B. Fogel. Springer, 2000. ISBN 3-540-66061-5.

The Kingdom of Infinite Number: A Field Guide, by Bryan Bunch. W. H. Freeman, January 2000. ISBN 0-716-73388-9.

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

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

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

Mathematics Unlimited: 2001 and Beyond, Björn Engquist and Wilfried Schmid, editors. Springer, September 2000. ISBN 3-540-66913-2.

My Numbers, My Friends: Popular Lectures on Number Theory, by Paulo Ribenboim. Springer, February 2000. ISBN 0-387-98911-0.

The Mystery of the Aleph: Mathematics, the Kabbalah, and the Search for Infinity, by Amir D. Aczel. Four Walls Eight Windows, November 2000. ISBN 1-568-58105-X.

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

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

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

The Parrot's Theorem, by Denis Guedj. Weidenfeld & Nicolson, June 2000. ISBN 0-297-64578-1. (To be published in the U.S. by St. Martin's Press, September 2001, ISBN 0-312-28055-6.) (Reviewed March 2001.)

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

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

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

Riemann, Topology, and Physics, by Michael Monastyrsky; translated by Roger Cooke, James King, and Victoria King. Birkhäuser, second edition, May 1999. ISBN 3-764-33789-3.

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

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

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

The Symbolic Universe: Geometry and Physics 1890–1930, edited by

Jeremy Gray. Oxford University Press, September 1999. ISBN 0-198-50088-2.

Two Millennia of Mathematics: From Archimedes to Gauss, by George M. Phillips. Springer, July 2000. ISBN 0-387-95022-2.

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

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

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

The Unknowable, by Gregory J. Chaitin. Springer, August 1999. ISBN 9-814-02172-5.

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

Where Mathematics Comes From: How the Embodied Mind Brings Mathematics into Being, by George Lakoff and Rafael Nuñez. Basic Books, October 2000. ISBN 0-465-03770-4.

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

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

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

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

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The Joint Committee on Employment Opportunities has adopted the cover sheet on the facing page as an aid to job applicants and prospective employers. The form is now available on e-math in a TEX format which can be downloaded and edited. The purpose of the cover form is to aid department staff in tracking and responding to each application.

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

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- **55** Algebraic topology
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- **65** Numerical analysis
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- **81** Quantum theory
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Applications and recommendations are invited for a full-time position as an Associate Editor of *Mathematical Reviews* (MR), to commence as soon as possible after September 1, 2001, and no later than January 1, 2002.

The Mathematical Reviews division of the American Mathematical Society (AMS) is located in Ann Arbor, Michigan, not far from the campus of the University of Michigan. The editors are employees of the AMS; they also enjoy many privileges at the University. At present, MR employs fourteen mathematical editors, about six consultants, and a further sixty nonmathematicians. MR's mission is to develop and maintain the AMS databases of secondary sources covering the published mathematical literature. The chief responsibility is the development and maintenance of the MR Database, from which all MR-related products are produced: MathSciNet, the journals *Mathematical Reviews* and *Current Mathematical Publications,* MathSciDisc, and various other derived products. The responsibilities of an Associate Editor fall primarily in the day-to-day operations of selecting articles and books suitable for coverage in the MR database, classifying these items, determining the type of coverage, assigning those selected for review to reviewers, and editing the reviews in galley proof. An individual with expertise in probability and statistics (Sections 60 and 62) is sought. Considerable breadth in the areas covered by the MR Database is also required; the ability to write good English is essential and the ability to read mathematics in major foreign languages is important. It is desirable that the applicant have several years' relevant academic (or equivalent) experience beyond the Ph.D.

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Mathematics Calendar

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

June 2001

2-10 **Topological Fluid Mechanics**, Cetraro (Cosenza), Italy. (Apr. 2001, p. 434)

3 **The Heritage of I. Schur's 1901 Dissertation**, Gregynog Hall, Newtown, Powys, Wales. (May 2001, p. 528)

3-8 **The 6th International Conference on Mathematical Population Dynamics**, Marrakech, Morocco. (Jan. 2001, p. 52)

4-8 **CBMS Conference on Algebraic Combinatorics**, North Carolina State University, Raleigh, North Carolina. (Apr. 2001, p. 434)

4-8 **Conference on Algebraic Topology**, Gdansk, Poland. (Apr. 2001, p. 434)

4-8 **International Conference of Computational Harmonic Analysis**, City University of Hong Kong. (Dec. 2000, p. 1435)

4-9 **Fractals in Graz 2001: Stochastics-Analysis-Dynamics-Geometry**, Technical University of Graz, Graz, Austria. (Oct. 2000, p. 1146)

4-10 **Second Goteborg Conference in Harmonic Analysis and Partial Differential Equations**, Chalmers University of Technology/Goteborg University, Goteborg, Sweden. (Jan. 2001, p. 52)

6-8 **Analysis Conference on Nonlinear Phenomena in Science**, Free University, Amsterdam, The Netherlands. (May 2001, p. 528)

6-10 **The 3rd International Conference on Mathematical Biology**, Guilin, China. (Sept. 2000, p. 978)

7-9 **Conference on Hypergraphs (Gyula O.H. Katona is 60)**, Renyi Institute of Mathematics of the Hungarian Academy, Budapest, Hungary. (Apr. 2001, p. 434)

8-10 **Joint Meeting of the Belgian and German Mathematical Societies 2001 BMS-DMV Meeting**, University of Liege, Belgium. (Sept. 2000, p. 978)

8-10 **Nonlinear Dynamics and Chaos: Where Should We Go from Here?**, Burwalls Conference Centre, University of Bristol, UK. (Mar. 2001, p. 335)

10-13 **7th International Meeting on DNA Based Computers**, University of South Florida, Tampa, Florida. (Jan. 2001, p. 53)

11-15 **4th PIMS Graduate Industrial Mathematics Modelling Camp**, PIMS, University of Victoria, British Columbia, Canada. (Apr. 2001, p. 434)

11-15 **IMA Workshop: Haptics, Virtual Reality and Human Computer Interaction**, IMA, University of Minnesota, Minneapolis, Minnesota. (Sept. 2000, p. 978)

11-15 **Wave Phenomena III: Waves in Fluids from the Microscopic to the Planetary Scale**, PIMS-UA, Edmonton, Alberta, Canada. (Apr. 2001, p. 434)

11-22 **ESMTB School**, Sigüenza, Spain. (May 2001, p. 528)

11-22 **Workshop on Fourier Analysis and Convexity**, Università di Milano-Bicocca, Milano, Italy. (Mar. 2001, p. 335)

12-14 **M^{2}SABI'01-The IMACS/IFAC Fourth International Symposium on Mathematical Modelling and Simulation in Agricultural and Bio-Industries**, Haifa, Israel. (Mar. 2001, p. 335)

14-15 **Workshop on Theory and Applications of Satisfiability Testing**, Boston, Massachusetts. (Apr. 2001, p. 435)

14-16 **Lehigh University Geometry/Topology Conference**, Lehigh University, Bethlehem, Pennsylvania. (Apr. 2001, p. 435)

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

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

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

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

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

The Mathematics Calendar, as well as Meetings and Conferences of the AMS, is now available electronically through e-MATH on the World Wide Web. To access e-MATH, use the URL: `http://e-math.ams.org/` (or `http://www.ams.org/`). (For those with VT100-type terminals or for those without WWW browsing software, connect to e-MATH via Telnet (`telnet e-math.ams.org`; login and password `e-math`) and use the Lynx option from the main menu.)

* 14-17 **CabriWorld 2001**, UQAM, Montreal, Quebec, Canada.
Information: CabriWorld 2001 invites you to its international conference, which will be held June 14-17, 2001, at the UQAM in Montreal (Canada). You can get the registration form on the official conference Web site, `http://www.cabriworld.net/`.

14-21 **Graphs and Patterns in Mathematics and Theoretical Physics, A Conference to Celebrate Dennis Sullivan's 60th Birthday**, SUNY at Stony Brook, New York. (Feb. 2001, p. 250)

14-23 **Third International Conference on Geometry, Integrability and Quantization**, Sts. Constantine and Elena Resort (near Varna), Bulgaria. (Jan. 2001, p. 53)

16-19 **Sixteenth Annual IEEE Symposium on Logic in Computer Science (LICS 2001)**, Boston, Massachusetts. (Dec. 2000, p. 1435)

* 16-22 **Kinetic Theory**, Anogia, Crete, Greece.
Organizers: A. Bobylev (Moscow, Russia/Karlstad, Sweden), L. Arkeryd (Goeteborg, Sweden).
Main Speakers: H. Andreasson (Goeteborg, Sweden), K. Aoki (Kyoto, Japan), L. Arkeryd (Goeteborg, Sweden), A. Bobylev (Karlstad, Sweden), P. Degond (Toulouse, France), S. Mischler (Versailles, France), M. Pulvirenti (Rome, Italy), A. Rendall (Potsdam, Germany), G. Toscani (Pavia, Italy), C. Villani (Lyon, France), B. Wennberg (Goeteborg, Sweden).
Information: S. Papadopoulou, Dept. of Math., Univ. of Crete; fax: 81-393881; e-mail: `souzana@math.uch.gr`.

* 17-19 **Frontiers in Mathematical and Computational Biology**, University of Texas at Dallas, Richardson, Texas.
Sponsors: University of Texas at Dallas, Program in Mathematics and Molecular Biology (PMMB), Bionumerik Pharmaceuticals.
Workshop Topics: Neuroscience, Cardiac Dynamics, Biochemical Reaction Networks and Cell Signaling, Bioinformatics and Functional Genomics, DNA Energetics.
Invited Speakers: C. Benham (Mount Sinai School of Medicine), L. Bulla (Univ. of Texas, Dallas), S. Jafri (Univ. of Texas, Dallas), J. Lederer (Univ. of Maryland), Y. Rudy (Case Western Reserve), I. Tobias (Rutgers), D. Tranchina (New York Univ.), E. Young (Johns Hopkins), J. Wagner (Univ. of Connecticut Health Center), T. Warnow (Univ. of Texas, Austin).
Information: `http://www.utdallas.edu/~darcy/CONF/2001/compbio.html`.

17-21 **Quantum Theory: Reconsideration of Foundations**, Vaxjo University, Sweden. (May 2001, p. 528)

17-22 **2001 Gordon Conference on Nonlinear Science**, Mt. Holyoke College, South Hadley, Massachusetts. (May 2001, p. 528)

18-22 **Fourth European Conference on Elliptic and Parabolic Problems—Part I**, Rolduc, Netherlands. (Jan. 2001, p. 53)

18-22 **5th PIMS Industrial Problem Solving Workshop**, PIMS-University of Washington, Seattle, Washington. (Apr. 2001, p. 435)

18-23 **The Fourth St. Petersburg Workshop on Simulation**, St. Petersburg State Univ., St. Petersburg, Russia. (Oct. 2000, p. 1146)

18-23 **Tools for Mathematical Modelling**, St. Petersburg State Technical University, St. Petersburg, Russia. (Dec. 2000, p. 1435)

* 19-22 **Meeting of Researchers in Computer Science, Information Systems, Operations Research and Statistics—ITI 2001**, Pula, Croatia.
Sponsor: IMACS.
Topics: Computer systems and networks; software engineering and programming languages; information systems and databases; intelligent systems; multimedia and Internet computing; data analysis and statistics; biometrics; modelling, simulation and optimisation; mathematics and computation; design methodologies and applications.
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21-22 (NEW DATE) **Integration of Diverse Biological Data**, DIMACS Center, Rutgers University, Piscataway, New Jersey. (Sept. 2000, p. 975)

23-29 **International Conference on Operator Theory and Its Applications, Dedicated to the Memory of Abraham V. Strauss**, Ulyanovsk, Russia. (Sept. 2000, p. 978)

23-30 **Intermediate Problems of Model Theory and Universal Algebra, ERLOGOL-2001**, Technical University, Novosibirsk, Russia. (Oct. 2000, p. 1146)

* 24-27 **European Workshop on Intelligent Forecasting, Diagnosis and Control— IFDICON 2001**, The Island of Santorini, Greece.
Sponsor: IMACS.
Information: S. Tzafestas, National Technical University of Athens, Dept. of Electrical and Computer Engineering, Division of Computer Science, GR-157 73 Athens, Greece; tel: 301 772 2489; fax: 301 772 1528; e-mail: `tzafesta@softlab.ece.ntua.gr`.

25-27 **Mathematics of Public Key Cryptography**, KIAS, Seoul, Korea. (Apr. 2001, p. 435)

* 25-29 **2nd IMACS Conference on Mathematical Modelling and Computational Methods in Mechanics, Physics and Geodynamics–Modelling 2001**, University of West Bohemia, Pilsen, Czech Republic.
Main Topics: Mathematical modelling in mechanics, biomechanics, heat transfer; variational inequality problems; computational plasticity problems; optimal design problems; nonlinear spectral problems; computational biomechanics problems; computational fluid dynamics and magnetodynamics; algebra problems.
Information: Modelling 2001, S. Mika, Faculty of Applied Sciences, Dept. of Math., Univ. of West Bohemia, P.O. Box 314, 306 14 Pilsen, Czech Republic; tel: 420 19 7491135; fax: 420 19 279989; e-mail: `modelling@kma.zcu.ca`; `http://www.modelling.zcu.cz/`.

25-29 **Cmft2001, Computational Methods and Function Theory**, Aveiro, Portugal. (Jan. 2001, p. 53)

25-29 **International Linear Algebra Conference (9th Conference of the International Linear Algebra Society)**, Technion, Israel Institute of Technology, Haifa, Israel. (Dec. 2000, p. 1436)

25-29 **Workshop on Groups and 3-Manifolds**, Centre de Recherches Mathématiques, Université de Montréal, Montréal, Québec, Canada. (Feb. 2001, p. 250)

25-July 6 **NATO Advanced Study Institute "Symmetric Functions 2001: Surveys of Developments and Perspectives"**, Isaac Newton Institute for Mathematical Sciences, Cambridge, UK. (Jan. 2001, p. 53)

25-July 6 **Workshop "Random Walks and Geometry"**, Erwin Schrödinger Institute, Vienna, Austria. (Jan. 2001, p. 53)

27-29 **MAA Summer Short Course**, Ashland University, Ashland, Ohio. (Feb. 2001, p. 250)

30-August 4 **2001 Summer Program for Women in Mathematics (SPWM 2001)**, George Washington University, Washington, DC. (Apr. 2001, p. 435)

July 2001

* 1-4 **12th Annual Symposium on Combinatorial Pattern Matching: CPM2001**, Jerusalem, Israel.
Note: The conference will be followed by SPAA 2001, STOC 2001, and ICALP 2001 in Crete.
Invited Speakers: A. Fraenkel, Z. Galil, R. Kosaraju, U. Vishkin.
Information: Accepted papers and registration information are posted at `http://csweb.haifa.ac.il/cpm/`.

1-5 **Warthog Delta'01 Conference on Undergraduate Teaching of Mathematics—Third Southern Hemisphere Symposium on**

Undergraduate Mathematics Teaching, Kruger Park, South Africa. (Sept. 2000, p. 979)

1-7 **International Symposium on Computational and Applied PDEs**, Zhangjiajie, Hunan, China. (Mar. 2001, p. 336)

1-8 **Spatial Stochastic Processes**, Martina Franca (Taranto), Italy. (Apr. 2001, p. 435)

2-6 **Singapore International Symposium on Topology and Geometry (SISTAG)**, Singapore. (Feb. 2001, p. 250)

2-7 **4th Operator Algebras International Conference: Operator Algebras and Mathematical Physics**, Constanta, Romania. (Feb. 2001, p. 251)

2-10 **PIMS Thematic Programme on Nonlinear Partial Differential Equations, Viscosity Methods in Partial Differential Equations**, PIMS-UBC, Vancouver, British Columbia, Canada. (Apr. 2001, p. 435)

*2-13 **A Course in Tame Congruence Theory**, Budapest, Hungary.
Organizers: K. Kearnes, E. Kiss, R. McKenzie, Á. Szendrei.
Program: During the first week there will be a course in tame congruence theory, and during the second week there will be lectures and discussion about areas of current research.
Speakers: J. Berman, P. Idziak, K. Kearnes, E. Kiss, R. McKenzie, P. P. Pálfy, Á. Szendrei, M. Valeriote, R. Willard.
Information: `http://www.math.u-szeged.hu/confer/algebra/`.

2-13 **ESSGT 2001 : The 11th European Summer School in Group Theory**, CIRM, Marseille-Luminy, France. (May 2001, p. 529)

3-5 **Mathematics and Design 2001**, Deakin University, Geelong, Australia. (Feb. 2001, p. 251)

3-5 **Mathematics & Design 2001: Mind/Ear/Eye/Hand/Digital**, School of Architecture, Australia School of Computing and Mathematics, Deakin University, Melbourne, Australia. (Nov. 2000, p. 1297)

3-7 **Barcelona 2001 EuroPhD Topology Conference**, Centre de Recerca Matemàtica, Bellaterra, Barcelona, Spain. (Apr. 2001, p. 435)

*4-6 **International Conference on New Technologies in Science Education**, University of Aveiro, Aveiro, Portugal.
Information: `http://www.mat.ua.pt/cintec/`.

*6-13 **London Mathematical Society Meeting**, Manchester, UK.
Workshop: The LMS meeting will be followed on July 7-13 by a workshop on "Quantization deformations, and new homological and categorical methods in mathematical physics".
Contact: M. Prest, `mprest@ma.man.ac.uk`; T. Voronov, `theodore.voronov@umist.ac.uk`.
Meeting Plenary Speakers: B. Fedosov: "Deformation quantization: Pro and contra"; A. Vaintrob: "Homological vector fields".
Expected Workshop Speakers: M. Crainic, J. Jones, M. Karasev, H. Khudaverdian, Y. Kosmann-Schwarzbach, N.P. Landsman, Liu Zhang-Ju, K. Mackenzie, S. Merkulov, I. Moerdijk, J. Rawnsley, D. Roytenberg, A. Vaintrob, A. Voronov.
Information: `http://www.ma.umist.ac.uk/tv/LMS/`.

8-9 **TA and Instructor Development Using Case Studies: A Summer Workshop for Faculty**, Regis College, Weston, Massachusetts. (May 2001, p. 529)

8-13 **Second ICMS Workshop on Algebraic Graph Theory**, International Centre for Mathematical Sciences, Edinburgh, Scotland. (Feb. 2001, p. 251)

8-15 **5th WSES/IEEE World Multiconference on Circuits, Systems, Communications & Computers (CSCC 2001)**, Rethymnon, Crete, Greece. (May 2001, p. 529)

*9-11 **Functional and Spatial Data Analysis**, Leeds, UK.
Description: This is the 20th Leeds Annual Statistical Research Workshop. It will focus on the wide applications of functional and spatial modelling, such as environmental and ecological modelling, medical imaging and computer vision, as well as theoretical statistical aspects.
Invited Speakers: A. Baddeley (Australia), M. Berman (Australia), F. Bookstein (USA), C. Glasbey (UK), D. Hogg (UK), J. Kent (UK), K. Mardia (UK), B. Silverman (UK), C. Wikle (USA), K. Worsley (Canada). Those wishing to present a contributed paper or poster are requested to submit an abstract (maximum two pages) by e-mail: `workshop@amsta.leeds.ac.uk`.
Information: Full details of the workshop are available at the Web site `http://www.amsta.leeds.ac.uk/Statistics/workshop/` or from the conference organizers: LASR Workshop, Dept. of Stat., Univ. of Leeds, Leeds, LS2 9JT, UK.

*9-13 **Conference: Progress in Partial Differential Equations**, International Centre for Mathematical Sciences, Edinburgh, UK.
Information: Please see the ICMS Web pages for further details on programme, speakers, registration, etc.: `http://www.ma.hw.ac.uk/icms/current/progpde/`.

*9-13 **EuroWorkshop: Algebraic Graph Theory**, International Centre for Mathematical Sciences, Edinburgh, UK.
Information: Please see the ICMS Web pages for information on speakers, scientific programme, and how to register: `http://www.ma.hw.ac.uk/icms/current/graph/`.

9-13 **Galois Modules in Arithmetic Geometry**, University Lille I, Lille, France. (Apr. 2001, p. 435)

9-13 **Workshop on Geometric Group Theory**, Centre de Recherches Mathématiques, Université de Montréal, Montréal, Québec, Canada. (Feb. 2001, p. 251)

9-14 **Designs, Codes, Cryptography and Graph Theory**, PIMS, University of Lethbridge, Alberta, Canada. (Apr. 2001, p. 435)

*9-15 **The Fourth International Conference "Symmetry in Nonlinear Mathematical Physics"**, Institute of Mathematics, Kyiv (Kiev), Ukraine.
Topics: Classical, Nonclassical, Conditional and Approximate Symmetry of Equations of Mathematical Physics; Symmetry in Nonlinear Quantum Mechanics, Quantum Fields, Gravity, Fluid Mechanics, Mathematical Biology, Mathematical Economics; Representation Theory; q-Algebras and Quantum Groups; Symbolic Computations in Symmetry Analysis; Dynamical Systems, Solitons and Integrability; Supersymmetry and Parasupersymmetry.
Information: A. Nikitin, Inst. of Math., National Acad. of Sci. of Ukraine, 3 Tereshchenkivska Street, Kyiv 4, 01601, Ukraine; e-mail: `appmath@imath.kiev.ua`; fax: +38 044 235 20 10; tel: +38 044 224 63 22, +38 044 250 08 96; `http://www.imath.kiev.ua/~appmath/conf.html`.

9-20 **SMS-NATO ASI: Modern Methods in Scientific Computing and Applications**, Université de Montréal, Montréal, Québec, Canada. (Dec. 2000, p. 1436)

9-22 **NATO Advanced Study Institute: Asymptotic Combinatorics with Applications to Mathematical Physics (European Summer School-2001 in Russia)**, Euler International Mathematical Institute, St. Petersburg, Russia. (Nov. 2000, p. 1297)

9-25 **Summer School of Probability Theory**, Saint-Flour, France. (Apr. 2001, p. 435)

10-15 **Advanced Course on Symplectic Geometry of Integrable Hamiltonian Systems**, Centre de Recerca Matemàtica, Bellaterra, Barcelona, Spain. (Apr. 2001, p. 436)

11-16 **Geometry, Symmetry and Mechanics**, Instituto Superior Técnico, Lisbon, Portugal. (Apr. 2001, p. 436)

11-18 **PIMS Thematic Programme on Nonlinear Partial Differential Equations, Phase Transitions**, PIMS-UBC, Vancouver, British Columbia, Canada. (Apr. 2001, p. 436)

12-14 **Fifth SIAM Conference on Control and Its Applications (CT01)**, Town & Country Hotel, San Diego, California. (Sept. 2000, p. 979)

13-27 **Summer 2001 Workshop on Graphs and Combinatorial Designs,** University of Hawaii at Manoa, Honolulu, Hawaii. (Mar. 2001, p. 336)

15-27 **Summer School in Low-Dimensional Topology,** Banach Center, Warsaw, Poland. (Apr. 2001, p. 436)

16-20 **Algorithms for Approximation IV,** University of Huddersfield, Huddersfield, UK. (Sept. 2000, p. 979)

16-20 **Probability on Geometric Structures,** CIRM Marseille, Luminy, France. (Nov. 2000, p. 1298)

16-20 **Summer School on Nonlinear Partial Differential Equations,** Instituto Superior Técnico, Lisbon, Portugal. (May 2001, p. 529)

16-20 **Workshop on the Mathematical Foundations of Coding Theory and Cryptology,** Institute for Mathematical Sciences, National University of Singapore, Singapore. (Apr. 2001, p. 436)

16-21 **Workshop on the Skorokhod Problem,** Mathematical Conference Center, Bedlewo, Poland. (May 2001, p. 529)

16-27 **PIMS Summer Workshop on Particles, Fields and Strings,** PIMS-SFU, Burnaby, Canada. (Apr. 2001, p. 436)

*17-21 **3rd Panhellenic Logic Symposium (PLS),** Anogia Academic Village, Crete, Greece.
Topics: Mathematical logic and set theory, logic in computer science, history of logic, methodology and philosophy of science.
Scientific Chair: E. Kranakis (KRANAKIS@SCS.CARLETON.CA).
Submission of Papers: April 6, 2001.
Information: http://www.math.uoa.gr/pls3/.

17-23 **Advanced Course on Global Riemannian Geometry: Curvature and Topology,** Universitat Jaume I, Castelló de la Plana, Spain. (Apr. 2001, p. 436)

*18-21 **Sixteenth Summer Conference on Topology and Applications,** The City College of New York, CUNY, New York, New York.
Program: This conference continues its focus on topology and its broad applications as indicated by its six main speakers, five special sessions, and two workshops.
Main Speakers: K. Hofmann (Tech. Univ. Darmstadt, Germany), L. Junqueira (Univ. of Sao Paulo, Brazil), K. Kunen (Univ. of Wisconsin, Madison), J. Lawson (LSU, Baton Rouge), L. Narici (St. John's Univ., New York), S. Newhouse (Michigan State Univ., East Lansing).
Special Sessions and Organizers: Asymmetric Topology and Computer Science: M. Mislove (Tulane Univ., New Orleans), H. Priestley (Univ. of Oxford), M. Smyth (Imperial Coll., Univ. of London), J. Webster (Imperial Coll., Univ. of London); Dynamical Systems: E. Akin (City College-CUNY), A. Crannell (Franklin and Marshall College, Lancaster, PA), T. Pignataro (City College-CUNY); Topological Algebra and Functional Analysis: E. Beckenstein (St. John's Univ., New York), I. Namioka (Univ. of Washington, Seattle), N. Shell (City College-CUNY); Set-Theoretic Topology: I. Farah (CSI and Graduate Center-CUNY), G. Gruenhage (Auburn Univ., Alabama), J. Vaughan (Univ. of North Carolina, Greensboro); Topological Groups and Semigroups: N. Hindman (Howard Univ., Washington, DC), S. Morris (Univ. of South Australia, Adelaide), M. Tkachenko (Univ. Autonoma Metropolitana-Iztapalapa, Mexico DF). Workshops and Leaders: "Aspects of Elementary Submodels in Topology", T. Eisworth (Univ. of Northern Iowa); "Developments in Domain Theory", M. Reed (Univ. of Oxford).
Information: More details and guidance (on housing, registration, transportation in New York, tourism, etc.) are available at the site http://sumtopo.home.att.net/ or through R. Kopperman, either by e-mail at sumtopo@att.net or by regular mail at Dept. of Math., City College-CUNY, New York, NY 10031.

18-28 **Advanced Course on Modular Forms and p-Adic Hodge Theory,** Centre de Recerca Matemàtica, Bellaterra, Barcelona, Spain. (Apr. 2001, p. 436)

19-27 **PIMS Thematic Programme on Nonlinear Partial Differential Equations, Concentration Phenomena and Vortex Dynamics,** PIMS-UBC, Vancouver, British Columbia, Canada. (Apr. 2001, p. 436)

22-25 **International Symposium on Symbolic and Algebraic Computation (ISSAC 2001),** University of Western Ontario, London, Ontario, Canada. (Sept. 2000, p. 979)

22-26 **Experimental Chaos Conference 2001,** University of Potsdam, Germany. (May 2001, p. 529)

22-28 **International Nearring and Nearfield Conference,** James Madison University, Harrisonburg, Virginia. (Oct. 2000, p. 1146)

23-August 3 **Combinatorics and Matrix Theory,** University of Wyoming, Laramie, Wyoming. (Jan. 2001, p. 53)

24-31 **Nonlinear Evolution Equations and Dynamical Systems,** Isaac Newton Institute for Mathematical Sciences, Cambridge, UK. (Apr. 2001, p. 437)

25-August 1 **Second Honolulu Conference of Abelian Groups and Modules,** Manoa Campus of the University of Hawaii, Honolulu, Hawaii. (Apr. 2001, p. 437)

27-29 **Conference and Reunion in Honor of Arnold Ross,** The Ohio State University, Columbus, Ohio. (Mar. 2001, p. 336)

27-29 **The Fourth Annual Conference of Bridges: Mathematical Connections in Art, Music, and Science,** Southwestern College, Wichita, Kansas. (Apr. 2001, p. 437)

27-31 **International Conference on Dynamics of Continuous, Discrete and Impulsive Systems,** London, Ontario, Canada. (Apr. 2001, p. 437)

29-August 3 **International Conference on Scientific Computation and Differential Equations,** Coast Plaza Hotel, Vancouver, British Columbia, Canada. (Apr. 2001, p. 437)

30-August 3 **6th International Conference on Difference Equations and Applications,** University of Augsburg, Augsburg, Germany. (May 2001, p. 529)

30-August 7 **PIMS Thematic Programme on Nonlinear Partial Differential Equations, Variational Methods,** PIMS-UBC, Vancouver, British Columbia, Canada. (Apr. 2001, p. 437)

30-August 17 **School on Dynamical Systems,** Trieste, Italy. (Jan. 2001, p. 54)

*31-August 10 **XIV Coloquio Latinoamericano de Algebra,** La Falda, Sierras de Cordoba, Argentina.
Program: The general field of this activity is algebra in a broad sense. There will be invited lectures, short courses and special sessions on Commutative Algebra and Applications, Hopf Algebras and Quantum Groups, Operator Algebras, Algebraic Geometry, Logic, Homological Methods, Representations of Algebras, Representations of Finite Groups, Representations of p-Adic Groups, Lie Theory and Number Theory.
Organizers: N. Andruskiewitsch (coordinator, Univ. Cordoba), F. Cukierman (Univ. Buenos Aires), R. Miatello (Univ. Cordoba), M. I. Platzeck (Univ. Bahia Blanca), N. Reshetikhin (Univ. California, Berkeley), J. Tirao (Univ. Cordoba), J. A. Wolf (Univ. California, Berkeley).
Speakers: Some confirmed speakers are: I. Assem (Univ. Sherbrooke, Canada), D. Cox (Amherst College, USA), C. de Concini (Univ. Rome, Italy), J. de la Peña (UNAM, Mexico), P. Etingof (MIT, USA), V. Ginzburg (Univ. Chicago, USA), F. Grunewald (Univ. Dusseldorf, Germany), V. Kac (MIT, USA), M. Kontsevich (IHES, Paris, France), B. Kostant (MIT, USA), Ph. Kutzko (Univ. Iowa, USA), J. Landsberg (Georgia Tech., USA), S. Montgomery (USC, Los Angeles, USA), D. Mundici (Univ. Milan, Italy), A. Ocneanu (Penn State Univ., USA), D. Radford (UIC, USA), N. Reshetikhin (Univ. California, Berkeley, USA), F. Shahidi (Purdue Univ., USA), B. Sturmfels (Univ. California, Berkeley, USA), D. Sullivan (CUNY, SUNY, USA), O. Villamayor (UAM, Spain), N. Wallach (UCSD, USA), J. A. Wolf (Univ. California, Berkeley, USA).
Information: The application form and other relevant information is available at the Web site http://www.mate.uncor.edu/vaq2001/.

August 2001

* 2-11 **Foliations and Geometry 2001**, Pontifical Catholic University (PUC-Rio), Rio de Janeiro, Brazil.
Topics: Foliations in 3-manifolds and related structures (laminations, contact structures, asymptotic linking number, Anosov flows); geometry of foliations, including applications of foliations in differential geometry; foliations and dynamical systems; holomorphic foliations; the classifying space $B\Gamma_q$; and related areas.
Planned Minicourses: 1. Asymptotic inking pairing, foliations, and contact structures–Y. Mitsumatsu; 2. Geometry of foliations in 3-manifolds–S. Fenley; 3. Holomorphic foliations (an introduction for foliators)–C. Camacho (speaker to be confirmed); 4. The classifying space for foliations $B\Gamma_q$–T. Tsuboi (speaker to be confirmed); 5. The Kronheimer-Mrowka Theorem–D. Gabai (minicourse and speaker to be confirmed).
Partial List of Expected Speakers: J. L. Arraut, F. Brito, M. Brittenham, H. Colman, L. Conlon, C. Gutierrez, J. Heitsch, K. Honda, S. Hurder, T. Inaba, W. Kazez, A. Lins Neto, S. Matsumoto, W. Meeks, G. Meigniez, H. Nakayama, U. Oertel, J. Rebelo, R. Roberts, R. Ruggiero, R. Sa Earp, E. Salem, J. Seade, E. Toubiana, P. Walczak.
Information: Web site for up-to-date information: `http://www.mat.puc-rio.br/foliations2001/`. This site also contains information on travel, housing, climate, registration, social activities, etc. e-mail address: `foliations2001@mat.puc-rio.br`.

5-18 **BALTICON 2001, Banach Algebra Theory in Context**, Krogerup Hojskole, Denmark. (Dec. 2000, p. 1436)

5-18 **Groups St. Andrews 2001**, University of Oxford, Oxford, England. (Apr. 2000, p. 503)

6-11 **2001 ASL European Summer Meeting (Logic Colloquium '01)**, Vienna, Austria. (Feb. 2001, p. 251)

6-24 **Mathematical Geophysics Summer School**, Stanford University, Stanford, California. (May 2001, p. 529)

7-9 **First Announcement—Nordic Conference on Topology and Applications**, Sophus Lie Conference Centre, Nordfjordeid, Norway. (May 2001, p. 530)

7-10 **The 4th Conference on Information Fusion**, Montréal, Québec, Canada. (Feb. 2001, p. 251)

8-12 **The 9th International Conference on Finite or Infinite Dimensional Complex Analysis and Applications**, Hanoi University of Technology, Hanoi, Vietnam. (Jan. 2001, p. 54)

8-17 **PIMS Thematic Programme on Nonlinear Partial Differential Equations, Geometric PDEs**, PIMS-UBC, Vancouver, British Columbia, Canada. (Apr. 2001, p. 437)

* 10-12 **Soliton Equations: Applications and Theory**, University of Colorado at Colorado Springs, Colorado Springs, Colorado.
Program: An interdisciplinary conference is planned, with speakers addressing successful applications of soliton equations to physical problems, computational studies which can illuminate new applications, and new theoretical results. Some of the applications we have in mind include the use of the nonlinear Schrödinger equation and its variants for modeling a design of fiber optic communication systems, as well as the appearance of solitons in other optical problems, magnetic thin films, and Bose-Einstein condensates. Possible theoretical topics include extensions of inverse scattering and inverse spectral theory to Schrödinger or Dirac-type operators with matrix coefficients, new methods for analyzing Riemann-Hilbert problems, connections of soliton equations with geometry, and new insights into meromorphic or real analytic solutions of soliton equations.
Support: We anticipate being able to offer financial support for some conference participants, particularly students and recent graduates.
Information: e-mail: `carlson@math.uccs.edu`.

10-14 **Svalbard Geometric Topology Conference**, Radisson SAS Polar Hotel Spitsbergen, Longyearbyen, Norway. (May 2001, p. 530)

13-15 (NEW DATE) **13th Canadian Conference on Computational Geometry**, University of Waterloo, Ontario, Canada. (Apr. 2001, p. 438)

13-16 **Fourth SIAM Conference on Linear Algebra in Signals, Systems and Control (LASSC01)**, Boston Park Plaza Hotel, Boston, Massachusetts. (Sept. 2000, p. 979)

* 13-24 **Euro Summer School–What Is Integrability?**, Isaac Newton Institute for Mathematical Sciences, Cambridge, UK.
Aim: The school is intended for young researchers (both postgraduates and postdocs) working in the field of integrable systems and related areas. World experts will provide a thorough introduction to the different definitions of integrability through lectures supplemented with discussions, tutorials, and example classes. The aim is to emphasize the links between the various approaches and points of view, resulting in a synthesis of the many answers to the question "What is integrability?"
Topics: Symmetries and conservation laws, Painlevé approach, integrable quantum systems, Hirota's method, geometric integrability, approximate integrability and normal forms, testing for integrability.
Lecturers: M. Ablowitz, P. Clarkson, A. Degasperis, J. Hietarinta, H. Flaschka, Y. Kodama, A. Mikhailov, S. Novikov, P. Olver, T. Miwa, A. Shabat, V. Sokolov, J. Sanders, P. Winternitz, V. Zakharov.
Support: The Euro Summer School is supported by the European Community, and funding is available to support a limited number of young (under 35 years of age) researchers and overseas senior researchers who are nationals of EC Member States or of the Associated States (Iceland, Liechtenstein, Norway, Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia, Israel, Switzerland). Self-supporting participants of any age and nationality are welcome to apply.
Information: Visit the Web site `http://www.newton.cam.ac.uk/programs/ITS/itsw02.html`.

15-20 **Fourth International Symposium on Classical and Celestial Mechanics**, Velikie Luki, Russia. (Apr. 2001, p. 438)

15-20 **SRTL-2: The Second International Research Forum on Statistical Reasoning, Thinking, and Literacy**, University of New England, Armidale, Australia. (Sept. 2000, p. 979)

18-23 **Algebra and Discrete Mathematics**, Hattingen (near Essen), Germany. (May 2001, p. 530)

* 18-24 **Convex Geometric Analysis**, Anogia, Crete, Greece.
Organizers: A. Giannopoulos (Crete, Greece), V. Milman (Tel Aviv, Israel), R. Schneider (Freiburg, Germany), S. Szarek (Case Western Reserve Univ. USA/Paris VI, France). Coorganized by the Univ. of the Aegean (Dept. of Math.).
Main Speakers: K. Ball (University College London, UK), I. Barany (Hungarian Academy of Sciences), P. Gruber (Wien, Austria), A. Koldobsky (Univ. of Missouri, Columbia), A. Pajor (Univ. de Marne La Vallee, France), G. Schechtman (Weizmann Inst., Israel), S. Szarek (Case Western Reserve Univ.).
Information: `http://www.convex.gr/conf2001/`.

19-25 **9th Prague Topological Symposium (General Topology and Its Relations to Modern Algebra and Analysis)**, Prague, Czech Republic. (Mar. 2001, p. 336)

20-22 **Seventh Annual International Computing and Combinatorics Conference (COCOON'01)**, Guilin, China. (Nov. 2000, p. 1298)

* 20-23 **Numerical Linear Algebra, Scientific Computing and Optimization**, Curitiba, Brazil.
Sponsor: IMACS.
Information: J. Y. Yuan, Dept. de Matematica-UFPR, Centro Politecnico, CP: 19.081, 81531-990, Curitiba, PR, Brazil; e-mail: `jin@gauss.mat.ufpr.br`.

20-24 **Ellipticity and Parabolicity in Analysis and Geometry (EPAG 2001)**, University of Potsdam, Potsdam, Germany. (Mar.

2001, p. 337)

20-25 **2001 Canada-China Math Congress**, Vancouver, British Columbia, Canada. (Apr. 2001, p. 438)

*20-25 **3rd International ISAAC Congress**, Freie Universitaet Berlin, Berlin, Germany.
Information: The International Society for Analysis, Applications and Computation (ISAAC) is organizing international congresses biannually. Information about deadlines, sessions, organizers, plenary speakers, registration, and accommodations can be found in the second announcement at `http://www.math.fu-berlin.de/~isaac/`. For information about ISAAC visit `http://www.math.udel.edu/isaac/` and `http://www.math.fu-berlin.de/rd/ag/isaac/`.

20-25 **International Conference on Theoretical and Numerical Fluid Mechanics II**, PIMS, Vancouver, British Columbia, Canada. (Apr. 2001, p. 438)

*21-23 **Ukrainian Congress of Mathematics 2001**, Institute of Mathematics of the Ukrainian National Academy of Sciences, Kyiv Shevchenko National University, Drahomanov National Pedagogic University, Kyiv, Ukraine.
Description: The congress is devoted to the 200th anniversary of the birth of M. V. Ostrohradsky, the prominent Ukrainian mathematician. Sections: Algebra and Theory of Numbers, Dynamical Systems, Differential Equations and Nonlinear Oscillations, Complex Analysis and Potential Theory, Mathematical Physics, Teaching Methods and History of Mathematics, Nonlinear Analysis, Computational Mathematics and Mathematical Problems of Mechanics, Probability Theory and Mathematical Statistics, Theory of Approximations and Harmonic Analysis, Theory of Operators and Differential Operator Equations, Topology and Geometry, Mathematical Theory of Control.
Information: A. M. Samoilenko, Chairman of UCM2001, Institute of Mathematics, Ukrainian National Academy of Sciences, 3 Tereshchenkivs'ka Str. 01601 Kyiv, Ukraine; e-mail: `congress@imath.kiev.ua`; fax: 380 44 235 20 10; `http://www.imath.kiev.ua/~congress/`.

22-26 **International Conference on Functional Analysis**, Kyiv, Ukraine. (Jan. 2001, p. 54)

*23-28 **Instructional and Research Workshop on Multiplicative Processes and Fluid Flows**, Department of Mathematical Sciences, University of Aarhus, Denmark.
Organizer: O. E. Barndorff-Nielsen, `oebn@imf.au.dk`.
Focus: The focus of the workshop is the widespread role of multiplicative structure in various models of flows found in geophysical sciences ranging from turbulent fluids, rainfall, and river networks to internet data flows and cash flows found in financial mathematics. Tutorial lectures by E. Waymire. The lectures will include illustrations of modelling hypothesis based on descriptive empirical data and phenomenological scaling arguments leading to rigorous statistical tests and precise mathematical derivations of stochastic multiplicative structure intrinsic to the physical equations of flow. Emphasis will be given to both model formulation as well as to some general mathematical methods and results for the analysis of such multiplicative structures. Background in basic probability and stochastic processes will be assumed, which includes martingales and Markov processes such as Poisson processes, random walk, diffusions, and Galton-Watson branching processes.
Preliminary List of Invited Speakers: N. Bhattacharya, Indiana Univ.: Multiscale diffusion equations; Martin Greiner, Max-Planck-Institut füer Physik Komplexer Systeme: From synthetic towards real fully developed turbulence; Vijay Gupta, Univ. of Colorado: Multiscale hydrologic analyses on self-similar river networks; Valerie Isham, Univ. College London: Models and analysis of spatio-temporal processes in hydrology and climate studies; Mina Ossiander, Oregon State Univ.: Multiplicative random cascades: Recent statistical developments; Enrique Thomann, Oregon State Univ.: Partial differential equations and multiplicative processes; Brent Troutman, U.S. Geological Survey: River flow mass exponents with fractal channel networks and rainfall.
Information: `http://www.maphysto.dk/events/MultProc2001/`.

24-29 **5th International Conference on Geometry and Applications**, Varna, Bulgaria. (Dec. 2000, p. 1436)

*25 **3rd Workshop on Geometric and Topological Methods in Concurrency Theory (GETCO 2001)—A Satellite Workshop to CONCUR 2001**, Aalborg University, Aalborg, Denmark.
Topics: Semantics, concurrency theory, model-checking, abstract interpretation, fault-tolerant protocols for distributed systems, geometrical/topological models, applications of algebraic topology, category theory, etc.
Deadline for submission of papers: May 20, 2001.
Publication: Papers will be refereed using usual standards and will be published in a special volume of *Electronic Notes in Theoretical Computer Science*.
Program Committee: P. Cousot and E. Goubault, Paris; L. Fajstrup and M. Raussen, Aalborg; J. Gunawardena, Bristol; V. Sassone, Catania.
Local Organization: L. Fajstrup, E. Goubault, M. Raussen.
Information: `http://www.math.auc.dk/~raussen/GETCO/getco.html` and `http://concur01.cs.auc.dk/`.

26-29 **Aspects of Symmetry on the Occasion of the 60th Birthday of Robert Moody**, PIMS, Banff, Alberta, Canada. (Apr. 2001, p. 438)

27-31 **8th International Conference on Differential Geometry and Its Applications**, Silesian University in Opava, Opava, Czech Republic. (Oct. 2000, p. 1146)

27-31 **Equadiff 10, Czechoslovak International Conference on Differential Equations and Their Applications**, Prague, Czech Republic. (Apr. 2000, p. 502)

*27-September 3 **International Conference on Complex Systems: Control and Modeling Problems**, Cruise on Volga River, Russia.
Sponsor: IMACS.
Information: V. A. Vittikh, Russian Academy of Sciences, Institute for the Control of Complex Systems, 61, Sadovaya str., Samara 443020, Russia; tel: 846 2 32 39 27; fax: 846 2 33 27 70; e-mail: `vittikh@iccs.samara.ru`.

*27-September 7 **Summer School and Workshop: Dimac Operators: Yesterday and Today**, Center for Advanced Mathematical Sciences, Beirut, Lebanon.
Topics: Basic Relevant Algebra: Clifford Algebras, Spinors; A Visit to Representation Theory: A Brief Survey; A Biased Introduction to Spin Geometry: Dirac Operators, Spectrum, Special Geometries; The Topological Connection: The Atiyah-Singer Index Theorem, Basics of K-Theory, Chern Character; The Physics Side: Dirac's Equation for the Relativistic Electron, Modern Use, Lagrangian, Supersymmetric Theories.
Organizing Committee: J.-P. Bourguignon (École Polytechnique/IHES, France), T. Branson (Univ. of Iowa), A. Chamseddine (CAMS, AUB, Lebanon), O. Hijazi (IECN, Nancy 1, France), R. J. Stanton (Ohio State Univ., Columbus).
Main Lecturers: C. Baer (Univ. Hamburg, Germany), J.-P. Bourguignon (IHES, Bures-sur-Yvette, France), R. Bryant (Duke Univ., Durham, NC), A. Chamseddine (CAMS, Beirut, Lebanon), O. Hijazi (IECN, Nancy 1, France), H. B. Lawson (SUNY, Stony Brook), R. J. Stanton (Ohio State Univ., Columbus).
Information: `http://www.aub.edu.lb/cams/Conferences.html`.

September 2001

*1-6 **WSES, IEEE Conference: Speech, Signal and Image Processing 2001 (SSIP 2001)**, Malta.
Information: `http://www.worldses.org/wses/conferences/malta/`.

1-6 **2001 WSES International Conference on Simulation (SIM'01)**, Malta. (Feb. 2001, p. 251)

1-6 **Number Theory and Arithmetical Geometry—Arithmetic Aspects of Fundamental Groups**, Acquafredda di Maratea (near Naples), Italy. (May 2001, p. 530)

1-May 31 **Institut Mittag-Leffler Call for Proposals**, Djursholm, Sweden. (Sept. 2000, p. 979)

2-8 **Optimal Transportation and Applications**, Martina Franca (Taranto), Italy. (Apr. 2001, p. 438)

*3-7 **Workshop on Foundational Theories in Mathematics**, Department of Mathematics, University of Trento, Italy.
Organizers: S. Baratella (Trento), G. Sommaruga (Freiburg).
Topic: The aim of the workshop is to present three different theories for the foundations of mathematics and to discuss their specific strengths, their mutual relationships, the extent to which they are comparable, and the open problems to be tackled in order to gain an even deeper understanding of the philosophical and technical interrelations between the various theories as potential foundations of mathematics.
Program and Speakers: There will be four series of lectures on: Set Theory, J. L. Bell (Univ. of Western Ontario); Topos Theory, I. Moerdijk (Univ. of Utrecht); Constructive Type Theory, G. Sambin (Univ.of Padua); and Synthesis, J. L. Bell. The intended audience for this workshop is mathematicians, philosophers and computer scientists with a solid background in logic, but who will not be expected to have a background in all three foundational theories mentioned above.
Deadline: July 31, 2001. No registration fee.
Information: http://www.science.unitn.it/~baratell/ftm.html.

3-8 **The Sixth International Conference on Function Spaces**, Institute of Mathematics, Wroclaw University of Technology, Wroclaw, Poland. (Mar. 2001, p. 337)

*3-14 **EuroWorkshop: Discrete Systems and Integrability**, Isaac Newton Institute for Mathematical Sciences, Cambridge, UK.
Organizers: F. W. Nijhoff, J. Hietarinta, P. M. Santini.
Topics: Partial difference equations, ordinary difference equations, integrable dynamical mappings, discrete Painlevé equations, quantum systems on the lattice, cellular automata, special functions and orthogonal polynomials, and applications. The purpose of the workshop is to provide a platform for presenting state-of-the-art results as well as to critically discuss open problems in the subject area.
Expected Speakers: V. Adler (Inst. of Math., Ufa), P. Clarkson (Univ. of Kent, Canterbury), R. Conte (Saclay), A. Doliwa (Warsaw Univ.), P. Hydon (Univ. of Surrey), N. Joshi (Univ. of Adelaide), K. Kajiwara (Doshisha Univ.), M. Kruskal (Rutgers Univ.), M. Noumi (Kobe Univ.), A. Ramani (École Polytech., France), S. Ruijsenaars (Amsterdam), J. Sanders (Free Univ., Amsterdam), J. Satsuma (Univ. of Tokyo), A. Shabat (Landau Inst.), V. Sokolov (Landau Inst.), C. Viallet (Univ. Paris VI).
Support: The EuroWorkshop is supported by the European Community, and funding is available to support a limited number of young (under 35 years of age) researchers and overseas senior researchers who are nationals of EC Member States or of the Associated States (Iceland, Liechtenstein, Norway, Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia, Israel, Switzerland). Self-supporting participants of any age and nationality are welcome to apply.
Information: Visit the Web site http://www.newton.cam.ac.uk/programs/ITS/itsw03.html. Alternatively, information can be obtained from F. W. Nijhoff (frank@amsta.leeds.ac.uk).

3-21 **School on Control Theory**, Trieste, Italy. (Jan. 2001, p. 54)

3-21 **Higher-Dimensional Varieties and Rational Points**, Hungarian Academy of Sciences, Budapest, Hungary. (Mar. 2001, p. 337)

4-7 **ECCOMAS 2001**, Swansea, UK. (Sept. 2000, p. 980)

9-13 **4th Dublin Differential Equations Conference**, Dublin City University, Dublin, Ireland. (Mar. 2001, p. 337)

9-15 **Multiscale Problems and Methods in Numerical Simulation**, Martina Franca (Taranto), Italy. (Apr. 2001, p. 438)

10-14 **3rd IMACS Seminar on Monte Carlo Methods MCM2001**, Salzburg University, Austria. (Nov. 2000, p. 1298)

10-14 **Workshop on Coding and Cryptography**, Institute for Mathematical Sciences, National University of Singapore, Singapore. (May 2001, p. 530)

12-15 **EuroConference on Combinatorics, Graph Theory and Applications**, Centre de Recerca Matemàtica, Bellaterra, Barcelona, Spain. (Apr. 2001, p. 438)

12-15 **International Conference on Nonlinear Operators, Differential Equations, and Applications (ICNODEA-2001)**, Babes-Bolyai University of Cluj-Napoca, Faculty of Mathematics and Informatics, Cluj-Napoca, Romania. (Apr. 2001, p. 438)

*14-18 **Function Spaces, Proximities and Quasi-Uniformities**, Caserta, Italy.
Program: The conference will consist of 50-min. plenary lectures by invited speakers and 25-min. contributed talks. It will open with a special invited lecture by Prof. Som Naimpally on the occasion of his 70th birthday.
Invited Speakers: A. Arhangel'skii (New Mexico, USA - Univ. Moscow, Russia); U. B. Darji (Univ. Louisville, USA); P. de Lucia (Federico II, Naples); S. Dolecki (Univ. di Digione, France); J. Hocking (Michigan State Univ., USA); L. Hola (Accademia delle Scienze della Repubblica Slovacca, Rep. Slovakia); H.-P. Kunzi (Univ. Cape Town, So. Africa); R. Lowen (Univ. di Antwerp, Belgium); J. Pelant (Acad. delle Scienze, Prague, Czech Rep.); S. Watson (York Univ., Toronto, Canada).
Call for Papers: Participants are invited to present a 25-min. talk. They are invited to submit an abstract to topological.sun@unina2.it no later than June 30, 2001.
Deadlines: Registration and payment of conference fees: May 31, 2001. Reservation of hotel accommodations: May 31, 2001. Abstract submission: June 30, 2001. Registration, accommodations, forms and the submission of abstracts must be mailed to topological.sun@unina2.it.
Information: G. Di Maio-Topological SUN, Seconda Università degli Studi di Napoli-S.U.N., Facoltà di Scienze MM.FF.NN., Dipartimento di Matematica, Via Antonio Vivaldi, 43, 81100 Caserta, Italia; tel: +39+(0)823/274426; fax: +39+(0)823/274753; http://www.unina2.it/topological.sun/homesun.html.

*17-21 **Euroconference on Asymptotic Methods and Applications in Kinetic and Quantum-Kinetic Theory**, Granada, Spain.
Sponsors: European Commission, Spanish Government, Junta de Andalucia, Universidad Carlos III de Madrid, Universidad Autonoma de Madrid, Universidad de Granada.
Program: The program of the conference will offer invited talks, contributed talks, and a poster session. Talks and posters will be selected by the scientific committee from submitted abstracts. Submission: kinetic@ugr.es. Deadline for submission: May 31, 2001; Notification of acceptance: June 20, 2001.
Invited Speakers (to date): H. Andreasson, A. Bobylev, O. Bokanowski, L. Boudin, J. Brey, E. Caglioti, A. Carpio, M. Carvalho, F. Castella, I. Catto, C. Cercignani, L. Desvilletes, J. Dolbeault, M. Fischetti, I. Gamba, V. Garzo, P. Gerard, R. Glassey, F. Golse, T. Goudon, K. P. Hadeler, R. Illner, P.E. Jabin, A.P. Jauho, A. Juengel, A. Klar, H. Lange, C. LeBris, A. Linan, S. Mischler, E. Oran, G. Papanicolau, L. Pareschi, P. Pietra, F. Poupaud, M. Pulvirenti, V. Ricci, C. Ringhofer, C. Rosier, G. Russo, L. Saint-Raymond, P. Souganidis, W. Strauss, L. Vega, J. L. L. Velazquez, C. Villani, B. Wennberg, G. Wolansky, W. Zimmermann.
Information: J. Soler, Universidad de Granada (jsoler@uqr.es, kinetic@ugr.es).

17-26 **Functional Analysis VII**, Inter-University Center, Dubrovnik, Croatia. (Apr. 2001, p. 438)

18-22 **Euro Summer School on Proper Group Actions**, Centre de Recerca Matemàtica, Bellaterra, Barcelona, Spain. (Apr. 2001, p. 438)

18-22 **The Fifth International Workshop on Differential Geometry and Its Applications**, Timisoara, Romania. (Feb. 2001, p. 251)

* 20-22 **5th Hellenic European Research on Computer Mathematics and Its Applications—Hercma 2001**, Athens, Greece.
Sponsor: IMACS.
Framework-Objectives: The main theme within the conference will be computer mathematics and its applications, and special emphasis will be given to computational mathematics, high-performance computing, operational research and statistics, mathematics in economics and industry.
Information: E. A. Lipitakis, Chairman of the HERCMA Conference, Athens University of Economics and Business, 74, Patission Street, Athens 104-34, Greece; tel: 301 8237 361; fax: 301 8226 204; e-mail: eal@aueb.gr; http://www.aueb.gr/conferences/hercma2001/.

* 20-22 **Interphase 2001 Conference on Numerical Methods for Free Boundary Problems**, University of Maryland, College Park, Maryland.
Organizers: R. H. Nochetto, D. Levermore, J-G. Liu, R. Pego.
Description: This ninth conference of the series will be held in College Park with the intention of encouraging more participation of U.S. researchers and stimulating the exchange of ideas between American and European peers. The conference will focus on scientific computing, numerical analysis, modeling and application issues of problems involving interfaces. Topics of interest include, but are not limited to, thin films, epitaxial growth of crystals, surface tension effects and surface diffusion, morphological changes of stressed solids, microstructure evolution, solidification, image processing, free surface hydrodynamics, novel numerical methods, fast algorithms, and numerical analysis.
Invited Speakers: A. Bertozzi, J. Blowey, F. Bornemann, P. Colli-Franzone, K. Deckelnick, G. Dolzmann, G. Dziuk, W. E. C. Elliott, H. Garcke, K. Gaertner, P. Gremaud, G. Gruen, T. Hou, D. Kinderlehrer, R. Kohn, R. Kornhuber, R. Le Veque, B. Li, J. Lowengrub, M. Luskin, J. McFadden, S. Osher, C. Peskin, A. Quarteroni, A. Schmidt, J. Sethian, M. Shelley, K. Siebert, P. Smereka, W. Szymczak, A. Veeser, C. Verdi, P. Voorhees, N. Walkington, J. Weeks.
Scientific Committee: E. Baensch (Berlin, Germany), G. Dziuk (Freiburg, Germany), C.M. Elliott (Brighton, England), R.H. Nochetto (College Park, USA), J. Sprekels (Berlin, Germany), C. Verdi (Milano, Italy).
Information: http://www.math.umd.edu/research/interphase/

* 21-24 **PhD EuroConference Foundations of the Formal Sciences III (FotFS III): Complexity in Mathematics and Computer Science**, Universität Wien, Wien, Austria.
Organizing & Scientific Committee: B. Löwe (Bonn, coordinator), B. Piwinger (Wien, local organizer), T. Räsch (Potsdam).
Speakers: P. Berenbrink (Warwick), J. Brendle (Kobe), R. Camerlo (Wien), L. Engebretsen (Cambridge, MA), M. Grohe (Edinburgh), J. D. Hamkins (New York, NY), E. M. Camara (Zaragoza), S. Mikulas (London), R.-D. Schindler (Wien), H. Veith (Wien), J. Zapletal (Gainesville, FL).
Information: e-mail: fotfs@math.uni-bonn.de; http://www.math.uni-bonn.de/people/fotfs/III/.

* 22-23 **International Conference on Optimization Techniques & Itô's Applications in Engineering and Technology**, Agra, India.
Theme: An international conference will be held to celebrate the 149th birthday of Raja Balwant Singhji. Papers on optimization techniques and its applications in modern industry, engineering, and technology with adequate mathematical input/applications are invited. Conference topics include: applied mathematics, electronics & communications, information technology, computer applications, artificial intelligence, chemical engineering, statistical signal processing, resource planning, variational & equilibrium problems, economic & financial decision making.
Information: Information about the conference can be obtained from: S. K. Mishra (Org. Secretary), Dept. of Mathematics, Faculty of Eng. & Tech., R.B.S. College, Bichpuri, Agra (283105), India; tel: +91 (0562) 776675; fax: +91 (0562) 520075; e-mail: shashikMishra@usa.net.

22-26 **Application of Discrete Mathematics**, Australian National University, Canberra, Australia. (Feb. 2001, p. 251)

24-26 **ECCOMAS 2001**, Keble College, Oxford, UK. (Sept. 2000, p. 980)

24-28 **Fourth European Conference on Elliptic and Parabolic Problems—Part II**, Gaeta, Italy. (Jan. 2001, p. 54)

24-28 **Vertical Integration in Biology: From Molecules to Organisms**, Isaac Newton Institute, Cambridge, UK. (May 2001, p. 530)

24-30 **11th International Symposium on Classical Analysis**, Kazimierz Dolny, Poland. (Dec. 2000, p. 1437)

25-29 **Algebraic Geometry Conference**, University of Genova, Italy. (Apr. 2001, p. 438)

26-28 **ASCM 2001 (The Fifth Asian Symposium on Computer Mathematics)**, Ehime University, Matsuyama, Japan. (Jan. 2001, p. 54)

26-28 **First SIAM Conference on Imaging Science**, Boston Park Plaza Hotel, Boston, Massachusetts. (Feb. 2001, p. 251)

26-28 **Fluid Structure Interaction 2001**, Halkidiki, Greece. (Jan. 2001, p. 54)

* 26-28 **International Conference "Differential Equations and Their Applications"**, Institute of Mathematics, Almaty, Republic of Kazakhstan.
Organizers: Institute of Mathematics of Education and Science Ministry of the Republic of Kazakhstan.
Organizing Committee: U. M. Sultangazin (Kazakhstan, co-chair), A. M. Samoilenko (Ukraine, co-chair), S. N. Kharin (Kazakhstan-Pakistan, co-chair), N. K. Bliev (Kazakhstan), A. A. Zhensykbaev (Kazakhstan), Ki Sik Ha (Korea), L. D. Kudryavzev (Russia), B. Kendirli (Turkey), M. I. Imanaliev (Kyrgyzstan), M. S. Salakhitdinov (Uzbekistan), R. Kh. Rozov (Russia), V. M. Amerbayev (Russia), I. T. Pak (Kazakhstan), K. K. Kenzhebayev (Kazakhstan), K. A. Kasymov (Kazakhstan), M. O. Otelbayev (Kazakhstan), M. I. Rakhimberdiev (Kazakhstan), D. S. Dzhumabayev (Kazakhstan), M. T. Dzhenaliev (Kazakhstan), L. A. Alexeyeva (Kazakhstan), G. I. Bizhanova (Kazakhstan), G. K. Zakiryanova (Kazakhstan, scientific secretary).
Program: The conference is organized in sessions as Differential Equations and Mathematical Physics.
Deadlines: For submission of applications is April 10, 2001; for submission of theses, June 20, 2001.
Information: Information on the conference is on the Web site http://www.math.kz/info/diffeq_conf.html. Z. G. Kozhahmetovna, Institute of Mathematics of the ME&S of the RK, Pushkin street, 125, Almaty 480100, Kazakhstan; tel: +7(3272) 913764; fax: +7(3272) 913740; e-mail: zakir@math.kz.

* 27-30 **WSES Conference AITA 2001: Automation and Information: Theory and Applications**, Skiathos Island, Greece.
Information: http://www.worldses.org/wses/conferences/skiathos/aita/.

October 2001

1-5 **Aspects of Hyperbolic Geometry**, University of Fribourg, Fribourg, Switzerland. (May 2001, p. 530)

1-5 **International Conference on Numerical Algorithms, Dedicated to Claude Brezinski on the occasion of his 60th birthday**, Marrakesh, Morocco. (Oct. 2000, p. 1146)

* 1-6 **Workshop: Circuit and Proof Complexity**, International Centre for Mathematical Sciences, Edinburgh, UK.
Information: Please see the ICMS Web pages for further details on programme, speakers, registration, etc.: http://www.ma.hw.ac.uk/icms/current/.

13–14 **AMS Eastern Sectional Meeting,** Williams College, Williamstown, Massachusetts. (Sept. 1997, p. 1031)
Information: W. Drady, wsd@ams.org.

18–21 **2001 Ahlfors-Bers Colloquium,** University of Connecticut at Storrs. (Apr. 2001, p. 439)

24–26 **DIMACS Workshop on Analysis of Gene Expression Data,** DIMACS Center, Rutgers University, Piscataway, New Jersey. (Feb. 2001, p. 252)

*25–28 **2001 Annapolis Algebraic Geometry Conference in Memory of Ruth Michler,** U.S. Naval Academy, Annapolis, Maryland.
Topics: Singularities, commutative algebra, computational methods and applications.
Organizers: C. G. Melles, U.S. Naval Academy, tel: 410-293-6708, fax: 410-293-4883, cgg@usna.edu; L. J. McEwan, Ohio State Univ., mcewan@math.ohio-state.edu; G. Kennedy, Ohio State Univ., tel: 419-755-4291, kennedy@math.ohio-state.edu; K. Lauter, Microsoft Research, tel: 425-703-8335, klauter@microsoft.com.
Confirmed Speakers: S. Abhyankar (Purdue), E. Bierstone (Univ. Toronto), A. Brudnyi (Univ. Calgary), E. Hironaka (Florida State Univ.), G. Kennedy (Ohio State Univ.), K. Lauter (Microsoft), D. Massey (Northeastern Univ.), A. Nemethi (Ohio State Univ.), H. Schenck (Harvard), M. Seppala (Florida State Univ.), A. Silverberg (MSRI/Ohio State), K. Smith (Univ. Michigan), H. Stark (UC San Diego), H. Srinivasan (Univ. Missouri), A. Szilard (Barnard), M. Vitulli (Univ. Oregon), J. F. Voloch (Univ. Texas, Austin).
Registration: $25 for mathematicians with full-time employment; $15 for graduate students and others.
Information: http://mathweb.mathsci.usna.edu/Faculty/Conferences/AlgGeom2001/aagc.html.

November 2001

*2–3 **21st Annual Southeastern-Atlantic Regional Conference on Differential Equations,** Wake Forest University, Winston-Salem, North Carolina.
Description: The primary purpose of the conference is to promote research and education in the field of differential equations. These meetings bring together established and new researchers and advanced graduate students for an exchange of ideas and discussions on all aspects of differential equations. The conference will consist of a series of four plenary one-hour lectures and sessions for contributed papers.
Invited Speakers: A. Castro (Univ. of Texas at San Antonio), S. Lenhart (Univ. of Tennessee), J. Selgrade (N.C. State Univ.), and J. Serrin (Univ. of Minnesota).
Contributed Talks: There will be sessions of contributed talks. Deadline for submission of abstracts for contributed talks is October 12, 2001.
Financial Assistance: Contingent on NSF funding, some financial assistance may be available to offset travel and housing expenses for graduate students and recent Ph.D. recipients. Requests postmarked by October 1, 2001, are guaranteed consideration. Eligible persons who belong to currently underrepresented groups are especially encouraged to apply to the conference for financial assistance.
Information: Updated information can be obtained at the conference Web site: http://www.math.wfu.edu/SEARCDE_2001/ or by contacting: J. Baxley, SEARCDE Coordinator, Dept. of Math., Wake Forest Univ., Winston-Salem, NC 27109; tel: (336) 758-5336; fax: (336) 758-7190; e-mail: baxley@mthcsc.wfu.edu.

5–8 **Seventh SIAM Conference on Geometric Design (SIAG/GD) (GD01),** Holiday Inn Capitol Plaza Hotel, Sacramento, California. (Sept. 2000, p. 980)

26–30 **AAECC-14, The 14th International Symposium on Applied Algebra, Algebraic Algorithms, and Error-Correcting Codes,** RMIT University, Melbourne, Australia. (Jan. 2001, p. 55)

December 2001

1–3 **First International Conference on Neutrosophy, Neutrosophic Logic, Set, Probability and Statistics,** University of New Mexico, Gallup, New Mexico. (May 2001, p. 531)

*2–8 **Quantum and Classical Integrability and Infinite Dimensional Systems,** International Centre for Mathematical Sciences, Edinburgh, UK.
Information: Please see the ICMS Web pages for further details on programme, speakers, registration, etc.: http://www.ma.hw.ac.uk/icms/current/.

*3–7 **LPAR'2001: 8th International Conference on Logic for Programming, AI and Reasoning,** Havana, Cuba.
Information: http://www.lsi.upc.es/~roberto/lpar2001.html.

*3–7 **Workshop on Applied Cryptology,** Institute for Mathematical Sciences, National University of Singapore, Singapore.
Organizing Committee: S.-P. Chan (Singapore), R. Deng (Singapore), S. Ling (Singapore), H. Niederreiter (Singapore, chair), E. Okamoto (Japan), I. E. Shparlinski (Australia), N. J. A. Sloane (USA), C. P. Xing (Singapore).
Description: The workshop is part of the inaugural program of the Institute for Mathematical Sciences on coding theory and data integrity which will run from July to December 2001. There will be invited talks and shorter contributed talks. Specific topics include (but are not limited to) software implementations, design of cryptochips, key management, quantum cryptography, security issues in applications (e-commerce, banking, mobile communications), and current standards.
Call for Papers: Authors of contributed papers should e-mail an abstract of 300–500 words to H. Niederreiter (nied@math.nus.edu.sg) by September 21, 2001. Authors of accepted papers will be notified by October 5, 2001.
Information: http://www.ims.nus.edu.sg/programs/coding.html.

*3–8 **NIPS 2001, Neural Information Processing Systems: Natural and Synthetic,** Vancouver, Canada.
Information: Submissions: due June 20, 2001. Contact nipsinfo@salk.edu, or see http://www.cs.cmu.edu/Web/Groups/NIPS/.

*7–10 **2001 Annual Australasian Research Symposium on Lie Groups, Algebraic Groups, Quantum Groups, and Their Representations (LAQ'2001),** The University of Auckland, Auckland, New Zealand.
Organizers: R. Gover (Auckland), r.gover@auckland.ac.nz; and V. Pestov (Wellington), vova@mcs.vuw.ac.nz.
Information: http://www.mcs.vuw.ac.nz/~vova/laq.html.

*10–13 **International Congress on Modelling and Simulation–Modsim 2001,** Australian National University, Canberra, Australia.
Sponsor: IMACS.
Theme: Integrating Models for Natural Resources Management across Disciplines, Issues and Scales.
Information: F. Ghassemi, Centre for Resource and Environmental Studies, The Australian National University, Canberra ACT 0200, Australia; tel: 61 2 6249 0653; fax: 61 2 6249 0757; e-mail: fredg@cres.anu.edu.au; http://cres.anu.edu.au/~tony/modsim2001.htm.

10–14 **ICMI Study Conference on the Future of the Teaching and Learning of Algebra,** University of Melbourne, Australia. (Jan. 2001, p. 55)

10–14 **Macroscopic Organisation from Microscopic Behaviour in Immunology, Ecology and Epidemiology,** Isaac Newton Institute, Cambridge, UK. (May 2001, p. 531)

10–14 **QMath-8. Mathematical Results in Quantum Mechanics,** Taxco, Mexico. (May 2001, p. 531)

15–19 **The Sixth Asian Technology Conference in Mathematics (ATCM2001) (Applications of Technology in Teaching and Research for the 21st Century),** RMIT University, Melbourne, Australia. (Apr. 2001, p. 439)

17-19 **Eighth Cryptography and Coding**, Royal Agricultural College, Cirencester, UK. (Sept. 2000, p. 980)

* 17-21 **2nd WSES Conference: Algorithms Theory, Discrete Mathematics, Systems and Control (ADISC 2001)**, Cairns, Queensland, Australia.
Information: http://www.worldses.org/wses/conferences/cairns/adisc/.

17-22 **First Announcement and Call for Papers, The Second International Congress of Chinese Mathematicians (ICCM 2001)**, The Grand Hotel, Taipei, Taiwan. (Apr. 2001, p. 439)

19-21 **International Conference on Statistics, Combinatorics and Related Areas and The Eighth International Conference of the Forum for Interdisciplinary Mathematics**, University of Wollongong, Wollongong, NSW, Australia. (Mar. 2001, p. 338)

January 2002

6-9 **Joint Mathematics Meetings**, San Diego Convention Center, San Diego, California. (Nov. 1998, p. 1378)

* 9-12 **International Conference on Inverse Problems-Recent Development in Theories and Numeric**, City University of Hong Kong, Hong Kong.
Objective: The purpose of this conference is to establish a first and strong collaboration link between the universities of Hong Kong and worldwide leading researchers in inverse problems. The conference will address both theoretical (mathematics), applied (engineering) and development aspects of inverse problems.
Topics: Financial Problems, Image Processing Problems, Inverse Problems Related to the Industries, Medical Problems, Nodal Problems, Optimization Problems, Parameter Identification and Control, Sampling Problems, Spectral Problems. The following recent theoretical developments and numerical approaches related to the above topics are emphasized: Well-Posedness, Uniqueness, Stability, Reconstruction Scheme, Numerical Methods.
Invited Plenary Speakers (keynote talks): G. Bao (Michigan Univ.), J. Cheng (Fudan Univ., China), V. Isakov (Wichita State Univ., KS), P. C. Sabatier (Univ. des Sciences et Techniques du Languedoc, France),
Invited Speakers (introductory talks): D. Anikonov (Inst. of Applied Mathematics, Vladivostok, Russia), H. Engl (Johannes Kepler Univ., Linz, Austria), J. Frankel (Tennessee Univ.), D. Fujiwara (Kyoto Univ., Japan), A. Kirsch (Fridericiana Karlsruhe Univ., Germany), J. S. Pang (The Johns Hopkins Univ.), J. K. Seo (Yonsei Univ., Korea), K. Tanuma (Osaka Kyoiku Univ., Japan), D. D. Trong (Ho Chi Ming City Univ., Vietnam), J. Z. Zhang (City Univ. of Hong Kong).
Call for Papers: Titles and abstracts of contributed papers must be received by August 31, 2001. The abstracts should be typed in LaTeX, not to exceed one A4 page, and sent to the secretary by e-mail. Address: J. Hui, Secretary, Department of Mathematics, City Univ. of Hong Kong, 83 Tat Chee Avenue, Kowloon Tong, Hong Kong; tel: (852) 2788 7140; fax: (852) 2788 8561; e-mail: maip@cityu.edu.hk.

* 14-17 **International Conference on Combinatorial Matrix Theory**, Postech, Pohang, Korea.
Conference Theme: Combinatorics, Combinatorial Matrix Theory and related areas of Computational and core Matrix Theory.
Conference Chairs: R. A. Brualdi (Univ. of Wisconsin-Madison, brualdi@math.wisc.edu), S.-G. Hwang (Kyungpook Univ., Korea, sghwang@knu.ac.kr).
Invited Speakers: R. Brualdi, A. Kraeuter, B. Shader, J.-y. Shao, S. Kirkland (plenary), J. Shen (plenary), D. Hershkowitz, J. Seberry, C. Onn, K. Okubo, Y. Nam, B. Liu, I. Wanless, M. Fiedler, T.S. Michael, J. Li, P. Tetali, F. Zhang, L. Qiao, W. Haemers, B.-S. Tam, C. Johnson.
Call for Papers: The program will consist of an hour or 40-minute-long invited lectures and 25-minute contributed talks. Abstracts, at most one page and typed in English, are invited by June 15, 2001.
Information: e-mail: sglee@math.skku.ac.kr; fax: 82-31-290-7033; mailing address: Co-organizer, International Conference on Combinatorial Matrix Theory, Department of Mathematics, College of Science, SungKyunKwan University, Suwon 440-746, Korea; http://matrix.skku.ac.kr/sglee/postech/postech.htm.

* 28-February 1 **The International Conference on Factorization, Singular Operators and Related Problems, dedicated to the 70th anniversary of Professor Gueorguii Litvinchuk**, Madeira University, Madeira, Portugal.
Scientific Program Committee: A. Antonevich (Belarussia), A. Boettcher (Germany), B. Bojarskii (Poland), R. Duduchava (Georgia), M. Kaashoek (Netherlands), N. Karapetiants (Russia), Yu. Karlovich (Mexico), V. Kokilashvili (Georgia), N. Krupnik (Israel), V. Mazya (Sweden), V. Rabinovich (Mexico), B. Silbermann (Germany), I. Simonenko (Russia), I. Spitkovsky (USA), N. Vasilevskii (Mexico).
Information/Registration: http://www.digiways.com/fsorp/.

February 2002

* 2-3 **9th Southern California Geometric Analysis Seminar**, University of California at Irvine.
Description: There will be six top mathematicians in geometric analysis giving talks. Enough time will be allowed for participants to communicate with each other in this two-day seminar.
List of Speakers: TBA.
Information: http://www.math.uci.edu/~scgas. Contact Z. Lu zlu@math.uci.edu.

March 2002

21-22 **8th Rhine Workshop on Computer Algebra**, Mannheim, Germany. (May 2001, p. 531)

* 26-April 4 **Instructional Conference on Combinatorial Aspects of Mathematical Analysis**, International Centre for Mathematical Sciences, Edinburgh, UK.
Information: Please see the ICMS Web pages for further details on programme, speakers, registration, etc.: http://www.ma.hw.ac.uk/icms/current/.

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

June 2002

* 10-13 **The Tenth Conference of the International Linear Algebra Society**, Auburn University, Auburn, Alabama.
Theme: The theme of the conference is "Challenges in Matrix Theory" and will encompass all branches of linear algebra and matrix theory, i.e., core, applied, and numerical.
Information: More details on the conference, such as the list of invited speakers, social events, travel, registration, and hotel information, as well as abstract deadlines, etc., will be made available on the dedicated Web site http://www.auburn.edu/event/ilas2002/ and on ILASNET.

* 17-21 **Seventh International Conference on p-Adic Functional Analysis**, University of Nijmegen, The Netherlands.
Program: Research talks on analysis over valued fields other than the real or complex numbers (such as the p-adic number field or Krull valued fields). Main mathematics subject classifications: 46S10, 47S10, 32P05, 26E30.
Scientific Committee: W. Schikhof (Nijmegen, The Netherlands), A. Escassut (Clermont Ferrand, France), C. Perez-Garcia (Santander, Spain).
Speakers (preliminary list): J. Araujo, J. M. Bayod, M. Berz, A. Boutabaa, B. Diarra, A. Escassut, N. De Grande-De Kimpe, L. Van Hamme, J. Kakol, A. Katsaras, H. Keller, A. Khrennikov, A. Kochubei, A. Lemin, H. Ochsenius, C. Perez-Garcia, Dinamerico Pombo Jr., S. Priess, P. Ribenboim, A. Salinier, W. Schikhof, N. Shell, W. Sliwa, S. Vega.
Information: http://www.sci.kun.nl/math/p-adic2002/ or e-mail: schikhof@sci.kun.nl.

July 2002

*1–6 **2nd International Conference on the Teaching of Mathematics**, Island of Crete, Greece.
Sponsors: Capital Univ., ETH-Zurich, Harvey Mudd College, The Ohio State Univ., Univ. of Crete, John Wiley & Sons.
Organizers: I. Vakalis, Capital Univ.; D. Hughes Hallett, Univ. of Arizona; C. Kourouniotis, Univ. of Crete, Greece; C. Tzanakis, Univ. of Crete, Greece.
Scope: The conference will address new ways of teaching undergraduate mathematics. It will provide a unique and centralized forum and bring together faculty members from countries with varied educational systems who are committed to introducing innovative teaching methods and new pedagogies. The conference will be of great interest to mathematics faculty as well as to anyone involved in the teaching and learning of mathematics.
Invited Speakers: (The following are confirmed speakers. List updated as invitations are accepted.) H. Bass, D. Ball (Univ. of Michigan); O.-N. Kwon (Ewha Women's Univ., Korea); A. Schoenfeld (UC, Berkeley); M. de Guzman (Univ. Complutense de Madrid, Spain); J. P. Bourguignon (Institut des Hautes Études Scientifiques, France); D. Smith (Duke Univ.).
Format of Proposals/Deadlines: Contributed papers will be 30-minute presentations. Proposals for papers and poster sessions should contain: (a) an identification of the proposal as an oral or poster presentation, (b) title and names of authors (full address and e-mail of the contact author), (c) a one-page abstract. More detailed submission guidelines and procedures will be posted on the Web site during summer 2001. Electronic submissions to: D. Quinney, Dept. of Mathematics, Keele University, UK; e-mail: D.Quinney@Keele.ac.uk.
Submission of Proposals: (received by): November 10, 2001; Notification to authors (send by): January 15, 2002; Submission of full paper: February 28, 2002.
Information: http://www.math.uoc.gr/~ictm2/.

*14–18 **The Fourth International Conference on Matrix Analytic Methods in Stochastic Models**, University of Adelaide, Adelaide, Australia.
Scope: The conference will provide an international forum for the presentation of recent results on matrix-analytic methods in stochastic models. Its scope includes development of the methodology as well as the related algorithmic implementations and applications in communications, production and manufacturing engineering; it also includes computer experiments in the investigation of specific probability models. The program committee would particularly like to encourage submissions that report the application of matrix analytic methods to practical problems which have arisen in industry.
Submission Procedure: Prospective authors are invited to submit a full paper. Manuscripts should be original, as they will be peer refereed, with the conference proceedings being published for broad circulation.
Deadlines: Full paper submission: September 1, 2001. Notification of acceptance/revision required/rejection: December 21, 2001. Revised version due: March 1, 2002. Final notification for papers with delayed decision: March 15, 2002.
Student Papers: The organizers wish to encourage students to attend the conference. To that effect, financial assistance will be made available on a limited basis and a streamlined submission procedure will be implemented. Details will be published on the conference Web page.
Information: http://www.trc.adelaide.edu.au/mam4/. Queries should be addressed to MAM4@trc.adelaide.edu.au.

August 2002

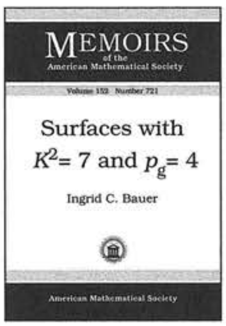
*3–10 **Logic Colloquium 2002 (ASL European Summer Meeting)**, Westfälische Wilhelms-Universität, Münster, Germany.
Invited One-Hour Talks: J. Avigad (Pittsburgh, PA), A. Beckmann (Münster), T. Carlson (Columbus, OH), R. Constable (Ithaca, NY), K. Dosen (Toulouse), M. Gitik (Tel Aviv), V. Halbach (Konstanz), B. Khoussainov (Auckland), S. Lempp (Madison, WI), T. Pitassi (Tucson, AZ), R. Schindler (Wien), K. Tent (Würzburg).
Tutorials: L. Beklemishev (Moscow/Utrecht), S. Cook (Toronto, ON), O. Lessmann (Chicago, IL), S. Thomas (Piscataway, NJ).
Special Sessions: Computability Theory, Non-monotonic Logic, Set Theory.
Information: http://www.math.uni-muenster.de/LC2002/.

*5–15 **New Directions in Dynamical Systems 2002 (ICM 2002 Satellite Conference)**, Ryukoku University and Kyoto University, Kyoto, Japan.
Objective: The objective of the conference is to stimulate the exchange of new ideas in various fields of dynamical systems. Any field of dynamical systems theory will be treated in NDDS2002, with special emphasis on new directions of research for future development. The topics include: smooth dynamical systems, complex dynamical systems and foliations, ergodic theory, Hamiltonian systems, low-dimensional dynamics, topological methods, rigidity, bifurcation theory.
Program: The conference will consist of two parts: The first week is mainly formed by a series of lectures on selected topics. This will be held at Ryukoku University from August 5 to 9. The second week is formed by invited and contributed talks, including short communications, which will be held at Kyoto University from August 11 to 15.
Invited Speakers: M. Lyubich (SUNY Stony Brook), L.-S. Young* (Courant Institute), E. R. Pujals (UFRJ), J. Xia (Northwestern Univ.). (* to be confirmed)
Plenary Lecturers: V. Baladi (Univ. de Paris-Sud), V. Y. Kaloshin (Princeton Univ.), C. McMullen (Harvard Univ.), J. Palis (IMPA), M. Shub (IBM Watson), M. Viana (IMPA), J.-C. Yoccoz* (College de France), J. Yorke (Univ. of Maryland). (* to be confirmed)
Information: http://ndds.math.h.kyoto-u.ac.jp/.

*16–18 **Symposium on Stochastics and Applications (SSA)—An ICM-2002 Satellite Conference**, National University of Singapore, Singapore.
Topics: Financial mathematics, Gaussian random fields, Markov chain Monte Carlo, probability approximations, random matrices.
Organizing Committee: L. H. Y. Chen, National Univ. of Singapore (chair); Z. Bai, National Univ. of Singapore; K.-P. Choi, National Univ. of Singapore; A. Y. C. Kuk, National Univ. of Singapore; S.-L. Lee, National Univ. of Singapore; W.-L. Loh, National Univ. of Singapore; J.-H. Lou, National Univ. of Singapore; Q.-M. Shao, Univ. of Oregon; Y. Sun, National Univ. of Singapore; Y. K. N. Truong, National Univ. of Singapore and Univ. of North Carolina at Chapel Hill.
Contacts: The Organising Committee, SSA 2002, c/o Department of Mathematics, National Univ. of Singapore, 2 Science Drive 2, Singapore 117543, Republic of Singapore.
Information: fax: 65-779 5452; e-mail: ssa@math.nus.edu.sg; http://www.math.nus.edu.sg/ssa/.

New Publications Offered by the AMS

Algebra and Algebraic Geometry



Surfaces with $K^2 = 7$ and $p_g = 4$

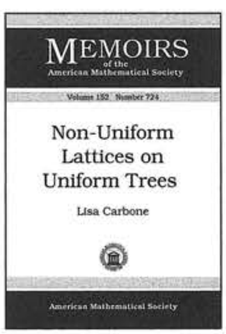
Ingrid C. Bauer, *University of Gottingen, Germany*

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

Contents: Introduction; The canonical system; Some known results; Surfaces with $K^2 = 7, p_g = 4$, such that the canonical system doesn't have a fixed part; $|K|$ has a (non trivial) fixed part; The moduli space; Bibliography.

Memoirs of the American Mathematical Society, Volume 152, Number 721

July 2001, 79 pages, Softcover, ISBN 0-8218-2689-1, LC 2001022723, 2000 *Mathematics Subject Classification*: 14J10, 14J25, 32J15, **Individual member $26**, List $43, Institutional member $34, Order code MEMO/152/721N



Non-Uniform Lattices on Uniform Trees

Lisa Carbone, *Columbia University, New York, NY*

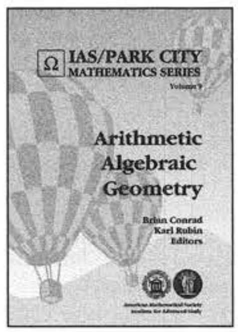
Contents: Introduction; Graphs of groups, tree actions and edge-indexed graphs; $Aut(X)$ and its discrete subgroups; Existence of tree lattices; Non-uniform coverings of indexed graphs with an arithmetic bridge; Non-uniform coverings of indexed graphs with a separating edge; Non-uniform coverings of indexed graphs with a ramified loop; Eliminating multiple edges; Existence of arithmetic bridges; Bibliography.

Memoirs of the American Mathematical Society, Volume 152, Number 724

July 2001, 127 pages, Softcover, ISBN 0-8218-2721-9, LC 2001023977, 2000 *Mathematics Subject Classification*: 20-02; 22-02, **Individual member $28**, List $47, Institutional member $38, Order code MEMO/152/724N

Supplementary Reading

Recommended Text



Arithmetic Algebraic Geometry

Brian Conrad, *University of Michigan, Ann Arbor*, and **Karl Rubin**, *Stanford University, CA*, Editors

The articles in this volume are expanded versions of lectures delivered at the Graduate Summer School and at the Mentoring Program for Women in Mathematics held at the Institute for Advanced Study/Park City Mathematics Institute. The theme of the program was arithmetic algebraic geometry. The choice of lecture topics was heavily influenced by the recent spectacular work of Wiles on modular elliptic curves and Fermat's Last Theorem. The main emphasis of the articles in the volume is on elliptic curves, Galois representations, and modular forms. One lecture series offers an introduction to these objects. The others discuss selected recent results, current research, and open problems and conjectures. The book would be a suitable text for an advanced graduate topics course in arithmetic algebraic geometry.

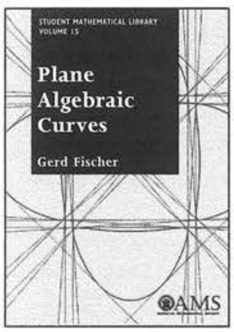
Contents: Introduction; *Joe P. Buhler, Elliptic curves, modular forms, and applications:* Preface; Elliptic curves; Points on elliptic curves; Elliptic curves over **C**; Modular forms of level 1; L-series; Modular forms of higher level; l-adic representations; The rank of elliptic curves over **Q**; Applications of elliptic curves; Bibliography; *Alice Silverberg, Open questions in arithmetic algebraic geometry:* Overview; Torsion subgroups; Ranks; Conjectures of Birch and Swinnerton-Dyer; ABC and related conjectures; Some other conjectures; Bibliography; *Kenneth A. Ribet and William A. Stein, Lectures on Serre's conjectures:* Preface; Introduction to Serre's conjecture; Optimizing the weight; Optimizing the level; Exercises; Appendix by Brian Conrad: The Shimura construction in weight 2; Appendix by Kevin Buzzard: A mod ℓ multiplicity one result; Bibliography; *Fernando Q. Gouvêa, Deformations of Galois representations:* Introduction; Galois groups and their representations; Deformations of representations; The universal deformation:

existence; The universal deformation: properties; Explicit deformations; Deformations with prescribed properties; Modular deformations; p-adic families and infinite ferns; A criterion for existence of a universal deformation ring; An overview of a theorem of Flach; An introduction to the p-adic geometry of modular curves; Bibliography; *Ralph Greenberg, Introduction to Iwasawa theory for elliptic curves:* Preface; Mordell-Weil groups; Selmer groups; Λ-modules; Mazur's control theorem; Bibliography; *John Tate, Galois cohomology:* Galois cohomology; Bibliography; *Wen-Ching Winnie Li, The arithmetic of modular forms:* Introduction; Introduction to elliptic curves, modular forms, and Calabi-Yau varieties; The arithmetic of modular forms; Connections among modular forms, elliptic curves, and representations of Galois groups; Bibliography; *Noriko Yui, Arithmetic of certain Calabi-Yau varieties and mirror symmetry:* Introduction; The modularity conjecture for rigid Calabi-Yau threefolds over the field of rational numbers; Arithmetic of orbifold Calabi-Yau varieties over number fields; $K3$ surfaces, mirror moonshine phenomenon; Bibliography.

IAS/Park City Mathematics Series, Volume 9

August 2001, 569 pages, Hardcover, ISBN 0-8218-2173-3, LC 2001035291, 2000 *Mathematics Subject Classification*: 11F11, 11F33, 11F70, 11F80, 11G07, 11G18, 11R23, 11S25, 11G05, **All AMS members $60,** List $75, Order code PCMS/9N

Recommended Text



Plane Algebraic Curves

Gerd Fischer, *Heinrich-Heine-Universität, Düsseldorf, Germany*

From a review for the German Edition:

The present book provides a completely self-contained introduction to complex plane curves from the traditional algebraic-analytic viewpoint. The arrangement of the material is of outstanding instructional skill, and the text is written in a very lucid, detailed and enlightening style ... Compared to the many other textbooks on (plane) algebraic curves, the present new one comes closest in spirit and content, to the work of E. Brieskorn and H. Knoerrer ... One could say that the book under review is a beautiful, creative and justifiable abridged version of this work, which also stresses the analytic-topological point of view ... the present book is a beautiful invitation to algebraic geometry, encouraging for beginners, and a welcome source for teachers of algebraic geometry, especially for those who want to give an introduction to the subject on the undergraduate-graduate level, to cover some not too difficult topics in substantial depth, but to do so in the shortest possible time.

—Zentralblatt für Mathematik

The study of the zeroes of polynomials, which for one variable is essentially algebraic, becomes a geometric theory for several variables. In this book, Fischer looks at the classic entry point to the subject: plane algebraic curves. Here one quickly sees the mix of algebra and geometry, as well as analysis and topology, that is typical of complex algebraic geometry, but without the need for advanced techniques from commutative algebra or the abstract machinery of sheaves and schemes.

In the first half of this book, Fischer introduces some elementary geometrical aspects, such as tangents, singularities, inflection points, and so on. The main technical tool is the concept of intersection multiplicity and Bézout's theorem. This part culminates in the beautiful Plücker formulas, which relate the various invariants introduced earlier.

The second part of the book is essentially a detailed outline of modern methods of local analytic geometry in the context of complex curves. This provides the stronger tools needed for a good understanding of duality and an efficient means of computing intersection multiplicities introduced earlier. Thus, we meet rings of power series, germs of curves, and formal parametrizations. Finally, through the patching of the local information, a Riemann surface is associated to an algebraic curve, thus linking the algebra and the analysis.

Concrete examples and figures are given throughout the text, and when possible, procedures are given for computing by using polynomials and power series. Several appendices gather supporting material from algebra and topology and expand on interesting geometric topics.

This is an excellent introduction to algebraic geometry, which assumes only standard undergraduate mathematical topics: complex analysis, rings and fields, and topology. Reading this book will help the student establish the appropriate geometric intuition that lies behind the more advanced ideas and techniques used in the study of higher dimensional varieties.

This is the English translation of a German work originally published by Vieweg Verlag (Wiesbaden, Germany).

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

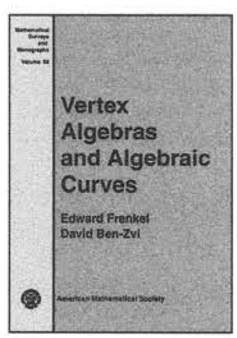
Contents: Introduction; Affine algebraic curves and their equations; The projective closure; Tangents and singularities; Polars and Hessian curves; The dual curve and the Plücker formulas; The ring of convergent power series; Parametrizing the branches of a curve by Puiseux series; Tangents and intersection multiplicities of germs of curves; The Riemann surface of an algebraic curve; The resultant; Covering maps; The implicit function theorem; The Newton polygon; A numerical invariant of singularities of curves; Harnack's inequality; Bibliography; Subject index; List of symbols.

Student Mathematical Library, Volume 15

August 2001, approximately 206 pages, Softcover, ISBN 0-8218-2122-9, 2000 *Mathematics Subject Classification*: 14H50, 14Hxx, 14-01, **All AMS members $28,** List $35, Order code STML/15N

Independent Study

Recommended Text



Vertex Algebras and Algebraic Curves

Edward Frenkel, *University of California, Berkeley*, and **David Ben-Zvi**, *University of Chicago, IL*

Vertex algebras were first introduced about 15 years ago as a tool used in the description of the algebraic structure of certain quantum field theories. In recent years it became increasingly important that vertex algebras are useful not only in the representation theory of infinite-dimensional Lie algebras, where they are by now ubiquitous, but also in other fields, such as algebraic geometry, theory of finite groups, modular functions, topology, etc. This book is an introduction to the theory of vertex algebras with a particular emphasis on the relationship between vertex algebras and the geometry of moduli spaces of algebraic curves. The authors make the first steps toward reformulating the theory of vertex algebras in a way that is suitable for algebraic-geometric applications.

The notion of a vertex algebra is introduced in the book in a coordinate independent way, allowing the authors to give global geometric meaning to vertex operators on arbitrary smooth algebraic curves, possibly equipped with some additional data. To each vertex algebra and a smooth curve, they attach an invariant called the space of conformal blocks. When the complex structure of the curve and other geometric data are varied, these spaces combine into a sheaf on the relevant moduli space. From this perspective, vertex algebras appear as the algebraic objects that encode the geometric structure of various moduli spaces associated with algebraic curves.

Numerous examples and applications of vertex algebras are included, such as the Wakimoto realization of affine Kac-Moody algebras, integral solutions of the Knizhnik-Zamolodchikov equations, classical and quantum Drinfeld-Sokolov reductions, and the W-algebras.

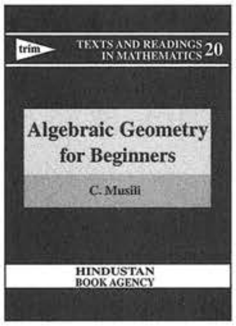
The authors also establish a connection between vertex algebras and chiral algebras, recently introduced by A. Beilinson and V. Drinfeld.

Contents: Definition of vertex algebras; Vertex algebras associated to Lie algebras; Associativity and operator product expansion; Rational vertex algebras; Vertex algebra bundles; Action of internal symmetries; Vertex algebra bundles: Examples; Conformal blocks I; Conformal blocks II; Free field realization I; Free field realization II; The Knizhnik-Zamolodchikov equations; Solving the KZ equations; Quantum Drinfeld-Sokolov reduction and $\mathcal{W}$; Vertex Lie algebras and classical limits; Vertex algebras and moduli spaces I; Vertex algebras and moduli spaces II; Chiral algebras; Appendix A; List of frequently used notation; Index; Bibliography.

Mathematical Surveys and Monographs, Volume 88

August 2001, approximately 376 pages, Hardcover, ISBN 0-8218-2894-0, 2000 *Mathematics Subject Classification*: 17B69; 81R10, 81T40, 17B65, 17B67, 17B68, 14D20, 14D21, 14H10, 14H60, 14H81, **Individual member $33**, List $55, Institutional member $44, Order code SURV/88N

Recommended Text



Algebraic Geometry for Beginners

C. Musili, *University of Hyderabad, India*

A publication of the Hindustan Book Agency.

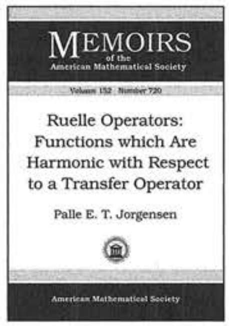
This volume offers a nearly self-contained introduction to some of the basic concepts of algebraic geometry. Prerequisites have been kept to a minimum in order to examine the following areas and some of their standard applications: Bézout's Theorem, the Fundamental Theorem of Projective Geometry, and Zariski's Main Theorem. The exposition is modern, but in the language of "varieties", rather than that of "schemes", making it more accessible to the non-expert. There is extensive coverage of plane curves, including elliptic curves and complex tori, moduli questions, and applications to cryptology.

Distributed worldwide except in India by the American Mathematical Society.

Contents: Commutative algebra; Affine varieties; Projective varieties; Non-singular varieties; Plane curves; Zariski's main theorem; Bibliography; Index; Glossary.

Number 7

March 2001, 335 pages, Hardcover, ISBN 81-85931-27-5, 2000 *Mathematics Subject Classification*: 13-XX, 14-XX, **All AMS members $30**, List $38, Order code HIN/7N



Ruelle Operators: Functions which Are Harmonic with Respect to a Transfer Operator

Palle E. T. Jorgensen, *University of Iowa, Iowa City*

Contents: Introduction; A discrete $ax + b$ group; Proof of Theorem 2.4; Wavelet filters; Cocycle equivalence of filter functions; The transfer operator of Keane; A representation theorem for R-harmonic functions; Signed solutions to $R(f) = f$; Bibliography.

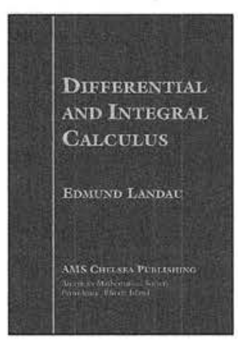
Memoirs of the American Mathematical Society, Volume 152, Number 720

July 2001, 60 pages, Softcover, ISBN 0-8218-2688-3, LC 2001022581, 2000 *Mathematics Subject Classification*: 46L60, 42A16, 43A65; 46L45, 42A65, 41A15, **Individual member $24**, List $40, Institutional member $32, Order code MEMO/152/720N

Classic

Recommended Text

Back in Print from the AMS



Differential and Integral Calculus

Third Edition

Edmund Landau

And what a book it is! The marks of Landau's thoroughness and elegance, and of his undoubted authority, impress themselves on the reader at every turn, from the opening of the preface ... to the closing of the final chapter. It is a book that all analysts ... should possess ... to see how a master of his craft like Landau presented the calculus when he was at the height of his power and reputation.

—Mathematical Gazette

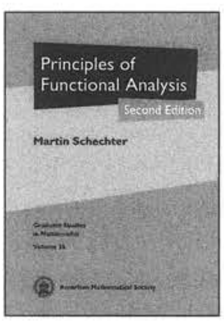
After completing his famous *Foundations of Analysis* (See AMS Chelsea Publishing, Volume 79.H for the English Edition and AMS Chelsea Publishing, Volume 141 for the German Edition, *Grundlagen der Analysis*), Landau turned his attention to this book on calculus. The approach is that of an unrepentant analyst, with an emphasis on functions rather than on geometric or physical applications. The book is another example of Landau's formidable skill as an expositor. It is a masterpiece of rigor and clarity.

Contents: *Part One. Differential Calculus:* Limits as $n = \infty$; Logarithms, powers, and roots; Functions and continuity; Limits as $x = \xi$; Definition of the derivative; General theorems on the formation of the derivative; Increase, decrease, maximum, minimum; General properties of continuous functions on closed intervals; Rolle's theorem and the theorem of the mean; Derivatives of higher order; Taylor's theorem; "0/0" and similar matters; Infinite series; Uniform convergence; Power series; Exponential series and binomial series; The trigonometric functions; Functions of two variables and partial derivatives; Inverse functions and implicit functions; The inverse trigonometric functions; Some necessary algebraic theorems; *Part Two. Integral Calculus:* Definition of the integral; Basic formulas of the integral calculus; The integration of rational functions; The integration of certain non-rational functions; Concept of the definite integral; Theorems on the definite integral; The integration of infinite series; The improper integral; The integral with infinite limits; The gamma function; Fourier series; Index of definitions; Subject index.

AMS Chelsea Publishing

January 1965, 372 pages, Hardcover, ISBN 0-8218-2830-4, LC 60-8966, 2000 *Mathematics Subject Classification*: 26-01, 01A75, **All AMS members $32**, List $35, Order code CHEL/78.HN

Recommended Text



Principles of Functional Analysis

Second Edition

Martin Schechter, *University of California, Irvine*

From a review for the First Edition:

"Charming" is a word that seldom comes to the mind of a science reviewer, but if he is charmed by a treatise, why not say so? I am charmed by this book.

Professor Schechter has written an elegant introduction to functional analysis including related parts of the theory of integral equations. It is easy to read and is full of important applications. He presupposes very little background beyond advanced calculus; in particular, the treatment is not burdened by topological "refinements" which nowadays have a tendency of dominating the picture.

The book can be warmly recommended to any reader who wants to learn about this subject without being deterred by less relevant introductory matter or scared away by heavy prerequisites.

—Einar Hille in The American Scientist

Functional analysis plays a crucial role in the applied sciences as well as in mathematics. It is a beautiful subject that can be motivated and studied for its own sake. In keeping with this basic philosophy, the author has made this introductory text accessible to a wide spectrum of students, including beginning-level graduates and advanced undergraduates.

The exposition is inviting, following threads of ideas, describing each as fully as possible, before moving on to a new topic. Supporting material is introduced as appropriate, and only to the degree needed. Some topics are treated more than once, according to the different contexts in which they arise.

The prerequisites are minimal, requiring little more than advanced calculus and no measure theory. The text focuses on normed vector spaces and their important examples, Banach spaces and Hilbert spaces. The author also includes topics not usually found in texts on the subject.

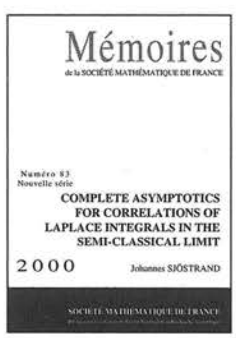
This Second Edition incorporates many new developments while not overshadowing the book's original flavor. Areas in the book that demonstrate its unique character have been strengthened. In particular, new material concerning Fredholm and semi-Fredholm operators is introduced, requiring minimal effort as the necessary machinery was already in place. Several new topics are presented, but relate to only those concepts and methods emanating from other parts of the book. These topics include perturbation classes, measures of noncompactness, strictly singular operators, and operator constants.

Overall, the presentation has been refined, clarified, and simplified, and many new problems have been added.

Contents: Basic notions; Duality; Linear operators; The Riesz theory for compact operators; Fredholm operators; Spectral theory; Unbounded operators; Reflexive Banach spaces; Banach algebras; Semigroups; Hilbert space; Bilinear forms; Selfadjoint operators; Measures of operators; Examples and applications; Bibliography; Index.

Graduate Studies in Mathematics, Volume 36

September 2001, 393 pages, Hardcover, ISBN 0-8218-2895-9, LC 2001031601, 2000 *Mathematics Subject Classification*: 46-01, 47-01, 46B20, 46B25, 46C05, 47A05, 47A07, 47A12, 47A53, 47A55, **All AMS members $47**, List $59, Order code GSM/36N



Complete Asymptotics for Correlations of Laplace Integrals in the Semi-Classical Limit

Johannes Sjöstrand, *Centre Mathématiques, Palaiseau, France*

A publication of the Société Mathématique de France.

The author studies the exponential decay asymptotics of correlations at large distance, associated to a measure of Laplace type, in the semi-classical limit. The new feature, compared to earlier works by V. Bach, T. Jecko, and the author, is that full asymptotics of the decay rate and the prefactor are given, instead of just the leading terms. He also treats the thermodynamical limit. As before, the Witten-Laplacian via a Grushin (Feshbach) problem is studied, but now higher order problems are used involving multiparticle states.

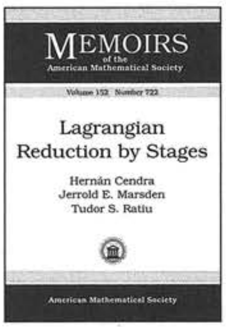
Distributed by the AMS in the United States, Canada, and Mexico. Orders from other countries should be sent to the SMF, Maison de la SMF, B.P. 67, 13274 Marseille cedex 09, France, or to Institut Henri Poincaré, 11 rue Pierre et Marie Curie, 75231 Paris cedex 05, France. Members of the SMF receive a 30% discount from list.

Contents: Introduction; Slight generalization of the main result; Assumptions on ϕ; The spaces $\mathcal{H}_{\pm 1}$; Reshuffling of Z and Z^*; Study of $((1/\alpha!)(Z^*)^\alpha(e^{-\phi/h})|(1/\beta!)(Z^*)^\beta(e^{-\phi/h}))$; Higher order Grushin problems; Asymptotics of the solutions of the Grushin problems; Exponential weights; Parameter dependent exponents; Asymptotics of the correlations; Extraction of a main result; Non-commutative Taylor expansions; Hilbert-Schmidt property of tensors; Bibliography.

Mémoires de la Société Mathématique de France, Number 83

December 2000, 104 pages, Softcover, ISBN 2-85629-097-3, 2000 *Mathematics Subject Classification*: 82B20, 81Q20, **Individual member $30**, List $33, Order code SMFMEM/83N

Differential Equations



Lagrangian Reduction by Stages

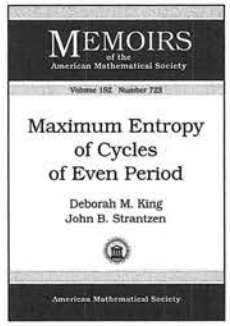
Hernán Cendra, *Universidad Nacional del Sur, Bahia Blanca, Argentina*, **Jerrold E. Marsden**, *California Institute of Technology, Pasadena*, and **Tudor S. Ratiu**, *École Polytechnique Fédérale de Lausanne, Switzerland*

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

Contents: Introduction; Preliminary constructions; The Lagrange-Poincaré equations; Wong's equations and coordinate formulas; The Lie algebra structure on sections of the reduced bundle; Reduced tangent bundles; Further examples; The category $\mathfrak{LP}^*$ and Poisson geometry; Bibliography.

Memoirs of the American Mathematical Society, Volume 152, Number 722

July 2001, 108 pages, Softcover, ISBN 0-8218-2715-4, LC 2001023978, 2000 *Mathematics Subject Classification*: 37J15; 70H33, 53D20, **Individual member $28**, List $47, Institutional member $38, Order code MEMO/152/722N



Maximum Entropy of Cycles of Even Period

Deborah M. King, *University of New South Wales, Sydney, NSW, Australia*, and **John B. Strantzen**, *La Trobe University, Bundoora, Victoria, Australia*

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

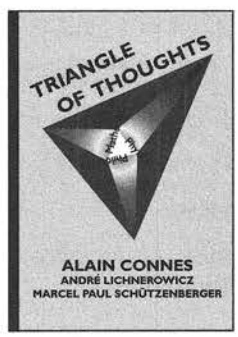
Contents: Introduction; Preliminaries; Some useful properties of the induced matrix of a maximodal permutation; The family of orbit types; Some easy lemmas; Two inductive lemmas; The remaining case; References.

Memoirs of the American Mathematical Society, Volume 152, Number 723

July 2001, 59 pages, Softcover, ISBN 0-8218-2707-3, LC 2001023976, 2000 *Mathematics Subject Classification*: 37B40, 37E15, **Individual member $24**, List $40, Institutional member $32, Order code MEMO/152/723N

General and Interdisciplinary

Recommended Text



Triangle of Thoughts

Alain Connes, **André Lichnerowicz**, and **Marcel Paul Schützenberger**

Our view of the world today is fundamentally influenced by twentieth century results in physics and mathematics. Here, three members of the French Academy of Sciences: Alain Connes, André Lichnerowicz, and Marcel Paul Schützenberger, discuss the relations among mathematics, physics, and philosophy, and other sciences. Written in the form of conversations among three brilliant scientists and deep thinkers, the book touches on, among others, the following questions:

- Is there a "primordial truth" that exists beyond the realm of what is provable? More generally, is there a distinction between what is true in mathematics and what is provable?
- How is mathematics different from other sciences? How is it the same? Does mathematics have an "object" or an "object of study", the way physics, chemistry and biology do?
- Mathematics is a lens, through which we view the world. Connes, Lichnerowicz, and Schützenberger examine that lens, to understand how it affects what we do see, but also to understand how it limits what we can see.
- How does a well-informed mathematician view fundamental topics of physics, such as: quantum mechanics, general relativity, quantum gravity, grand unification, and string theory?
- What are the relations between computational complexity and the laws of physics?

- Can pure thought alone lead physicists to the right theories, or must experimental data be the driving force? How should we compare Heisenberg's arrival at matrix mechanics from spectral data to Einstein's arrival at general relativity through his thought experiments?

The conversations are sprinkled with stories and quotes from outstanding scientists, which enliven the discourse. The book will make you think again about things that you once thought were quite familiar.

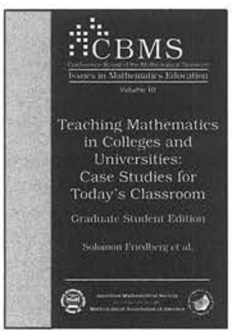
Alain Connes is one of the founders of non-commutative geometry. He holds the Chair of Analysis and Geometry at the Collège de France. He was awarded the Fields Medal in 1982.

André Lichnerowicz, mathematician, noted geometer, theoretical physicist, and specialist in general relativity, was a professor at the Collège de France.

Marcel Paul Schützenberger made brilliant contributions to combinatorics and graph theory. He was simultaneously a medical doctor, a biologist, a psychiatrist, a linguist, and an algebraist.

Contents: Logic and reality; The nature of mathematical objects; Physics and mathematics: The double-edged sword; Fundamental theory and real calculation; Mathematics and the description of the world; Cosmology and grand unification; Interpreting quantum mechanics; Reflections on time; Biographical Note: André Lichnerowicz; Biographical Note: Marcel Paul Schützenberger.

July 2001, 181 pages, Hardcover, ISBN 0-8218-2614-X, LC 00-065064, 2000 *Mathematics Subject Classification*: 00A30, **All AMS members $24**, List $30, Order code TOTN



Teaching Mathematics in Colleges and Universities: Case Studies for Today's Classroom

Graduate Student Edition

Solomon Friedberg, *Boston College, Chestnut Hill, MA,* **Avner Ash, Elizabeth Brown, Deborah Hughes Hallett, Reva Kasman, Margaret Kenney, Lisa A. Mantini, William McCallum, Jeremy Teitelbaum, and Lee Zia**

Progress in mathematics frequently occurs first by studying particular examples and then by generalizing the patterns that have been observed into far-reaching theorems. Similarly, in teaching mathematics one often employs examples to motivate a general principle or to illustrate its use. This volume uses the same idea in the context of learning *how* to teach: By analyzing particular teaching situations, one can develop broadly applicable teaching skills useful for the professional mathematician. These teaching situations are the Case Studies of the title.

Just as a good mathematician seeks both to understand the details of a particular problem and to put it in a broader context, the examples presented here are chosen to offer a serious set of detailed teaching issues and to afford analysis from a broad perspective.

Each case raises a variety of pedagogical and communication issues that may be explored either individually or in a group facilitated by a faculty member. Teaching notes for such a facilitator are included for each Case in the Faculty Edition.

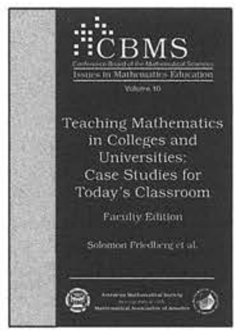
The methodology of Case Studies is widely used in areas such as business and law. The consideration of the mathematics cases presented here will help readers to develop teaching skills for their own classrooms.

This series is published in cooperation with the Mathematical Association of America.

Contents: Introduction; *Fourteen case studies:* Changing sections; Emily's test; Fundamental problems; Making the grade (College algebra version/Calculus I version/Multivariable calculus version); Making waves; Order out of chaos; Pairing up; The quicksand of problem four; Salad days; Seeking points; Study habits; Studying the exam (College algebra questions/Calculus II questions/Multivariable calculus questions); There's something about Ted; What were they thinking?.

CBMS Issues in Mathematics Education, Volume 10

June 2001, 67 pages, Softcover, ISBN 0-8218-2823-1, LC 2001022683, 2000 *Mathematics Subject Classification*: 00A35, 97D40; 00A05, 97C70, 97D30, 97D50, 97D60, 97D70, 97U70, **All AMS members $13**, List $16, Order code CBMATH/10N



Teaching Mathematics in Colleges and Universities: Case Studies for Today's Classroom

Faculty Edition

Solomon Friedberg, *Boston College, Chestnut Hill, MA* and members of the Boston College Mathematics Case Studies Project Development Team

Contents: Introduction; *Fourteen case studies:* Changing sections; Emily's test; Fundamental problems part I; Making the Grade (College algebra version/Calculus I version/Multivariable calculus version); Making waves; Order out of chaos; Pairing up; The quicksand of problem four; Salad days; Seeking points; Study habits; Studying the exam (College algebra questions/Calculus II questions/Multivariable calculus questions); There's something about Ted part I; What were they thinking?; *Supporting materials for faculty:* Developing effective mathematics teaching assistants using case studies: An introduction for faculty; Using case studies in a TA-development program; Types of cases; Summaries of cases; How these cases were created; Changing sections, teaching guide; Emily's test, teaching guide; Fundamental problems part II (Fundamental problems, teaching guide); Making the grade, teaching guide; Making waves part II (Making waves, teaching guide); Order out of chaos, teaching guide; Pairing up, teaching guide; The quicksand of problem four, teaching guide; Salad days, teaching guide; Seeking points, teaching guide; Study habits, teaching guide; Studying the exam, teaching guide (College algebra version/Calculus II version/Multivariable calculus version); There's something about Ted Part II/There's something about Ted, teaching guide; What were they thinking?, teaching guide.

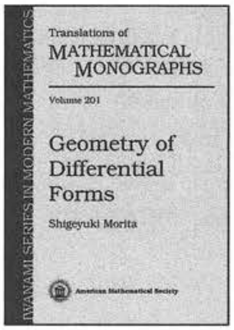
CBMS Issues in Mathematics Education, Volume 10.F

June 2001, 158 pages, Softcover, ISBN 0-8218-2875-4, 2000 *Mathematics Subject Classification*: 00A35, 97D40; 00A05, 97C70, 97D30, 97D50, 97D60, 97D70, 97U70, **All AMS members $23**, List $29, Order code CBMATH/10.FN

Geometry and Topology

Recommended Text

Geometry of Differential Forms



Shigeyuki Morita, *University of Tokyo, Japan*

Since the times of Gauss, Riemann, and Poincaré, one of the principal goals of the study of manifolds has been to relate local analytic properties of a manifold with its global topological properties. Among the high points on this route are the Gauss-Bonnet formula, the de Rham complex, and the Hodge theorem; these results show, in particular, that the central tool in reaching the main goal of global analysis is the theory of differential forms.

The book by Morita is a comprehensive introduction to differential forms. It begins with a quick introduction to the notion of differentiable manifolds and then develops basic properties of differential forms as well as fundamental results concerning them, such as the de Rham and Frobenius theorems. The second half of the book is devoted to more advanced material, including Laplacians and harmonic forms on manifolds, the concepts of vector bundles and fiber bundles, and the theory of characteristic classes. Among the less traditional topics treated is a detailed description of the Chern-Weil theory.

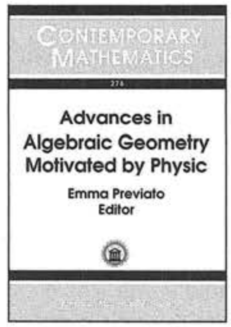
The book can serve as a textbook for undergraduate students and for graduate students in geometry.

Contents: Manifolds; Differential forms; de Rham theorem; Laplacian and harmonic forms; Vector bundles and characteristic classes; Fiber bundles and characteristic classes; Perspectives; References; Solutions; Index.

Translations of Mathematical Monographs (*Iwanami Series in Modern Mathematics*), Volume 201

July 2001, approximately 352 pages, Softcover, ISBN 0-8218-1045-6, LC 2001022608, 2000 *Mathematics Subject Classification*: 57Rxx, 58Axx, **All AMS members $42**, List $53, Order code MMONO/201N

Mathematical Physics



Advances in Algebraic Geometry Motivated by Physics

Emma Previato, *Boston University, MA*, Editor

Our knowledge of objects of algebraic geometry such as moduli of curves, (real) Schubert classes, fundamental groups of complements of hyperplane arrangements, toric varieties, and variation of Hodge structures, has been enhanced recently by ideas and constructions of quantum field theory, such as mirror symmetry, Gromov-Witten invariants, quantum cohomology, and gravitational descendants.

These are some of the themes of this refereed collection of papers, which grew out of the special session, "Enumerative Geometry in Physics," held at the AMS meeting in Lowell, MA, April 2000. This session brought together mathematicians and physicists who reported on the latest results and open questions; all the abstracts are included as an Appendix, and also included are papers by some who could not attend.

The collection provides an overview of state-of-the-art tools, links that connect classical and modern problems, and the latest knowledge available.

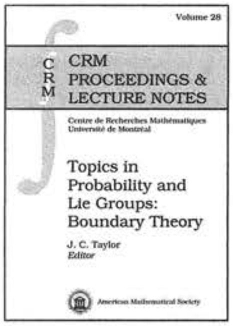
This item will also be of interest to those working in algebra and algebraic geometry.

Contents: *Enumerative or reality problems:* **S. J. Kovács**, Number of automorphisms of principally polarized abelian varieties; **F. Sottile**, Rational curves on Grassmannians: Systems theory, reality, and transversality; **A. I. Suciu**, Fundamental groups of line arrangements: Enumerative aspects; *Variational and moduli problems:* **D. Abramovich** and **A. Bertram**, The formula $12 = 10 + 2 \times 1$ and its generalizations: Counting rational curves on F_2; **D. Abramovich** and **F. Oort**, Stable maps and Hurwitz schemes in mixed characteristics; **L. Caporaso**, On modular properties of odd theta-characteristics; **E. Cattani** and **J. Fernandez**, Asymptotic Hodge theory and quantum products; **H. Clemens**, On rational curves in n-space with given normal bundle; **R. Vakil**, A tool for stable reduction of curves on surfaces; *Mirror symmetry and Gromov-Witten invariants:* **D. A. Cox**, **S. Katz**, and **Y.-P. Lee**, Virtual fundamental classes of zero loci; **T. J. Jarvis**, **T. Kimura**, and **A. Vaintrob**, Gravitational descendants and the moduli space of higher spin curves; **B. Kreußler**, Homological mirror symmetry in dimension one; **A. R. Mavlyutov**, The Hodge structure of semiample hypersurfaces and a generalization of the monomial-divisor mirror map; **A. Polishchuk** and **A. Vaintrob**, Algebraic construction of Witten's top Chern class; **A. Postnikov**, Symmetries of Gromov-Witten invariants; **S. Rosenberg** and **M. Vajiac**, Gauge theory techniques in quantum cohomology; **C. Woodward**, Gromov-Witten invariants of flag manifolds and products of conjugacy classes; *Appendix:* **E. Previato**, The Lowell meeting.

Contemporary Mathematics, Volume 276

July 2001, 294 pages, Softcover, ISBN 0-8218-2810-X, LC 2001022549, 2000 *Mathematics Subject Classification*: 13P10, 14-XX, 32G20, 32S22, 53Cxx, 53D45; 20Fxx, 57M05, 65H20, 93B55, **Individual member $45**, List $75, Institutional member $60, Order code CONM/276N

Probability



Topics in Probability and Lie Groups: Boundary Theory

J. C. Taylor, *McGill University, Montreal, PQ, Canada*, Editor

This volume is comprised of two parts: the first contains articles by S. N. Evans, F. Ledrappier, and Figà-Talomanaca. These articles arose from a Centre de Recherches de Mathématiques (CRM) seminar entitiled, "Topics in Probability on Lie Groups: Boundary Theory".

Evans gives a synthesis of his pre-1992 work on Gaussian measures on vector spaces over a local field. Ledrappier uses the freegroup on d generators as a paradigm for results on the asymptotic properties of random walks and harmonic measures on the Martin boundary. These articles are followed by a case study by Figà-Talamanca using Gelfand pairs to study a diffusion on a compact ultrametric space.

The second part of the book is an appendix to the book *Compactifications of Symmetric Spaces* (Birkhauser) by Y. Guivarc'h and J. C. Taylor. This appendix consists of an article by each author and presents the contents of this book in a more algebraic way. L. Ji and J.-P. Anker simplifies some of their results on the asymptotics of the Green function that were used to compute Martin boundaries. And Taylor gives a self-contained account of Martin boundary theory for manifolds using the theory of second order strictly elliptic partial differential operators.

Contents: J.-P. Anker and **L. Ji**, Heat kernel and Green function estimates on noncompact symmetric spaces. II; **S. N. Evans**, Local fields, Gaussian measures, and Brownian motions; **A. Figà-Talamanca**, An application of Gelfand pairs to a problem of diffusion in compact ultrametric spaces; **Y. Guivarc'h**, **J. C. Taylor**, and **L. Ji**, Compactifications of symmetric spaces and positive eigenfunctions of the Laplacian; **F. Ledrappier**, Some asymptotic properties of random walks on free groups; **J. C. Taylor**, The Martin compactification associated with a second order strictly elliptic partial differential operator on a manifold **M**.

CRM Proceedings & Lecture Notes, Volume 28

July 2001, 202 pages, Softcover, ISBN 0-8218-0275-5, LC 2001032073, 2000 *Mathematics Subject Classification*: 60B99; 31C35, 22E30, 22E46, 60J50, **Individual member $35**, List $59, Institutional member $47, Order code CRMP/28N

Previously Announced Publications

A Classic

Supplementary Reading

Plateau's Problem

An Invitation to Varifold Geometry

Frederick J. Almgren, Jr.

There have been many wonderful developments in the theory of minimal surfaces and geometric measure theory in the past 25 to 30 years. Many of the researchers who have produced these excellent results were inspired by this little book—or by Fred Almgren himself.

The book is indeed a delightful invitation to the world of variational geometry. A central topic is Plateau's Problem, which is concerned with surfaces that model the behavior of soap films. When trying to resolve the problem, however, one soon finds that smooth surfaces are insufficient: Varifolds are needed. With varifolds, one can obtain geometrically meaningful solutions without having to know in advance all their possible singularities. This new tool makes possible much exciting new analysis and many new results.

Plateau's problem and varifolds live in the world of geometric measure theory, where differential geometry and measure theory combine to solve problems which have variational aspects. The author's hope in writing this book was to encourage young mathematicians to study this fascinating subject further. Judging from the success of his students, it achieves this exceedingly well.

This item will also be of interest to those working in analysis.

Student Mathematical Library, Volume 13

July 2001, approximately 88 pages, Softcover, ISBN 0-8218-2747-2, LC 2001022082, 2000 *Mathematics Subject Classification*: 49-01, 26-01, 28-01, 28A75, 49Q15, 49Q20, 58E12, **All AMS members $15**, List $19, Order code STML/13RT167

Supplementary Reading

Essays in the History of Lie Groups and Algebraic Groups

Armand Borel, *Institute for Advanced Study, Princeton, NJ*

Lie groups and algebraic groups are important in many major areas of mathematics and mathematical physics. We find them in diverse roles, notably as groups of automorphisms of geometric structures, as symmetries of differential systems, or as basic tools in the theory of automorphic forms. The author looks at their development, highlighting the evolution from the almost purely local theory at the start to the global theory that we know today. Starting from Lie's theory of local analytic transformation groups and early work on Lie algebras, he follows the process of globalization in its two main frameworks: differential geometry and topology on one hand, algebraic geometry on the other. Chapters II to IV are devoted to the former, Chapters V to VIII, to the latter.

The essays in the first part of the book survey various proofs of the full reducibility of linear representations of $\mathbf{SL}_2(\mathbb{C})$, the contributions of H. Weyl to representations and invariant theory for semisimple Lie groups, and conclude with a chapter on E. Cartan's theory of symmetric spaces and Lie groups in the large.

The second part of the book first outlines various contributions to linear algebraic groups in the 19th century, due mainly to E. Study, E. Picard, and above all, L. Maurer. After being abandoned for nearly fifty years, the theory was revived by C. Chevalley and E. Kolchin, and then further developed by many others. This is the focus of Chapter VI. The book concludes with two chapters on the work of Chevalley on Lie groups and Lie algebras and of Kolchin on algebraic groups and the Galois theory of differential fields, which put their contributions to algebraic groups in a broader context.

Professor Borel brings a unique perspective to this study. As an important developer of some of the modern elements of both the differential geometric and the algebraic geometric sides of the theory, he has a particularly deep understanding of the underlying mathematics. His lifelong involvement and his historical research in the subject area give him a special appreciation of the story of its development.

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

History of Mathematics, Volume 21

July 2001, approximately 184 pages, Hardcover, ISBN 0-8218-0288-7, LC 2001018175, 2000 *Mathematics Subject Classification*: 01A55, 01A60, 20-03, 20G15, 20G20, 22-03, 22E10, 22E46, 32M05, 32M15, 32-03, 53C35, 57T15, **All AMS members $31**, List $39, Order code HMATH/21RT167

Problèmes de Petits Diviseurs dans les Équations aux Dérivées Partielles

Walter Craig, *McMaster University, Hamilton, ON, Canada*

A publication of the Société Mathématique de France.

Many problems in nonlinear PDE which are of physical significance can be posed as Hamiltonian systems: Some principal examples include the nonlinear wave equations, the nonlinear Schrödinger equation, the KdV equation and the Euler equations of fluid mechanics. Complementing the theory of the initial value problem, it is natural to pose the question of stability of solutions for all times, and to describe the principal structures of phase space which are invariant under the flow. The subject of this volume is the development of extensions of KAM theory of invariant tori for PDE, for which the phase space is naturally infinite dimensional. The book starts with the definition of a Hamiltonian system in infinite dimensions. It reviews the classical theory of periodic solutions for finite dimensional dynamical systems, commenting on the role played by resonances. It then develops a direct approach to KAM theory in infinite dimensional settings, applying it to several of the PDE of interest. The volume includes a description of the methods of Fröhlich and Spencer for resolvant expansions of linear operators, as it is a basic technique used in this approach to KAM theory. The final chapter gives a presentation of the more recent developments of the subject. Text is in French.

Distributed by the AMS in the United States, Canada, and Mexico. Orders from other countries should be sent to the SMF, Maison de la SMF, B.P. 67, 13274 Marseille cedex 09, France, or to Institut Henri Poincaré, 11 rue Pierre et Marie Curie, 75231 Paris cedex 05, France. Members of the SMF receive a 30% discount from list.

Panoramas et Synthèses, Number 9

December 2000, 120 pages, Softcover, ISBN 2-85629-095-7, 2000 *Mathematics Subject Classification*: 35-XX, 37-XX, **Individual member $30**, List $33, Order code PASY/9RT167

Recommended Text

Problems in Mathematical Analysis II

Continuity and Differentiation

W. J. Kaczor and **M. T. Nowak,**, *Maria Curie-Sklodowska University, Lublin, Poland*

We learn by doing. We learn mathematics by doing problems. And we learn more mathematics by doing more problems. This is the sequel to *Problems in Mathematical Analysis I* (Volume 4 in the Student Mathematical Library series). If you want to hone your understanding of continuous and differentiable functions, this book contains hundreds of problems to help you do so. The emphasis here is on real functions of a single variable. Topics include: continuous functions, the intermediate value property, uniform continuity, mean value theorems, Taylors formula, convex functions, sequences and series of functions.

The book is mainly geared toward students studying the basic principles of analysis. However, given its selection of problems, organization, and level, it would be an ideal choice for tutorial or problem-solving seminars, particularly those geared toward the Putnam exam. It is also suitable for self-study. The presentation of the material is designed to help student comprehension, to encourage them to ask their own questions, and to start research. The collection of problems will also help teachers who wish to incorporate problems into their lectures. The problems are grouped into sections according to the methods of solution. Solutions for the problems are provided.

Student Mathematical Library, Volume 12

June 2001, 398 pages, Softcover, ISBN 0-8218-2051-6, LC 99-087039, 2000 *Mathematics Subject Classification*: 00A07; 26A06, 26A15, 26A24, **All AMS members $39**, List $49, Order code STML/12RT167

Also available ...

Problems in Mathematical Analysis I

W. J. Kaczor and **M. T. Nowak**, *Maria Curie-Sklodowska University, Lublin, Poland*

Student Mathematical Library

Volume 4: June 2001, 380 pages, Softcover, ISBN 0-8218-2050-8, LC 99-087039, 2000 *Mathematics Subject Classification*: 00A07, 40-01; 26A06, 26A15, 26A24, **All AMS members $31**, List $39, Order code STML/4RT167

Set: June 2001, 796 pages, Softcover, ISBN 0-8218-2849-5, LC 99-087039, 2000 *Mathematics Subject Classification*: 00A07, 40-01; 26A06, 26A15, 26A24, **All AMS members $62**, List $78, Order code STMLSETRT167

Ensembles Quasi-Minimaux avec Contrainte de Volume et Rectifiabilité Uniforme

Séverine Rigot, *Université de Paris-Sud, Orsay, France*

A publication of the Société Mathématique de France.

In this memoir, the author studies the regularity of quasi-minimal sets for the perimeter with a volume constraint, i.e., measurable subsets G of $\mathbb{R}^n$ which satisfy the following quasi-minimality condition: $\int_{\mathbb{R}^n} |\nabla \chi_G| \leq \int_{\mathbb{R}^n} |\nabla \chi_{G'}| + g(|G \triangle G'|)$, for every $G' \subset \mathbb{R}^n$ such that $G \triangle G' \Subset \mathbb{R}^n$ and $|G'| = |G|$. Here $\int_{\mathbb{R}^n} |\nabla \chi_G|$ denotes the perimeter of G and $g : [0, +\infty[\to [0, +\infty[$ is fixed such that $g(x) = o(x^{(n-1)/n})$. The main result of this memoir is the uniform rectifiability of their boundary with universal parameters. This result is then applied to the study of minimizers with prescribed Lebesgue measure of a functional E defined by $E(G) = H^{n-1}(\partial G) + \iint_{G \times G} K(x-y)\, dx\, dy$, where $G \subset \mathbb{R}^n$, $H^{n-1}(\partial G)$ denotes the $(n-1)$-Hausdorff measure of the boundary of G and $K \in L^1(\mathbb{R}^n)$ with compact support. Using the fact that the parameters in the regularity properties of quasi-minimizers with a volume constraint are universal, the author obtains the existence of optimal sets together with a description of these minimizers (regularity of their boundary, size and number of their connected components). Text is in French.

Distributed by the AMS in the United States, Canada, and Mexico. Orders from other countries should be sent to the SMF, Maison de la SMF, B.P. 67, 13274 Marseille cedex 09, France, or to Institut Henri Poincaré, 11 rue Pierre et Marie Curie, 75231 Paris cedex 05, France. Members of the SMF receive a 30% discount from list.

Mémoires de la Société Mathématique de France, Number 82

December 2000, 104 pages, Softcover, ISBN 2-85629-093-0, 2000 *Mathematics Subject Classification*: 49Q20, **Individual member $30**, List $33, Order code SMFMEM/82RT167

Topology, Ergodic Theory, Real Algebraic Geometry

Rokhlin's Memorial

V. Turaev, *Université Louis Pasteur—CNRS, Strasbourg, France*, and **A. Vershik**, *Steklov Mathematical Institute, St. Petersburg, Russia*, Editors

This book is dedicated to the memory of the outstanding Russian mathematician, V. A. Rokhlin (1919–1984). It is a collection of research papers written by his former students and followers, who are now experts in their fields. The topics in this volume include topology (the Morse-Novikov theory, spin bordisms in dimension 6, and skein modules of links), real algebraic geometry (real algebraic curves, plane algebraic surfaces, algebraic links, and complex orientations), dynamics (ergodicity, amenability, and random bundle transformations), geometry of Riemannian manifolds, theory of Teichmüller spaces, measure theory, etc. The book also includes a biography of Rokhlin by Vershik and two articles of historical interest.

Contributors include: A. M. Vershik, J. E. Andersen, V. Turaev, F. Bihan, A. Bufetov, Z. Coelho, W. Parry, A. Degtyarev, M. Farber, S. Finashin, I. Itenberg, N. V. Ivanov, V. A. Kaimanovich, V. Kharlamov, J.-J. Risler, E. Shustin, Y. Kifer, S. Yu. Orevkov, M. Pollicott, R. Sharp, O. Viro, B. Weiss, and A. V. Zhubr.

American Mathematical Society Translations—Series 2 (*Advances in the Mathematical Sciences*), Volume 202

March 2001, 286 pages, Hardcover, ISBN 0-8218-2740-5, LC 91-640741, 2000 *Mathematics Subject Classification*: 14P25, 37Axx; 28Axx, 28Dxx, 57Q25, **Individual member $71**, List $119, Institutional member $95, Order code TRANS2/202RT167

Recommended Text

Introduction to Topology

V. A. Vassiliev, *Independent University of Moscow, Russia*

From a review for the Russian edition ...

The book is based on a course given by the author in 1996 to first and second year students at Independent Moscow University ... the emphasis is on illustrating what is happening in topology, and the proofs (or their ideas) covered are those which either have important generalizations or are useful in explaining important concepts ... This is an excellent book and one can gain a great deal by reading it. The material, normally requiring several volumes, is covered in 123 pages, allowing the reader to appreciate the interaction between basic concepts of algebraic and differential topology without being buried in minutiae.

—Mathematical Reviews

This English translation of a Russian book presents the basic notions of differential and algebraic topology, which are indispensable for specialists and useful for research mathematicians and theoretical physicists. In particular, ideas and results are introduced related to manifolds, cell spaces, coverings and fibrations, homotopy groups, homology and cohomology, intersection index, etc. The author notes, "The lecture note origins of the book left a significant imprint on its style. It contains very few detailed proofs: I tried to give as many illustrations as possible and to show what really occurs in topology, not always explaining why it occurs." He concludes, "As a rule, only those proofs (or sketches of proofs) that are interesting *per se* and have important generalizations are presented."

Student Mathematical Library, Volume 14

March 2001, 149 pages, Softcover, ISBN 0-8218-2162-8, LC 2001018842, 2000 *Mathematics Subject Classification*: 55-01, **All AMS members $20**, List $25, Order code STML/14RT167

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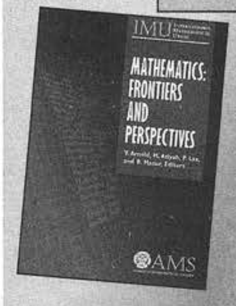

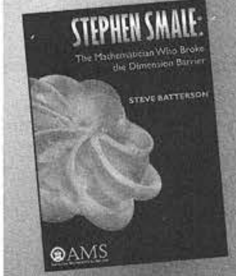

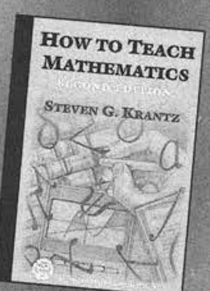

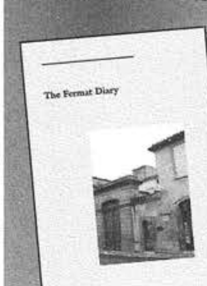

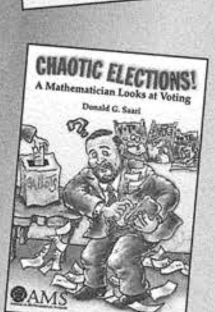

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Mathematics: Frontiers and Perspectives

V. Arnold, *University of Paris IX, France, and Steklov Mathematical Institute, Moscow, Russia*, **M. Atiyah**, *University of Edinburgh, Scotland*, **P. Lax**, *New York University-Courant Institute of Mathematical Sciences, NY*, and **B. Mazur**, *Harvard University, Cambridge, MA*, Editors

You can read this book as if listening to a succession of high-powered old school friends who are passing through ... most tell you about the mathematics that animates them ... you get a good sense of what they do, what's difficult about it, and why it matters ... provocative remarks ... vigorous account of much of the Russian school of mathematics ... thought-provoking reflections about mathematical life and language ... The most pleasing feature of this handsome book is the emphasis on the unity of mathematics ... The connections many people here want to make between mathematics and physics, von Neumann algebras and knot theory, number theory and analysis, are not only fresh and vivid, but oddly coherent. They give a sense not only of mathematics undergoing one of its characteristic contractions around a few organising principles, but how productive this reorganisation can be.

—The LMS Newsletter

One hundred years ago, David Hilbert's famous list of 26 mathematical problems began to catalyze the collective efforts of the world's mathematicians toward a century's worth of new research and achievement. The International Mathematical Union commissioned the current volume to do the same for the century just beginning. Fully half the contributors here own a Fields Medal, mathematics' highest honor (and that does not even count Andrew Wiles). Obviously, simply by dint of the prestige and caliber of the authors, this volume deserves reader attention and a place on every library's shelves. The essays themselves vary from the entirely technical to the purely personal. The sort of reading encounter they offer can set the direction of a whole career, so the undergraduate who picks up this volume now may expect to return here many times in the years to come.

—CHOICE

Among the authors there are many famous pure mathematicians whose contributions constitute a smorgasbord of delicacies sufficient to satisfy every taste. Do sample them!

—CMS Notes

Individual members of mathematical societies of the IMU member countries can purchase this volume at the AMS member price when buying directly from the AMS.

2000; ISBN 0-8218-2697-2; 459 pages; Softcover; **All AMS members $31**, List $39, Order Code MFP.SCT167

Biography

Stephen Smale: The mathematician who broke the dimension barrier

Steve Batterson, *Emory University, Atlanta, GA*

Batterson's book is readable by, and accessible to, high school students ... Smale's life is inspiring; Batterson's book is fascinating.

—The Mathematics Teacher

Steve Batterson's book lays many legends to rest and verifies much chronology and many details ... This fascinating life story makes for compelling reading ... [Batterson] gets not just mathematical details but their relative importance right ... Waiting for history's verdict on Smale's numerical analysis, we might just as well curl up with Batterson's book ... this is a fascinating biography of a fascinating mathematician.

—SIAM Review

This is a comprehensive and frank biography of Stephen Smale, one of the best-known American mathematicians ... I found the book fascinating ... Smale deserved his Fields Medal for his work in topology and his early work (e.g., the horseshoe) in dynamical systems ... he should be seen as an excellent example of how to avoid stagnation in a field one has pioneered and instead to stay active by trying new subjects ... All in all, Steve Smale is a first-rate Fields Medalist who has led a rich and varied life.

—Notices of the AMS

2000; ISBN 0-8218-2045-1; 306 pages; Hardcover; **All AMS members $28**, List $35, Order Code MBDBCT167

Recommended Text

How to Teach Mathematics

Second Edition

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

Praise for the First Edition ...

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

—Zentralblatt für Mathematik

[This book] is written in a lively and humorous style, even though the points discussed are entirely serious and sensible. The author succeeds in elucidating the fine points of excellent teaching and offers a lot of important practical advice. The book is strongly recommended to everybody who teaches mathematics.

—European Mathematical Society Newsletter

1999; ISBN 0-8218-1398-6; 307 pages; Softcover; **All AMS members $19**, List $24, Order Code HTM/2CT167

The Fermat Diary

C. J. Mozzochi, *Princeton, NJ*

2000; ISBN 0-8218-2670-0; 196 pages; Hardcover; **All AMS members $23**, List $29, Order Code FERMATDCT167

Timely Topic

Chaotic Elections! A Mathematician Looks at Voting

Donald G. Saari, *University of California, Irvine*

2001; ISBN 0-8218-2847-9; 159 pages; Softcover; **All AMS members $18**, List $23, Order Code ELECTCT167

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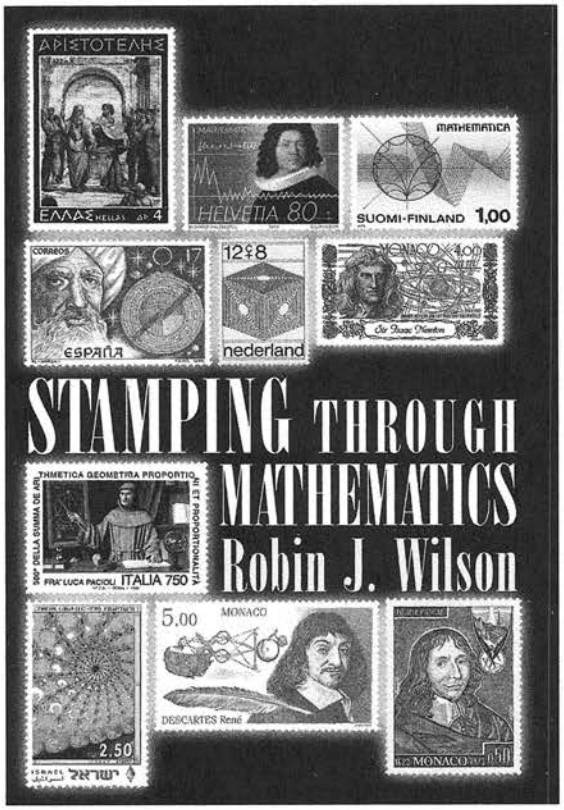

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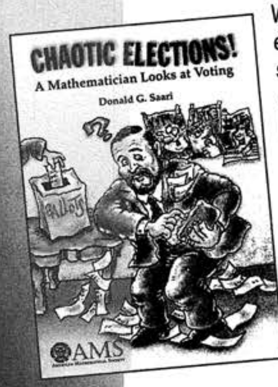
Timely Topic

CHAOTIC ELECTIONS!

A Mathematician Looks at Voting

Donald G. Saari, *University of California, Irvine*



What does the 2000 U.S. presidential election have in common with selecting a textbook for a calculus course in your department? Was Ralph Nader's influence on the election of George W. Bush greater than the now-famous chads? In *Chaotic Elections!*, Don Saari analyzes these questions, placing them in the larger context of voting systems in general. His analysis shows that the fundamental problems with the 2000 presidential election are not with the courts, recounts, or defective ballots, but are caused by the very way Americans vote for president.

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Saari's book should be required reading for anyone who wants to understand not only what happened in the presidential election of 2000, but also how we can avoid similar problems from appearing anytime any group is making a choice using a voting procedure. Reading this book requires little more than high school mathematics and an interest in how the apparently simple situation of voting can lead to surprising paradoxes.

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AMERICAN MATHEMATICAL SOCIETY

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Fields of Interest

If you wish to be on the mailing lists to receive information about publications in fields of mathematics in which you have an interest, please consult the list of major headings below. These categories will be added to your computer record so that you will be informed of new publications or special sales in the fields you have indicated.

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

Prepayment Methods and Mailing Addresses

All prices quoted in U.S. dollars.
Payment by check must be drawn on U.S. bank if paid in U.S. dollars.

Send checks, money orders, UNESCO coupons to American Mathematical Society, P.O. Box 845904, Boston, MA 02284-5904.

To use credit cards, fill in information requested and mail to American Mathematical Society, P.O. Box 6248, Providence, RI 02940-6248 or call (401) 455-4000 or 1-800-321-4AMS.

For Foreign Bank Transfers: Citizens Bank, 1 Citizens Drive, Riverside, RI 02915, ABA #011-500-120, for American Mathematical Society, Acct #1107802021.

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Membership Categories

Please read the following to determine what membership category you are eligible for, and then indicate below the category for which you are applying.

Introductory ordinary member rate applies to the first five ***consecutive*** years of ordinary membership. Eligibility begins with the first year of membership in any category other than student and nominee. Dues are $51.

For ***ordinary members*** whose annual professional income is below $75,000, the dues are $102; for those whose annual professional income is $75,000 or more, the dues are $136.

For a ***joint family membership,*** one member pays ordinary dues, based on his or her income; the other pays ordinary dues based on his or her income, less $20. (Only the member paying full dues will receive the *Notices* and the *Bulletin* as a privilege of membership, but both members will be accorded all other privileges of membership.)

Minimum dues for ***contributing members*** are $204. The amount paid which exceeds the higher ordinary dues level and is purely voluntary may be treated as a charitable contribution.

For either ***students*** or ***unemployed individuals,*** dues are $34, and annual verification is required.

The annual dues for ***reciprocity members*** who reside outside the U.S. are $68. To be eligible for this classification, members must belong to one of those foreign societies with which the AMS has established a reciprocity agreement, and annual verification is required. Reciprocity members who reside in the U.S. must pay ordinary member dues ($102 or $136).

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

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

2001 Dues Schedule (January through December)

Ordinary member, introductory rate			☐$51
Ordinary member		☐$102	☐$136
Joint family member (full rate)		☐$102	☐$136
Joint family member (reduced rate)		☐$82	☐$116
Contributing member (minimum $204)			☐
Student member (please verify)[1]			☐$34
Unemployed member (please verify)[2]			☐$34
Reciprocity member (please verify)[3]	☐$68	☐$102	☐$136
Category-S member [4]			☐$16
Multi-year membership	$........	for........	years

[1] ***Student Verification*** (sign below)
I am a full-time student at ____________________

____________________ currently working toward a degree.

[2] ***Unemployed Verification*** (sign below) I am currently unemployed and actively seeking employment.

[3] ***Reciprocity Membership Verification*** (sign below) I am currently a member of the society indicated on the right and am therefore eligible for reciprocity membership.

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Signature

[4] ☐ ***send*** **NOTICES** ☐ ***send*** **BULLETIN**

Reciprocating Societies

- ☐ Allahabad Mathematical Society
- ☐ Australian Mathematical Society
- ☐ Azerbaijan Mathematical Society
- ☐ Balkan Society of Geometers
- ☐ Berliner Mathematische Gessellschaft
- ☐ Calcutta Mathematical Society
- ☐ Canadian Mathematical Society
- ☐ Croatian Mathematical Society
- ☐ Cyprus Mathematical Society
- ☐ Dansk Matematisk Forening
- ☐ Deutsche Mathematiker-Vereinigung
- ☐ Edinburgh Mathematical Society
- ☐ Egyptian Mathematical Society
- ☐ European Mathematical Society
- ☐ Gesellschaft für Angewandte Mathematik und Mechanik
- ☐ Glasgow Mathematical Association
- ☐ Hellenic Mathematical Society
- ☐ Icelandic Mathematical Society
- ☐ Indian Mathematical Society
- ☐ Iranian Mathematical Society
- ☐ Irish Mathematical Society
- ☐ Israel Mathematical Union
- ☐ János Bolyai Mathematical Society
- ☐ The Korean Mathematical Society
- ☐ London Mathematical Society
- ☐ Malaysian Mathematical Society
- ☐ Mathematical Society of Japan
- ☐ Mathematical Society of Serbia
- ☐ Mathematical Society of the Philippines
- ☐ Mathematical Society of the Republic of China
- ☐ Mongolian Mathematical Society
- ☐ Nepal Mathematical Society
- ☐ New Zealand Mathematical Society
- ☐ Nigerian Mathematical Society
- ☐ Norsk Matematisk Forening
- ☐ Österreichische Mathematische Gesellschaft
- ☐ Palestine Society for Mathematical Sciences
- ☐ Polskie Towarzystwo Matematyczne
- ☐ Punjab Mathematical Society
- ☐ Ramanujan Mathematical Society
- ☐ Real Sociedad Matemática Española
- ☐ Saudi Association for Mathematical Sciences
- ☐ Singapore Mathematical Society
- ☐ Sociedad Colombiana de Matemáticas
- ☐ Sociedad Española de Matemática Aplicada
- ☐ Sociedad de Matemática de Chile
- ☐ Sociedad Matemática de la Republica Dominicana
- ☐ Sociedad Matemática Mexicana
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- ☐ Société Mathématique Suisse
- ☐ Société Mathématiques Appliquées et Industrielles
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- ☐ 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

Change of Address

Members of the Society who move or change positions are urged to notify the Providence Office as soon as possible.

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

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

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

If your address has changed or will change within the next two or three months, please fill out this form, supply any other information appropriate for the AMS records, and mail it to:

Customer Services
AMS
P.O. Box 6248
Providence, RI 02940

or send the information on the form by e-mail to:

amsmem@ams.org or
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New position ______________________________

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please supply the following informations:

New employer ______________________________

Location of employer (city, state, zip code, country)

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Call for Proposals for 2003 Conferences

Proposals are invited from mathematicians, either singly or in groups, for topics for the various conferences that will be organized by the Society in 2003. The deadlines for receipt of suggestions/proposals are given below, as well as some relevant information about each of the conferences. Specific questions about each conference series or the conference program in general may be addressed to meet@ams.org, or call 401-455-4138. Proposals should be sent to :

Meetings and Conferences Department
American Mathematical Society
P. O. Box 6887
Providence, RI 02940

Individuals willing to serve as organizers should be aware that the Society's professional meetings staff handles the logistical details of the conferences before, during, and after, thus making it possible for the organizers to focus almost exclusively on the scientific aspects of their conference.

Proposal preparation is straightforward. All proposals must include:

(1) The title of the proposed conference and the names and affiliations of proposed members and the chair(s) of the Organizing Committee.

(2) A three- to four-page narrative, written for the nonspecialist, describing the topics of the conference, explaining their importance to the field, and detailing the timeliness of a conference addressing these topics. Keep in mind that the members of the Selection Committee are active research mathematicians from a wide variety of fields.

(3) A list of the proposed principal speakers, the majority of whom have agreed to participate (denote with an asterisk those who have been contacted and have agreed to participate), and a description of how you plan to schedule the talks (i.e., number and length of talks per day).

(4) Estimated total attendance and a tentative list of individuals to be invited to participate.

(5) A list of the recent conferences in the same or closely related areas.

(6) The curriculum vitae of the chair(s) of the Organizing Committee, each in a compact version of no more than five pages.

Joint Summer Research Conferences in the Mathematical Sciences for 2003

The American Mathematical Society, the Institute of Mathematical Statistics, and the Society for Industrial and Applied Mathematics welcome proposals for conferences to take place in the summer of 2003 on the beautiful campus of Mount Holyoke College, situated in the quiet town of South Hadley in western Massachusetts. For almost twenty years these conferences have played a vital role in disseminating the latest research to more than 8,400 mathematicians whose research interests span the breadth of the mathematical sciences. In particular:

- Core funding for the conferences is provided by a grant from the National Science Foundation. It is anticipated that future funding will provide approximately $22,000 for direct support of conference participants for each of 6 to 8 one-week conferences.
- Organizers are strongly encouraged to publish conference proceedings with one of the sponsoring societies. The sponsoring societies are committed to the rapid and widest possible dissemination of these proceedings as a means of sharing the conference research with those unable to attend.

Conferences emulate the scientific structure of those held at Oberwolfach, although this structure is flexible. The proposals to be selected will represent diverse areas of mathematical activity, with emphasis on areas currently especially active. Conferences typically run for one week with forty-five to sixty-five participants. Conferences of longer duration are possible. Lists of the 2001 and 2002 series of conferences may be accessed from http://www.ams.org/meetings/.

Deadline for proposals is February 1, 2002.

Proposals will be evaluated by the AMS-IMS- SIAM Committee on Joint Summer Research Conferences in the Mathematical Sciences. (The committee is listed at http://www.ams.org/meetings/srcscomm.html.) Members of this committee are willing to provide guidance on the preparation of proposals. Complete information on submitting a proposal, including examples of recently successful proposals, is available at `http://www.ams.org/meetings/topics.html` or may be obtained by contacting the Meetings and Conferences Department.

Organizers may, at their option, submit a **preproposal** composed of items (1) and (2) above, together with a tentative list of principal speakers who will be contacted if a complete proposal is submitted. **Preproposals should be received by October 24, 2001,** to allow time for review by members of the Selection Committee and feedback to organizers by early December.

2003 von Neumann Symposium

Through a bequest from Carroll V. Newson to memorialize the late John von Neumann and his accomplishments, the Society established a quadrennial symposium called the von Neumann Symposium. This conference series will focus on concepts in the forefront of mathematics and occupy a position of importance in the evolution of mathematical thought. Subjects of these one-week symposia are to be topics of emerging significance, expected to underlie future mathematical development. Ideas expressed and shared at these symposia and the new understandings embodied in the von Neumann proceedings will reflect exceptional mathematical leadership. A member of the Organizing Committee must be willing to serve as editor of the proceedings, which will be published by the AMS.

Conference topics in this series include *Quantization and Nonlinear Wave Equations* (1994) and *Arithmetic Fundamental Groups and Noncommutative Algebra* (1999).

Deadline for proposals is October 1, 2001.

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.

Lyon, France

July 17–20, 2001

Meeting #968

First Joint International Meeting between the AMS and the Société Mathématique de France.
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: April 2001
Program first available on e-MATH: Not applicable
Program issue of electronic *Notices*: Not applicable
Issue of *Abstracts*: Expired

Deadlines

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

Invited Addresses

Sun-Yung Alice Chang, Princeton University, *Title to be announced.*

Jean-Pierre Demailly, Université de Grenoble, *Title to be announced.*

Persi Diaconis, Stanford University, *Title to be announced.*

Robert Gardner, University of Massachusetts, Amherst, *Title to be announced.*

Claude Le Bris, Université de Paris IX-Dauphine, *Title to be announced.*

Yves Meyer, École Normale Supérieure de Cachan, *Title to be announced.*

Michèle Vergne, École Polytechnique, *Title to be announced.*

Special Sessions

Additive Number Theory, **Melvyn B. Nathanson**, Herbert H. Lehman College (CUNY), and **Jean-Marc Deshouillers**, Université de Bordeaux II.

Commutative Algebra and Its Interactions with Algebraic Geometry, **Marc F. Chardin**, Université Pierre et Marie Curie-Paris VI, and **Claudia Polini**, University of Oregon.

Differential Geometric Methods in Mathematical Physics, **Johannes Huebschmann**, Université Lille I, **Yvette Kosmann-Schwarzbach**, École Polytechnique, and **Richard W. Montgomery**, University of California Santa Cruz.

Dynamics of Nonlinear Waves, **Christopher K. R. T. Jones**, Brown University, and **Jean-Michel Roquejoffre**, Université Toulouse III.

Fractal Geometry, Number Theory, and Dynamical Systems, **Michel Lapidus**, University of California Riverside, **Michel Mendes-France**, Université de Bordeaux, and **Machiel van Frankenhuysen**, University of California Riverside.

Gauge Theory, **Jean-Claude Sikorav**, École Normale Supérieure de Lyon, and **Ronald Fintushel**, Michigan State University.

Geometric Group Theory, **Gilbert Levitt**, Université Toulouse III, and **Karen Vogtmann**, Cornell University.

Geometric Methods in Low Dimensional Topology, **Hamish Short**, and **Daryl Cooper**, University of California Santa Barbara.

Geometric Structures in Dynamics, **M. Lyubich**, SUNY Stony Brook, **Etienne Ghys**, École Normale Supérieure de Lyon, and **Xavier Buff**, Université Toulouse III.

Geometry and Representation Theory of Algebraic Groups, **Michel Brion**, Université de Grenoble I, and **Andrei Zelevinsky**, Northeastern University.

History of Mathematics, **Thomas W. Archibald**, Acadia University, **Christian Gilain**, Université Pierre et Marie Curie-Paris VI, and **James J. Tattersall**, Providence College.

Logic and Interaction: From the Rules of Logic and the Logic of Rules, **Jean-Yves Girard**, Université de Marseille, and **Philip Scott**, University of Ottawa.

Mathematical Fluid Dynamics, **Yann Brenier**, Université Pierre et Marie Curie-Paris VI, **Susan J. Friedlander**, University of Illinois at Chicago, and **Emmanuel Grenier**, École Normale Supérieure de Lyon.

Mathematical Methods in Financial Modelling, **Marco Avellaneda**, Courant Institute, New York University, and **Rama Cont**, École Polytechnique.

Model Theory, **Gregory L. Cherlin**, Rutgers University, and **Frank Wagner**, Université Claude Bernard Lyon I.

Partial Differential Equations and Geometry, **Fabrice Bethuel**, Université Pierre et Marie Curie-Paris VI, and **Paul C. Yang**.

Probability, **Gerard Benarous**, École Normale Supérieure, and **George C. Papanicolaou**, Stanford University.

Registration

The correct address for online registration is `http://www.umpa.ens-lyon.fr/~smf-ams/InsReg.php`.

Columbus, Ohio

Ohio State University

September 21–23, 2001

Meeting #969

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: June/July 2001
Program first available on e-MATH: August 9, 2001
Program issue of electronic *Notices*: October 2001
Issue of *Abstracts*: Volume 22, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: July 13, 2001

Invited Addresses

Alex Eskin, University of Chicago, *Title to be announced.*

Dennis Gaitsgory, University of Chicago, *Title to be announced.*

Yakov B. Pesin, Pennsylvania State University, *Title to be announced.*

Thaleia Zariphopoulou, University of Texas at Austin, *Title to be announced.*

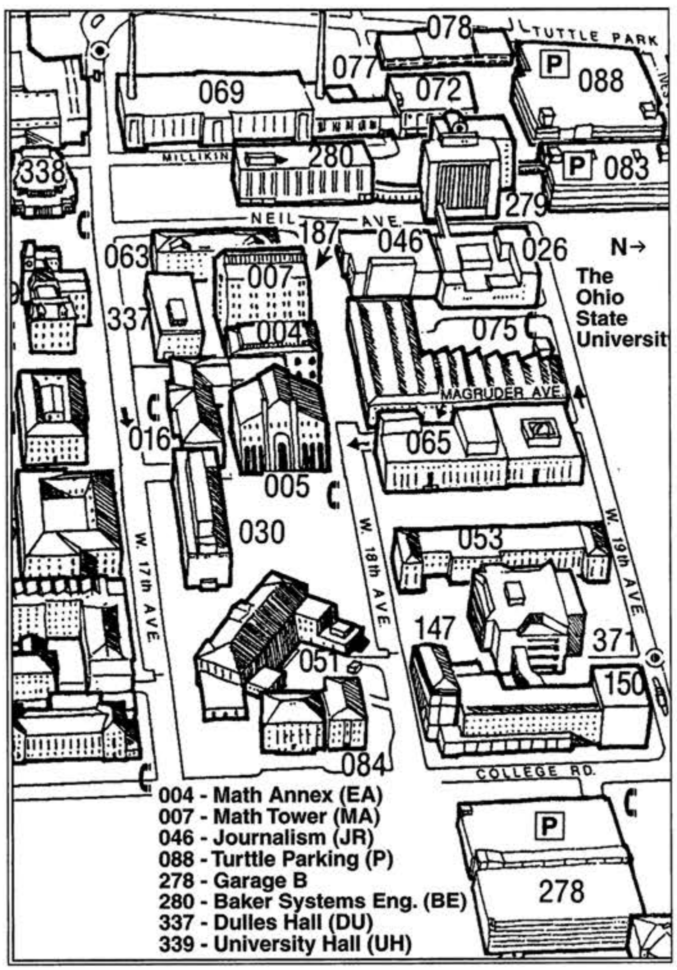
Special Sessions

L^2 Methods in Algebraic and Geometric Topology (Code: AMS SS G1), **Dan Burghelea** and **Michael Davis**, Ohio State University.

Algebraic Cycles, Algebraic Geometry (Code: AMS SS A1), **Roy Joshua**, Ohio State University.

Coding Theory and Designs (Code: AMS SS B1), **Tom Dowling**, Ohio State University, and **Dijen Ray-Chaudhuri**.

Commutative Algebra (Code: AMS SS C1), **Evan Houston**, University of North Carolina, Charlotte, and **Alan Loper**, Ohio State University.



Complex Approximation Theory via Potential Theory (Code: AMS SS R1), **V. V. Andrievskii** and **Richard S. Varga**, Kent State University.

Cryptography and Computational and Algorithmic Number Theory (Code: AMS SS E1), **Eric Bach**, University of Wisconsin-Madison, and **Jonathan Sorenson**, Butler University.

Differential Geometry and Applications (Code: AMS SS Q1), **Andrzej Derdzinski** and **Fangyang Zheng**, Ohio State University.

Fractals (Code: AMS SS P1), **Gerald Edgar**, Ohio State University.

Group Theory (Code: AMS SS F1), **Koichiro Harada**, **Surinder Seghal**, and **Ronald Solomon**, Ohio State University.

Multivariate Generating Functions and Automatic Computation (Code: AMS SS H1), **Robin Pemantle**, Ohio State University.

Proof Theory and the Foundations of Mathematics (Code: AMS SS K1), **Timothy Carlson**, Ohio State University.

Quantum Topology (Code: AMS SS L1), **Thomas Kerler**, Ohio State University.

Rings and Modules (Code: AMS SS M1), **S. K. Jain**, Ohio University, and **Tariq Rizvi**, Ohio State University.

Spectral Theory of Schrödinger Operators (Code: AMS SS N1), **Boris Mityagin**, Ohio State University, and **Sergei Novikov**, University of Maryland.

Stochastic Modeling in Financial Mathematics (Code: AMS SS D1), **Ronnie Sircar**, Princeton University.

Accommodations

Participants should make their own arrangements directly with a hotel of their choice. Special rates have been negotiated at the hotels listed below. Rates quoted do not include sales tax of 15.75%. The AMS is not responsible for rate changes or for the quality of the accommodations. When making a reservation, participants should state they are with the American Mathematical Society conference. The rates cited are effective for the nights of Friday and Saturday, September 21 and 22. Deadline for reservations is August 20, 2001.

The University Plaza Hotel, 3110 Olentangy River Rd., Columbus, OH 43202; 614-267-7461; $69/single or double; limited shuttle service to campus for the meeting (about 1.75 miles from campus).

Holiday Inn on the Lane, 328 West Lane Avenue, Columbus, OH 43201; 614-294-4848, 800-465-4329; $89/single or double; free shuttle to and from the airport; about .25 mile to campus.

Fawcett Center Hotel and Conference Center, 2400 Olentangy River Rd., Columbus, OH 43210; 614-292-3238; $79/single or double; about .75 mile or a 15-minute walk to campus; very limited number of rooms available.

Other Campus Area Accommodations

AmeriSuites Hotel, 7490 Vantage Dr., Columbus, OH 43235; 614-846-4355, 800-833-1516.

Best Western University Inn, 3232 Olentangy River Rd., Columbus, OH 43202; 614-261-7141.

Cross Country Inn-OSU South, 1445 Olentangy River Rd., Columbus, OH 43212; 614-291-2983, 800-621-1429.

Cross Country Inn, 3246 Olentangy River Rd., Columbus, OH 43202; 614-267-4646, 800-621-1429.

Days Inn-University, 3160 Olentangy River Rd., Columbus, OH 43202; 614-261-0523.

Double Tree Guest Suites, 50 South Front St., Columbus, OH 43215; 614-228-4600, 800-424-2900.

50 Lincoln-A Very Small Hotel, 50 East Lincoln St., Columbus, OH 43215; 614-291-5056.

Hyatt Regency of Columbus, 350 N. High St., Columbus, OH 43215; 614-463-1234, 800-233-1234.

Red Roof Inn-OSU, 441 Ackerman Rd., Columbus, OH 43202; 614-267-9941, 800-843-7663.

Food Service and Restaurants

There are a number of places to eat that are only a 5–10-minute walk from the math department. There are also some cafeterias on campus. For more information see `http://www.ohio-state.edu/visitors/shop.html`.

Local Information

The math department is located at 213 West 18th Avenue, near the corner of West 18th Avenue and Neil Avenue. The building code is either MA (Math Tower) or EA (Math Annex).

See the following Web pages for a clickable campus map, driving directions to OSU campus, and a close-up map of Math Tower. Please check out the bottom portion of Web page 2. The URLs of OSU and the math department are: `http://www.ohio-state.edu/`, `http://www.math.ohio-state.edu/Info/index.html`, and `http://www.math.ohio-state.edu/`. For the entry on this AMS meeting, please see `http://www.math.ohio-state.edu/research/ams_meeting/`. Please visit the Greater Columbus Convention and Visitors Bureau Web site at `http://www.surpriseitscolumbus.com/info.htm`.

Other Activities

AMS Book Sale: Examine the newest titles from the AMS! Most books will be available at a special 50% discount offered only at meetings. Complimentary coffee will be served, courtesy of AMS Membership Services. The book sale will be located in Room 724 MW (Math Tower).

Parking

Tuttle Garage (088 on campus map) and Garage B (278 on campus map) are the recommended parking areas for the meeting. The parking rate is $6.50 per day.

Registration and Meeting Information

The registration desk will be located in Room 154 in MA (Math Tower) and will be open from 12:30 p.m. to 4:30 p.m. on Friday and from 8:30 a.m. to 4:30 p.m. on Saturday.

Registration fees: (payable on-site only) $40/AMS members; $60/nonmembers; $5/emeritus members, students, or unemployed mathematicians. Fees are payable by cash, check, VISA, MasterCard, Discover, or American Express.

Travel

By Air: Port Columbus Airport, located just eight minutes from downtown, is served by 22 passenger airlines, providing 350 daily arrivals and departures to 30 nonstop destinations. Major carriers include Air Ontario, America West, American, Comair, Continental, Delta, Midway, Midwest Express, Northwest, Southwest, TWA, United, and US Airways.

The following specially negotiated rates on USAirways are available exclusively to mathematicians and their families for the period September 18–26, 2001. Discounts apply only to travel within the continental U.S. Other restrictions may apply and seats are limited. Receive a 5% discount off First or Envoy Class and any published US Airways promotional round-trip fare. By purchasing your ticket 60 days or more prior to departure, you can receive an additional bonus discount. Or, you may receive a 10% discount off unrestricted coach fares with seven-day advance purchase. For reservations call (or have your travel agent call) US Airways Group and Meeting Reservation Office toll-free at 877-874-7687 between 8:00 a.m. and 9:30 p.m. Eastern Time. Refer to **Gold File number 88111579.**

Driving: The directions given below take into account the temporary closure of State Route 315 south of the campus. If you are staying at the OSU Cross Country Inn South, you should take the Kinnear-King Exit off Route 315 immediately to the south of the Lane Avenue Exit referred to below, and take Olentangy River Road south (right turn) to the hotel. If you are staying at the Holiday Inn near campus, you should continue on Lane Avenue until you cross the Olentangy River, and then shortly thereafter make a left turn directly into the hotel. For most of the other hotels in the campus area, you should take Olentangy River Road north (left turn).

From the northeast (Cleveland and Mansfield), take I-71 South to I-270 West, take I-270 West to Route 315, take Route 315 South to the Lane Avenue Exit, turn left on Lane Avenue.

From the north (Sandusky), take Route 4 South to U.S. 23 South, take U.S. 23 South to I-270 West, take I-270 West to Route 315 South, take Route 315 South to the Lane Avenue Exit, turn left on Lane Avenue.

From the northwest (Toledo), take I-75 South to U.S. 23 South, take U.S. 23 South to I-270 West, take I-270 West to Route 315 South, take Route 315 South to the Lane Avenue Exit, turn left on Lane Avenue.

From the west (Indianapolis, Dayton, and Springfield), take I-70 West to I-71 North, take I-71 North to I-670 West (I-670 West will become SR 315 North), take Route 315 North to the Lane Avenue Exit, turn right on Lane Avenue.

From the southwest (Cincinnati), take I-71 North, stay on I-71 where it exits on the right and combines with I-70 East. After about one mile, exit on the left to I-71 North, exit on the left onto I-670 West (I-670 will become SR 315 North), take Route 315 North to the Lane Avenue Exit, turn right on Lane Avenue.

From the south (Portsmouth and Chillicothe), take U.S. 23 North to I-270 West, take I-270 West to I-71 North, stay on I-71 where it exits on the right to I-70. After about one mile, exit on the left to I-71 North, exit on the left onto I-670 West (I-670 will become SR 315 North), take Route 315 North to the Lane Avenue Exit, turn right on Lane Avenue.

From the southeast (Athens and Lancaster), take Route 33 Northwest to I-70 West, take I-70 West to I-71 North, exit on the left to I-670 West (I-670 West will become SR 315 North), take Route 315 North to the Lane Avenue Exit, turn right on Lane Avenue.

From the east (Pittsburgh and Zanesville), take I-70 West to I-71 North, exit on the left to I-670 West (I-670 West will become SR 315 North), take Route 315 North to the Lane Avenue Exit, turn right on Lane Avenue.

Car rental: Special rates have been negotiated with Avis Rent A Car for the period September 14–30, 2001. All rates include unlimited free mileage; the weekend rates quoted are available from noon Thursday until Monday at 11:59 p.m. Rates do not include state or local surcharges, tax, optional coverages, or gas refueling charges. Renter must meet Avis age, driver, and credit requirements. Make reservations by calling 800-331-1600 or online at `http://www.avis.com/`. Nonweekend and weekly rates are also available. Please quote **Avis Discount Number J098887** when making reservations.

Daily weekend rates are Subcompact, $39.99; Compact, $40.99; Intermediate, $42.99; Full-size 2-door, $44.99, Full-size 4-door, $46.99; Premium, $49.99; Luxury, $61.99; Mini-van, $61.99; and Sport Utility, $61.99.

Weather

Columbus has a moderate climate with four distinct seasons. Average annual temperature is 54°F, with the average monthly temperature in January at 38°F and July at 73°F. The city receives an average of 37 inches of rainfall and 28 inches of snowfall annually.

Chattanooga, Tennessee

University of Tennessee, Chattanooga

October 5–6, 2001

Meeting #970

Southeastern Section
Associate secretary: John L. Bryant
Announcement issue of *Notices*: August 2001
Program first available on e-MATH: August 23, 2001
Program issue of electronic *Notices*: November 2001
Issue of *Abstracts*: Volume 22, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: June 19, 2001
For abstracts: August 14, 2001

Invited Addresses

Susanne C. Brenner, University of South Carolina, Columbia, *Title to be announced.*

Edward B. Saff, University of South Florida, *Title to be announced.*

Joel H. Spencer, New York University, *Title to be announced.*

Roberto Triggiani, University of Virginia, *Title to be announced.*

Special Sessions

Applications of Partial Differential Equations in Geometric Analysis (Code: AMS SS N1), **Bo Guan** and **Changyou Wang**, University of Tennessee at Knoxville.

Asymptotic Behavior of Solutions of Differential and Difference Equations (Code: AMS SS B1), **John R. Graef**, University of Tennessee at Chattanooga, and **Chuanxi Qian**, Mississippi State University.

Commutative Ring Theory (Code: AMS SS A1), **David F. Anderson** and **David E. Dobbs**, University of Tennessee at Knoxville.

Differential Geometric Methods in the Control of Partial Differential Equations (Code: AMS SS L1), **Walter Littman**, University of Minnesota, and **Roberto Triggiani**, University of Virginia.

Mathematical and Numerical Aspects of Wave Propagation (Code: AMS SS F1), **Boris P. Belinskiy** and **Yongzhi Xu**, University of Tennessee at Chattanooga.

New Directions in Combinatorics and Graph Theory (Code: AMS SS C1), **Teresa Haynes** and **Debra J. Knisley**, East Tennessee State University.

Numerical Analysis and Approximation Theory (Code: AMS SS G1), **Tian-Xiao He**, Illinois Wesleyan University, and **Don Hong**, Eastern Tennessee State University.

Numerical Methods for PDEs (Code: AMS SS J1), **Susanne C. Brenner**, University of South Carolina, and **Craig C. Douglas**, University of Kentucky.

Real Analysis (Code: AMS SS D1), **Paul D. Humke**, Saint Olaf College, **Harry I. Miller**, University of Tennessee at Chattanooga, and **Clifford E. Weil**, Michigan State University.

Recent Advances in Optimization Methods (Code: AMS SS H1), **Jerald P. Dauer** and **Aniekan Ebiefung**, University of Tennessee at Chattanooga.

Sphere-Related Approximation and Applications (Code: AMS SS M1), **Edward B. Saff**, University of South Florida, and **Larry L. Schumaker**, Vanderbilt University.

Topics in Geometric Function Theory (Code: AMS SS E1), **Lelia Miller-Van Wieren**, Penn State Berks Campus, and **Bruce P. Palka**, University of Texas at Austin.

Variational Problems for Free Surface Interfaces (Code: AMS SS K1), **John E. McCuan**, Georgia Institute of Technology, **Thomas I. Vogel**, Texas A&M University, and **Henry C. Wente**, University of Toledo.

Williamstown, Massachusetts

Williams College

October 13–14, 2001

Meeting #971

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: August 2001
Program first available on e-MATH: August 30, 2001
Program issue of electronic *Notices*: November 2001
Issue of *Abstracts*: Volume 22, Issue 4

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: June 26, 2001
For abstracts: August 21, 2001

Invited Addresses

Hubert Bray, Massachusetts Institute of Technology, *Title to be announced.*

Robin Forman, Rice University, *Title to be announced.*

Emma Previato, Boston University, *Theta functions, old and new.*

Yisong Yang, Polytechnic University, *Title to be announced.*

Special Sessions

Abelian Varieties (Code: AMS SS K1), **Alexander Polishchuk** and **Emma Previato**, Boston University.

Algebraic and Topological Combinatorics (Code: AMS SS D1), **Eva Maria Feichtner**, ETH, Zürich, Switzerland, and **Dmitry N. Kozlov**, KTH, Stockholm, Sweden.

Commutative Algebra (Code: AMS SS C1), **Susan R. Loepp**, Williams College, and **Graham J. Leuschke**, University of Kansas.

Diophantine Problems (Code: AMS SS F1), **Edward B. Burger**, Williams College, and **Jeffrey D. Vaaler**, University of Texas at Austin.

Ergodic Theory (Code: AMS SS H1), **Cesar Silva**, Williams College.

Geometry and Topology of the Universe (Code: AMS SS E1), **Colin C. Adams**, Williams College, **Glenn Starkmann**, Case Western Reserve University, and **Jeffrey R. Weeks**, Canton, New York.

Harmonic Analysis since the Williamstown Conference of 1978 (Code: AMS SS G1), **Janine E. Wittwer**, Williams College, and **David Cruz-Uribe**, Trinity College.

History of Mathematics (Code: AMS SS A1), **Glen R. Van Brummelen**, Bennington College, **Della D. Fenster**, Richmond University, **James J. Tattersall**, Providence

College, and **Shawnee L. McMurran**, California State University, San Bernadino.

Integrable Systems and Quantum Groups (Code: AMS SS L1), **Pavel I. Etingof**, Massachusetts Institute of Technology, and **Emma Previato**, Boston University.

Nonlinear PDEs and Calculus of Variations (Code: AMS SS J1), **Yisong Yang**, Polytechnic University, and **Fanghua Lin** and **Nader Masmoudi**, Courant Institute, New York University.

Number Theory, Holomorphic Dynamics, and Algebraic Dynamics (Code: AMS SS B1), **Robert L. Benedetto**, University of Rochester, **John W. Milnor**, IMS and SUNY Stony Brook, and **Kevin M. Pilgrim**, University of Missouri, Rolla.

Irvine, California

University of California Irvine

November 10–11, 2001

Meeting #972

Western Section
Associate secretary: Bernard Russo
Announcement issue of *Notices*: September 2001
Program first available on e-MATH: September 27, 2001
Program issue of electronic *Notices*: December 2001
Issue of *Abstracts*: Volume 22, Issue 4

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: July 24, 2001
For abstracts: September 18, 2001

Invited Addresses

William Duke, University of California Los Angeles, *Title to be announced.*

Grigory Mikhalkin, University of Utah, *Title to be announced.*

Gigliola Staffilani, Stanford University, *Title to be announced.*

Jonathan Weitsman, University of California Santa Cruz, *Title to be announced.*

Special Sessions

Extremal Metrics and Moduli Spaces (Code: AMS SS F1), **Steven Bradlow**, University of Illinois, Urbana-Champaign, **Claude LeBrun**, SUNY Stony Brook, and **Yat Sun Poon**, University of California Riverside.

Groups and Covering Spaces in Algebraic Geometry (Code: AMS SS D1), **Michael Fried**, University of California Irvine, and **Helmut Voelklein**, University of Florida.

Harmonic Analysis and Complex Analysis (Code: AMS SS G1), **Xiaojun Huang**, Rutgers University, and **Song-Ying Li**, University of California Irvine.

Partial Differential Equations and Applications (Code: AMS SS C1), **Edriss S. Titi**, University of California Irvine.

Quantum Topology (Code: AMS SS A1), **Louis Kauffman**, University of Illinois at Chicago, **Jozef Przytyzki**, George Washington University, and **Fernando Souza**, University of Waterloo.

Random and Deterministic Schrödinger Operators (Code: AMS SS E1), **Svetlana Jitomirskaya** and **Abel Klein**, University of California Irvine.

Topology of Algebraic Varieties (Code: AMS SS B1), **Eriko Hironaka**, Florida State University, and **Grigory Mikhalkin**, University of Utah.

San Diego, California

San Diego Convention Center

January 6–9, 2002

Meeting #973

Joint Mathematics Meetings, including the 108th Annual Meeting of the AMS, 85th Meeting of the Mathematical Association of America (MAA), with minisymposia and other special events contributed by the Society for Industrial and Applied Mathematics (SIAM); the annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM); and the winter meeting of the Association for Symbolic Logic (ASL).
Associate secretary: John L. Bryant
Announcement issue of *Notices*: October 2001
Program first available on e-MATH: November 1, 2001
Program issue of electronic *Notices*: January 2002
Issue of *Abstracts*: Volume 23, Issue 1

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: August 7, 2001
For abstracts: October 2, 2001
For summaries of papers to MAA organizers: September 14, 2001

Joint Special Sessions

The History of Mathematics (Code: AMS SS A1), **David E. Zitarelli**, Temple University, and **Thomas Archibald**, Acadia University.

AMS Invited Addresses

Michael V. Berry, Bristol University, *Title to be announced* (Josiah Willard Gibbs Lecture).

Felix E. Browder, Rutgers University, *Title to be announced* (Retiring Presidential Address).

L. Craig Evans, University of California Berkeley, *Title to be announced* (Colloquium Lectures).

John M. Franks, Northwestern University, *Title to be announced.*

Jeffrey C. Lagarias, AT&T Laboratories Research, *Title to be announced.*

Fang-hua Lin, Courant Institute, New York University, *Title to be announced.*

John Preskill, California Institute of Technology, *Title to be announced.*

Richard L. Taylor, Harvard University, *Title to be announced.*

AMS Special Sessions

Dynamic Equations on Time Scales (Code: AMS SS B1), **Martin J. Bohner**, University of Missouri, Rolla, and **Billur Kaymakcalan**, Georgia Southern University.

Probablistic Methods in Combinatorics and the Internet (Code: AMS SS C1), **Fan Chung Graham** and **Van Vu**, University of California San Diego.

Preliminary Announcement of MAA Contributed Paper Sessions

The organizers listed below solicit contributed papers pertinent to their sessions. Sessions generally limit presentations to ten minutes, but selected participants may extend their contributions up to twenty minutes.

Each session room contains an overhead projector and screen; blackboards will not be available. Persons needing additional equipment should contact the session organizer, whose name is followed by an asterisk (*), as soon as possible and certainly prior to September 14, 2001. Please note that the dates and times scheduled for these sessions remain tentative.

Submission Procedures for MAA Contributed Papers

Submit your abstract directly to the AMS. Concurrently, send a more detailed one-page summary of your paper directly to the organizer, indicated with an (*). The summary need not duplicate the information in the abstract. In order to enable the organizer(s) to evaluate the appropriateness of your paper, include as much detailed information as possible within the one-page limitation. Papers should not be sent to more than one organizer. Your abstract and summary must reach the AMS and the organizer by Friday, September 14, 2001.

The AMS will publish abstracts for the talks in the MAA sessions. Abstracts must be submitted on the appropriate AMS form. Electronic submission is available via the Internet or e-mail. No knowledge of LaTeX is necessary; however, LaTeX and AMS-LaTeX can be accommodated. These are the only typesetting systems that can be used if mathematics is included. To see descriptions and to view the electronic templates available, visit the abstracts submission page on the Internet at `http://www.ams.org/abstracts/instructions.html`, or send e-mail to `abs-submit@ams.org`, typing HELP as the subject line.

Completed e-mail templates must be sent to `abs-submit@ams.org` with SUBMISSION as the subject line. Abstracts submitted electronically are quickly either acknowledged, with a unique abstract number assigned to the presentation, or rejected, with a short message on what information is missing or inappropriate. All questions concerning the submission of abstracts should be addressed to `abs-coord@ams.org`.

Here are the codes you will need: Meeting Number: 973; Event Code: the seven characters appearing after the title of the session in parentheses, e.g. (`MAA CP A1`); Subject Code: the last two-character letter/number combination from the event code list, i.e., `A1`, `B1`.

History of Mathematics in the Second Millennium (`MAA CP A1`), Sunday and Monday mornings. **Janet L. Beery***, University of Redlands, 1200 E. Colton Avenue, Redlands, CA 92373; tel: 909-793-2121, x3118; fax: 909-793-2029; `beery@uor.edu`; and **C. Edward Sandifer**, Western Connecticut State University. We invite original contributions to any portion of the history of mathematics of the second millennium BCE, the second millennium CE, or both, as well as expository discussions of this history and ideas for engaging students with it. Presentations connecting the mathematics history of the two millennia are especially welcome, as are reports of innovative uses of the mathematics history of the two millennia in the classroom.

Mathematics Courses for Teachers, K–12 (`MAA CP B1`), Sunday and Monday mornings. **Ira J. Papick***, University of Missouri, Columbia, MO 65211; tel. 573-882-7573; fax: 573-882-1869; `mathip@showme.missouri.edu`; **Duane Porter**, University of Wyoming; and **Diane M. Spresser**, National Science Foundation. There are numerous contemporary reports and studies which serve as catalysts to think more deeply about the mathematical qualifications needed for effective teaching in grades K–12. Among these are the NCTM *Principles and Standards for School Mathematics*, the insightful work of Liping Ma, and the CBMS *Report on the Mathematical Education of Teachers.* Research shows that mathematics students achieve more when taught by teachers with strong mathematical content preparation. Yet, because of the current national shortage of qualified mathematics teachers, many practicing teachers have backgrounds that are less than adequate in mathematics. This session seeks papers on innovative mathematics courses that target (a) middle/high school teachers who are teaching mathematics "out of field", (b) those teaching mathematics at the middle grades with elementary certification, or (c) preservice mathematics students (or inservice teachers) for whom a capstone experience would better prepare them for the demands of the high school mathematics classroom.

Integrating Mathematics and Other Disciplines (`MAA CP C1`), Sunday and Monday mornings. **William G. McCallum***, University of Arizona, Tucson, AZ 85721; tel: 520-621-6697; fax: 520-621-8322; `wmc@math.arizona.edu`; **Deborah Hughes Hallett**, University of Arizona, Tucson; and **Yajun Yang**, SUNY, Farmingdale. The session will present discussions of (1) the content of current mathematics courses in the first two years in the light of the way other disciplines use mathematics and the expectations they have of our students, (2) how applications of mathematics in other disciplines can be incorporated into mathematics courses in a way that enhances mathematical understanding, and (3) presentations of exemplary courses or course modules. Submissions are encouraged from teachers in engineering, the physical and social sciences, and management and public policy, showing examples of how mathematics is used in their courses. Submissions are also encouraged from mathematicians who have successfully incorporated such material into their courses.

Innovative Uses of the World Wide Web in Teaching Mathematics (MAA CP D1), Sunday and Monday mornings. **Marcelle Bessman***, Jacksonville University, Jacksonville, FL 32224; tel: 904-744-3950, x7304; mbessma@ju.edu; and **Brian E. Smith**, McGill University. This contributed paper session will focus on creative uses of the World Wide Web in mathematics instruction. Proposals are solicited on original uses of Web resources in the classroom. We are looking for presentations involving the use of real data sets, instructional materials, interactive simulations, video conferencing, or other topics of interest for educators who are currently using, or planning to use, the Web in their classes. The session is sponsored by the MAA Committee on Computers in Mathematics Education (CCIME).

Initiating and Sustaining Undergraduate Research Projects and Programs (MAA CP E1), Sunday and Monday afternoons. **John R. Swallow***, Davidson College, P. O. Box 1719/200 D Road, Davidson, NC 28036-1719; tel: 704-894-2316; fax: 704-894-2005; joswallow@davidson.edu; **Suzanne M. Lenhart**, University of Tennessee; and **Daniel J. Schaal**, South Dakota State University. This session seeks presentations from faculty supervisors of undergraduate research who have insights and experience which would assist others either in creating individual undergraduate research projects or in creating and maintaining longer-term undergraduate research programs. The broad spectrum of undergraduate research, from small projects in courses to honors projects and full-fledged summer research programs, will be represented.

Learning to Prove in Cooperative Learning and Technology Supported Environments (MAA CP F1), Sunday afternoon. **G. Joseph Wimbish**, Huntingdon College, Montgomery, AL 36106; tel: 334-283-8149; fax: 334-283-5413; jwimbish@huntingdon.edu; **Connie M. Campbell**, Millsaps College; and **Draga D. Vidakovic**, Georgia State College. For this session we welcome reports of research along with classroom experiences on topics relating to helping students learn to prove. We would particularly welcome those contributions arising from explicit use of cooperative learning with technology-supported environments. Topics of interest could include sources of difficulties and misconceptions; importance of pedagogical approaches in identifying and overcoming difficulties and misconceptions; learning to formulate ideas within groups; and the respective roles of discovery, construction, empirical methods and refutations. We would also be interested in topics that explore sources of student theorems and the methods and timing of instructor intervention when working with cooperative learning.

Changing Student Views regarding the Usefulness of Mathematics in Order to Increase the Number of Mathematics Majors (MAA CP G1), Sunday afternoon. **Sarah L. Mabrouk***, Framingham State College, 100 State Street, P.O. Box 9101, Framingham, MA 01701-9101; tel: 508-626-4785; fax: 508-626-4003; smabrouk@frc.mass.edu. Many students select a major based on future earnings rather than interest/aptitude, choosing not to major in mathematics because they do not view mathematics as useful for life/career. While encouraging students to choose a major that fits their interests/abilities, mathematics departments must be concerned about the number of majors in order to maintain/expand the department. If we demonstrate how studying mathematics is useful in the "real world" or leads to an interesting career, then we enable students to pursue their interests in mathematics while maintaining/expanding the department. This session invites papers highlighting efforts of departments to attract mathematics majors. Of interest are activities such as lectures, workshops, math clubs, math days, math fairs, and career days designed to help students to view mathematics as useful and to attract majors. Of special interest are the benefits to students, the affect on the number of mathematics majors, and the benefit(s) to the department.

Computational Mathematics in Linear Algebra and Differential Equations (MAA CP H1), Sunday and Monday afternoons. **Richard J. Marchand***, SUNY at Fredonia, Fredonia, NY 14063; tel: 716-673-3871; fax: 716-673-3804; marchand@cs.fredonia.edu; **Elias Y. Deeba**, University of Houston-Downtown; and **Timothy J. McDevitt**, Millersville University. Recent advances in computer algebra systems, spreadsheets, and calculators facilitate numerical investigations of many meaningful problems in linear algebra and differential equations. Such investigations often increase students' understanding of mathematical concepts and empowers them with the capabilities to analyze more "real-world" problems. This session invites papers from these disciplines where these technologies are utilized. The session is sponsored by the MAA Committee on Computers in Mathematics Education (CCIME).

Deep Understanding of School Mathematics Needed by Teachers (MAA CP I1), Monday afternoon. **Albert D. Otto***, Campus Box 4520, Illinois State University, Normal, IL 61790-4520; tel: 309-438-5767; fax: 309-438-5866; otto@ilstu.edu; **Catherine M. Murphy**, Purdue University-Calumet; and **Philip Quartararo**, Southern University. The CBMS *Report on the Mathematical Education of Teachers* has as a central theme a call for K–12 teachers to develop a deep understanding of fundamental school mathematics. Papers in this session should illustrate, through specific and well-developed examples, what it means to understand school mathematics deeply, how such understanding can be fostered, and how such understanding can be demonstrated. All papers should show a clear connection to the CBMS report. This session is sponsored by the MAA Committee on the Mathematical Education of Teachers (COMET).

Best Practices in Undergraduate Statistics Education (MAA CP J1), Tuesday morning. **Mary M. Sullivan***, Rhode Island College, 600 Mt. Pleasant Avenue, Providence, RI 02908; tel: 401-456-9851; fax: 401-456-8379; mmsullivan@ric.edu; and **Carolyn M. Cuff**, Westminster College. Many contemporary courses in statistics include classroom/laboratory activities and/or projects that require active involvement with real data analysis enhanced by technology and communication of the results. Faculty who teach statistics and include activities and projects in their courses are invited to contribute papers that describe successfully implemented activities or projects. Faculty will demonstrate the activity during the session, and handouts are expected. Activities can be selected from a range of courses, from those in which only a portion of the course examines statistics through upper-level statistics courses.

Redefining What a Modern "College Algebra" Experience Means (MAA CP K1), Tuesday and Wednesday mornings. **Sheldon P. Gordon***, SUNY at Farmingdale, Farmingdale, NY 11735; tel: 516-451-4720; fax: 516-420-2211; gordonsp@farmingdale.edu; **Florence S. Gordon**, New York Institute of Technology; **Arlene H. Kleinstein**, SUNY at Farmingdale; **Mary Robinson**, University of New Mexico, Valencia Campus; **Linda H. Boyd**, Georgia Perimeter College; and **Richard A. Gillman**, Valparaiso University. The term "college algebra" encompasses a wide variety of offerings ranging from elementary algebra through college algebra/trigonometry courses and even precalculus courses. What is common is an image of the students who take such courses—those who lack some or all of the traditional algebraic skills needed for calculus. Today there are many pressures to redefine all of these traditional courses, which prompted a major MAA curriculum initiative to redefine what a "college algebra" experience should be. This session seeks contributed papers that will: (1) Present new visions for any of the courses that fall under the "college algebra" rubric. (2) Present new visions for courses and programs in quantitative literacy. (3) Describe individual experiences implementing such courses. This includes new content, new pedagogical features (collaborative learning, student projects, communication of ideas, etc.), assessment and evaluation, student reactions to the courses, and so forth. (4) Discuss what is known about enrollment trends relating to these courses. (5) Describe the connections between college algebra courses and courses in other disciplines. (6) Describe connections between college algebra courses and programs in quantitative literacy. The session is being cosponsored by the MAA Task Force on the First College Level Mathematics Course, the Committee on the Undergraduate Program in Mathematics (CUPM), the Committee on Calculus Reform At the First Two Years (CRAFTY), the Committee on Two-Year Colleges (CTYC), the Committee on Quantitative Literacy (CQL), and the Committee on Service Courses.

Strategies for Increasing the Diversity of Students in Mathematics (MAA CP L1), Tuesday morning. **William Yslas Velez***, University of Arizona, Tucson, AZ 85721; tel. 520-621-2259; fax: 520-621-8322; velez@math.arizona.edu; **Marjorie Enneking**, Portland State University; **William A. Hawkins**, SUMMA; **Michael B. Freeman**, University of Kentucky; **Robert E. Megginson**, University of Michigan; **Wade Ellis**, West Valley College. This session will present strategies for recruiting students from diverse backgrounds into mathematics, programs to support high success rates and level of achievement by these students, and faculty development initiatives which help faculty and departments initiate such programs. Presenters will describe methods for evaluating such programs and evidence to document the success of their program.

Using Examples from Sports to Enhance the Teaching of Mathematics (MAA CP M1), Tuesday morning. **Robert E. Lewand***, Goucher College, 1021 Dulaney Valley Road, Baltimore, MD 21204; tel: 410-337-6239, fax: 410-337-6408; blewand@goucher.edu; and **Howard L. Penn**, U.S. Naval Academy. The world of sports provides numerous applications that can enrich the teaching of various mathematics courses. This session seeks talks on the successful use of sports applications to enrich the teaching of any college-level mathematics course.

Classroom Demonstrations and Course Projects That Make a Difference (MAA CP N1), Tuesday and Wednesday afternoons. **David R. Hill***, Temple University, Philadelphia, PA 19122; tel: 215-204-1654; fax: 215-204-6433; hill@math.temple.edu; **Sarah L. Mabrouk**, Framingham State College; and **Lila F. Roberts**, Georgia Southern University. The use of course projects and classroom demonstrations enables instructors to show students that mathematics is meaningful and applicable in a variety of real-life situations. Demos, important tools for instruction in any class format, enable instructors to engage the students on a level beyond that created by lectures. Projects are useful in helping students to apply the course material and to make connections between mathematics and the real world. This session invites papers about favorite instructional demos and course projects appropriate for any level in the undergraduate curriculum designed to engage students and to enable them to gain insight into mathematics. Presenters of demos are encouraged to give the demonstration, if time and equipment allow, and to discuss how to use it in a classroom setting. Presenters of projects are encouraged to discuss the specifics of how the project was conducted and how it was evaluated. Proposals should describe how the demo/project fits into a course; the use of technology or technology requirements, if any; and the effect of the demo/project on student attitudes toward mathematics.

Environmental Mathematics in the Classroom (MAA CP P1), Tuesday and Wednesday afternoons. **Ben Fusaro***, Florida State University, Tallahassee, FL 32306-4510; tel: 850-644-9717; fax: 850-644-4053; fusaro@math.fsu.edu; and **Marty E. Walter**, University of Colorado. We invite papers that deal with all aspects of the applicability of mathematics to the environment at grade levels 12–15. Presentations that deal with exposition, pedagogy, or modeling are welcome. Also welcome are talks about successful experiences with getting this intrinsically interdisciplinary subject into the curriculum. Please keep your titles short and descriptive.

Innovative Outcome Assessment in Statistics Education (MAA CP Q1), Tuesday afternoon. **Robert del Mas***, University of Minnesota, 128 Pleasant Street, SE, Minneapolis, MN 55455; tel: 612-625-2076; fax: 612-625-0709; delma001@umn.edu; and **Carolyn M. Cuff**, Westminster College. Statistics education advocates innovative, interactive instruction in the classroom. Faculty report that students comprehend and enjoy statistics more, but how do we know for certain? How do we assess the learning outcomes in our courses at the level of literacy, reasoning, and statistical thinking? Beyond assessment itself, how do we use the results from assessment to inform future instruction? Faculty are invited to submit papers that describe course activities and objectives, include examples of assessment (traditional and alternative) of students that are linked to those activities and objectives, and demonstrate how information from the assessments is used to modify instruction. Papers that demonstrate the use of assessment for purposes other than examination, homework, and paper grading are encouraged and welcome.

Who Needs Algebra! Alternative Introductory Mathematics Courses (MAA CP R1), Tuesday afternoon. **Judy E. Ackerman***, Montgomery College, 51 Mannakee Street, Rockville, MD 20850; tel: 301-279-5027; fax: 301-279-5028; jackerma@mc.cc.md.us; **Susan L. Forman**, Bronx Community College; and **Kathie A. Yoder**, L.A. Pierce College. Many departments, and even colleges, require all students to study "college algebra", a title that spans a wide variety of precalculus topics. However, such courses may not contain the most appropriate subject matter for many students, particularly those who do not plan to continue the study of mathematics. Many courses such as the history of mathematics, discrete math topics, courses linked with applied fields, introductory statistics and probability, college geometry, finite mathematics, and so on may better serve the mathematical needs of many students and/or their major departments. This session will showcase alternatives to college algebra that meet mathematics graduation requirements. We particularly welcome presentations that reflect new thinking about mathematics courses, pedagogy, delivery mode and/or utilize technology as a tool to access mathematical objectives. Presentations should address the issues of prerequisites and transferability. This session is sponsored by the Committee on Two-Year Colleges (CTYC) and the Committee on Quantitative Literacy (CQL).

SIGMAA on RUME Contributed Paper Session (MAA CP S1), Tuesday and Wednesday mornings. **Julie Morrisett Clark***, Hollins University, Roanoke, VA 24020; tel: 540-362-6595; fax: 540-362-6629; jclark@hollins.edu. The Association for Research on Undergraduate Mathematics (ARUME) aims to foster a professional atmosphere for quality research in the teaching and learning of undergraduate mathematics. These contributed paper sessions are for mathematics educators and professional mathematicians interested in research on undergraduate mathematics education. Research papers that address issues concerning the teaching and learning of undergraduate mathematics are invited. Theoretical and empirical investigations using qualitative and quantitative methodologies are appropriate. These should be set within established theoretical frameworks and should further existing work. Reports on completed studies are especially welcome.

General Contributed Paper Session (MAA CP T1), Sunday and Monday afternoons. **Shawnee L. McMurran***, California State University, San Bernardino, CA; tel: 909-880-7249; fax: 909-880-7119; mcmurran@math.csusb.edu; **Emelie Kenney**, Siena College; and **Sarah L. Mabrouk**, Framingham State College. This session is designed for papers that do not fit into one of the other sessions. Papers may be presented on any mathematics-related topic. Papers that fit into one of the other sessions should be sent to that organizer, not to this session. E-mail submissions are preferred.

Ann Arbor, Michigan

University of Michigan

March 1–3, 2002

Meeting #974

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: To be announced
Program first available on e-MATH: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: August 3, 2001
For consideration of contributed papers in Special Sessions: November 13, 2001
For abstracts: January 9, 2002

Special Sessions

Quantum Topology in Dimension Three (Code: AMS SS A1), **Charles Frohman**, University of Iowa, and **Joanna Kania-Bartoszynska**, Boise State University.

Atlanta, Georgia

Georgia Institute of Technology

March 8–10, 2002

Meeting #975

Southeastern Section
Associate secretary: John L. Bryant
Announcement issue of *Notices*: To be announced
Program first available on e-MATH: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: October 8, 2001
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

AMS Invited Addresses

Nigel J. Kalton, University of Missouri, Columbia, *Title to be announced.*

Montréal, Quebec, Canada

Centre de Recherches Mathématiques, Université de Montréal

May 3-5, 2002

Meeting #976

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: To be announced
Program first available on e-MATH: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: October 3, 2001
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Pisa, Italy

June 12-16, 2002

Meeting #978

First Joint International Meeting between the AMS and the Unione Matematica Italiana.
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: To be announced
Program first available on e-MATH: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Invited Addresses

Luigi Ambrosio, Scuola Normale Superiore, *Title to be announced.*

Luis A. Caffarelli, University of Texas at Austin, *Title to be announced.*

Claudio Canuto, University of Torino, *Title to be announced.*

L. Craig Evans, University of California Berkeley, *Title to be announced.*

Giovanni Gallivotti, University of Rome I, *Title to be announced.*

Sergiu Klainerman, Princeton University, *Title to be announced.*

Rahul V. Pandharipande, California Institute of Technology, *Title to be announced.*

Claudio Procesi, University of Rome, *Title to be announced.*

Portland, Oregon

Portland State University

June 20-22, 2002

Meeting #977

Western Section
Associate secretary: Bernard Russo
Announcement issue of *Notices*: To be announced
Program first available on e-MATH: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: November 20, 2001
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Boston, Massachusetts

Northeastern University

October 5-6, 2002

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: To be announced
Program first available on e-MATH: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: March 6, 2002
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Madison, Wisconsin

University of Wisconsin-Madison

October 12-13, 2002

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: To be announced
Program first available on e-MATH: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: March 12, 2002
For consideration of contributed papers in Special Sessions: June 25, 2002
For abstracts: August 20, 2002

Special Sessions

Arithmetic Algebraic Geometry (Code: AMS SS A1), **Ken Ono** and **Tonghai Yang**, University of Wisconsin-Madison.

Arrangements of Hyperplanes (Code: AMS SS E1), **Peter Orlik** and **Anne Shepler**, University of Wisconsin-Madison.

Biological Computation and Learning in Intelligent Systems (Code: AMS SS S1), **Shun-ichi Amari**, RIKEN, **Amir Assadi**, University of Wisconsin-Madison, and **Tomaso Poggio**, Massachusetts Institute of Technology.

Combinatorics and Special Functions (Code: AMS SS T1), **Richard Askey** and **Paul Terwilliger**, University of Wisconsin-Madison.

Dynamical Systems (Code: AMS SS P1), **Sergey Bolotin** and **Paul Rabinowitz**, University of Wisconsin-Madison.

Effectiveness Questions in Model Theory (Code: AMS SS J1), **Charles McCoy**, **Reed Solomon**, and **Patrick Speissegger**, University of Wisconsin-Madison.

Geometric Methods in Differential Equations (Code: AMS SS H1), **Gloria Mari Beffa**, University of Wisconsin-Madison, and **Peter Olver**, University of Minnesota.

Geophysical Waves and Turbulence (Code: AMS SS M1), **Paul Milewski**, **Leslie Smith**, and **Fabian Waleffe**, University of Wisconsin-Madison.

Group Cohomology and Homotopy Theory (Code: AMS SS G1), **Alejandro Adem**, University of Wisconsin-Madison, and **Jesper Grodal**, Institute for Advanced Study.

Harmonic Analysis (Code: AMS SS C1), **Alex Ionescu** and **Andreas Seeger**, University of Wisconsin-Madison.

Hyperbolic Differential Equations and Kinetic Theory (Code: AMS SS K1), **Shi Jin**, **Marshall Slemrod**, and **Athanassios Tzavaras**, University of Wisconsin-Madison.

Lie Algebras and Related Topics (Code: AMS SS N1), **Georgia Benkart** and **Arun Ram**, University of Wisconsin-Madison.

Multiresolution Analysis and Data Presentation (Code: AMS SS F1), **Amos Ron**, University of Wisconsin-Madison.

Partial Differential Equations and Geometry (Code: AMS SS D1), **Sigurd Angenent** and **Mikhail Feldman**, University of Wisconsin-Madison.

Probability (Code: AMS SS R1), **David Griffeath**, University of Wisconsin-Madison, and **Timo Seppalainen**, Iowa State University.

Ring Theory and Related Topics (Code: AMS SS L1), **Don Passman**, University of Wisconsin-Madison.

Several Complex Variables (Code: AMS SS B1), **Pat Ahern**, **Xianghong Gong**, **Alex Nagel**, and **Jean-Pierre Rosay**, University of Wisconsin-Madison.

Orlando, Florida

University of Central Florida

November 9-10, 2002

Southeastern Section
Associate secretary: John L. Bryant
Announcement issue of *Notices*: To be announced
Program first available on e-MATH: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 10, 2002
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Baltimore, Maryland

Baltimore Convention Center

January 15-18, 2003

Joint Mathematics Meetings, including the 109th Annual Meeting of the AMS, 86th Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL).
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: To be announced
Program first available on e-MATH: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 15, 2002
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

Baton Rouge, Louisiana

Louisiana State University

March 14-16, 2003

Southeastern Section
Associate secretary: John L. Bryant
Announcement issue of *Notices*: To be announced
Program first available on e-MATH: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: August 14, 2002
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Bloomington, Indiana

Indiana University

April 4–6, 2003

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: To be announced
Program first available on e-MATH: 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

Seville, Spain

June 25–28, 2003

First Joint International Meeting between the AMS and the Real Sociedad Matematica Espanola (RSME)
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: To be announced
Program first available on e-MATH: 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

Phoenix, Arizona

Phoenix Civic Plaza

January 7–10, 2004

Associate secretary: Bernard Russo
Announcement issue of *Notices*: To be announced
Program first available on e-MATH: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 2, 2003
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

Meetings and Conferences of the AMS

Associate Secretaries of the AMS

Western Section: Bernard Russo, Department of Mathematics, University of California Irvine, CA 92697; e-mail: brusso@math.uci.edu; telephone: 949-824-5505.

Central Section: Susan J. Friedlander, Department of Mathematics, University of Illinois at Chicago, 851 S. Morgan (M/C 249), Chicago, IL 60607-7045; e-mail: susan@math.nwu.edu; telephone: 312-996-3041.

Eastern Section: Lesley M. Sibner, Department of Mathematics, Polytechnic University, Brooklyn, NY 11201-2990; e-mail: lsibner@duke.poly.edu; telephone: 718-260-3505.

Southeastern Section: John L. Bryant, Department of Mathematics, Florida State University, Tallahassee, FL 32306-4510; e-mail: bryant@math.fsu.edu; telephone: 850-644-5805.

The Meetings and Conferences section of the *Notices* gives information on all AMS meetings and conferences approved by press time for this issue. Please refer to the page numbers cited in the table of contents on this page for more detailed information on each event. Invited Speakers and Special Sessions are listed as soon as they are approved by the cognizant program committee; the codes listed are needed for electronic abstract submission. For some meetings the list may be incomplete. **Information in this issue may be dated. Up-to-date meeting and conference information** at www.ams.org/meetings/.

Meetings:

Important Information regarding AMS Meetings

Potential organizers, speakers, and hosts should refer to page 87 in the January 2001 issue of the *Notices* for general information regarding participation in AMS meetings and conferences.

Abstracts

Several options are available for speakers submitting abstracts, including an easy-to-use interactive Web form. No knowledge of LaTeX is necessary to submit an electronic form, although those who use LaTeX or AMS-LaTeX may submit abstracts with such coding. To see descriptions of the forms available, visit http://www.ams.org/abstracts/instructions.html, or send mail to abs-submit@ams.org, typing help as the subject line; descriptions and instructions on how to get the template of your choice will be e-mailed to you.

Completed abstracts should be sent to abs-submit@ams.org, typing submission as the subject line. Questions about abstracts may be sent to abs-info@ams.org.

Paper abstract forms may be sent to Meetings & Conferences Department, AMS, P.O. Box 6887, Providence, RI 02940. There is a $20 processing fee for each paper abstract. There is no charge for electronic abstracts. Note that all abstract deadlines are strictly enforced. Close attention should be paid to specified deadlines in this issue. Unfortunately, late abstracts cannot be accommodated.

Conferences: (See http://www.ams.org/meetings/ for the most up-to-date information on these conferences.)

June 10-August 9, 2001: Joint Summer Research Conferences in the Mathematical Sciences, Mount Holyoke College, South Hadley, MA. See pages 1331-1335, November 2000 issue, for details.

Cosponsored Conferences:

June 3-8, 2002: Abel Bicentennial Conference 2002, University of Oslo, Norway.

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