ISSN 0002-9920

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of the American Mathematical Society

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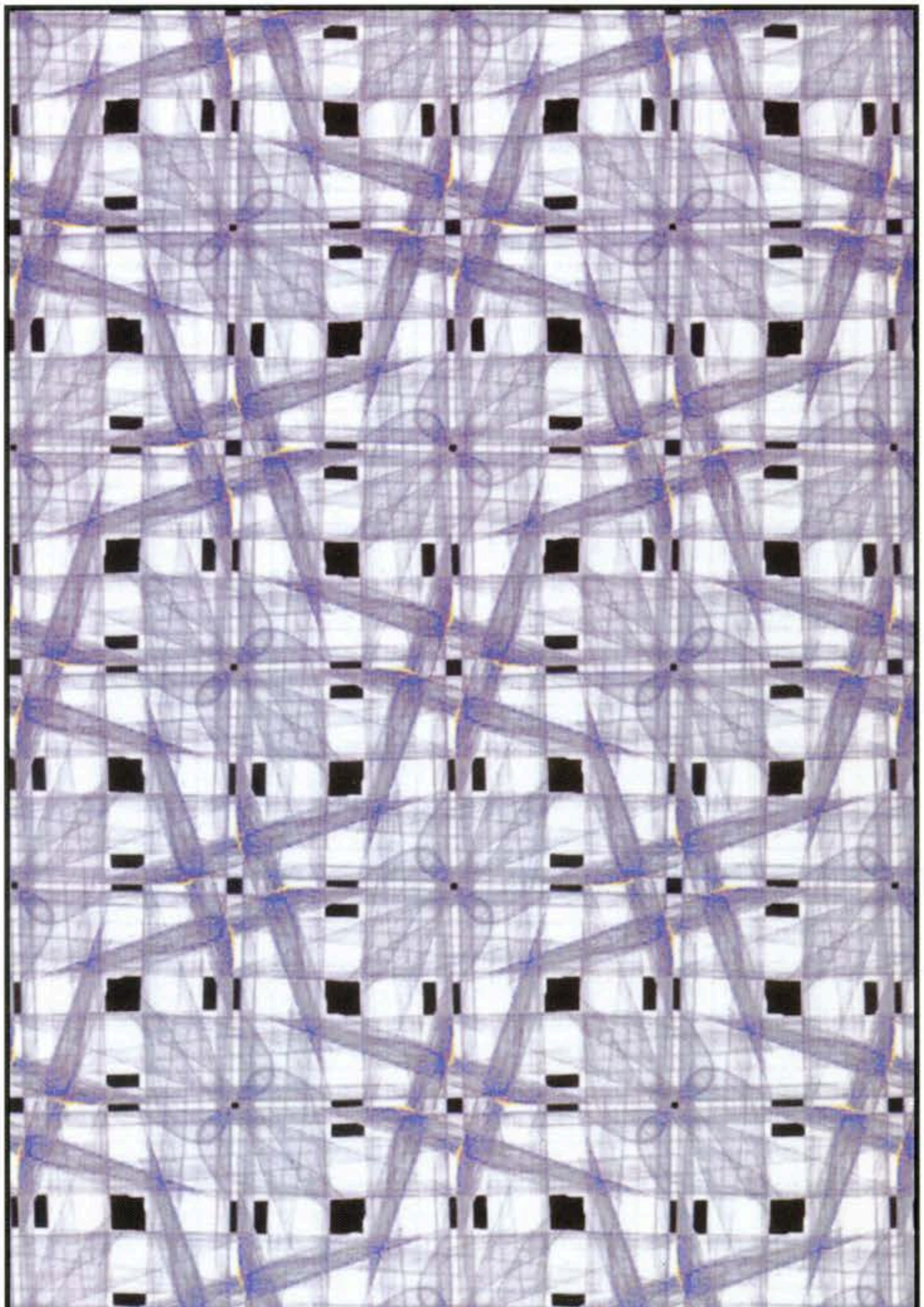

Twisted Symmetries (*See page 620*)

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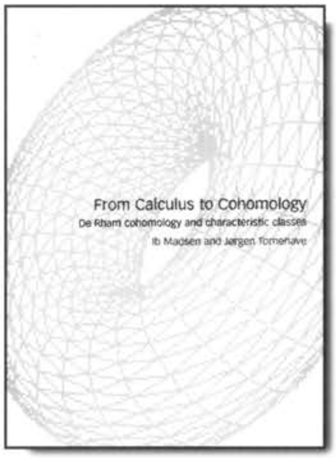

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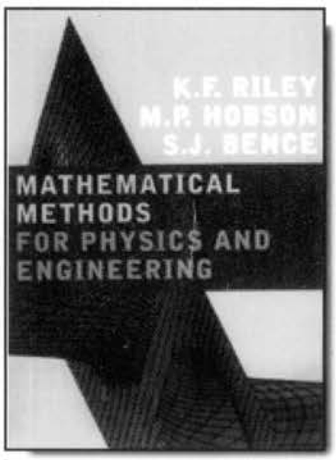

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A Comprehensive Guide

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1998 1028 pp. 55506-X Hardback $110.00
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This volume, an outgrowth of a 1995 program at the Mathematical Sciences Research Institute, contains expository articles by program participants describing the present state of the art. Here researchers and graduate students will encounter Hardy spaces, Bergman spaces, Dirichlet spaces, Hankel and Toeplitz operators, and a sampling of the role these objects play in modern analysis.

Mathematical Sciences Research Institute Publications 33

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Cambridge Studies in Advanced Mathematics 60

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Coppel presents the foundations of Euclidean geometry from the point of view of mathematics, taking advantage of all the developments since the appearance of Hilbert's classic work. Here real affine space is characterized by a small number of axioms involving points and line segments making the treatment self contained and thorough.

Australian Mathematical Society Lecture Series 12

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This book provides a detailed but concise account of the theory of structure of finite p-groups admitting p-automorphisms with few fixed points. The relevant preliminary material on Lie rings is introduced and the main theorems of the book on the solubility of finite p-groups are then presented.

London Mathematical Society Lecture Note Series 246

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Flavors of Geometry

Silvio Levy, *Editor*

Flavors of Geometry is a collection of lectures on four geometrically-influenced fields of mathematics that have experienced great development in recent years. It presents chapters by masters in their fields on hyperbolic geometry, dynamics in several complex variables, convex geometry, and volume estimation. The style and presentation of the chapters are clear and accessible, and many of the lectures are richly illustrated.

Mathematical Sciences Research Institute Publications 31

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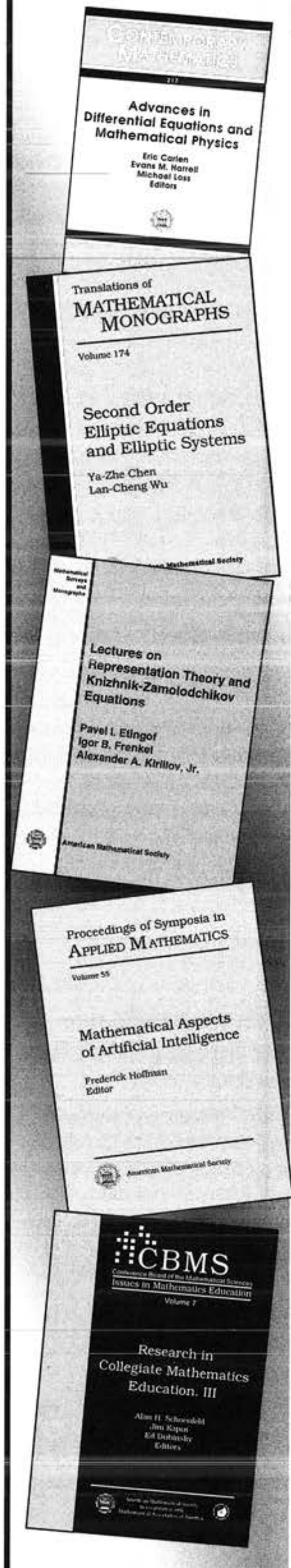

AMERICAN MATHEMATICAL SOCIETY

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Advances in Differential Equations and Mathematical Physics

Eric Carlen, **Evans M. Harrell**, and **Michael Loss**, *Georgia Institute of Technology, Atlanta*, Editors

This volume consists of selected contributions from the "1997 Georgia Institute of Technology-UAB International Conference on Differential Equations and Mathematical Physics". The book offers a combination of certain emerging topics and important research advances in this active area. The topics range widely and include magnetic Schrödinger operators, the Boltzmann equations, nonlinear variational problems and noncommutative probability theory. Some articles were included for their aesthetic value and others to present an overview. All articles were reviewed for scientific content and readability. The text is suitable for graduate and advanced graduate courses and seminars on the topic.

Contemporary Mathematics, Volume 217; 1998; 221 pages; Softcover; ISBN 0-8218-0861-3; List $44; Individual member $26; Order code CONM/217NT85

Second Order Elliptic Equations and Elliptic Systems

Ya-Zhe Chen and **Lan-Cheng Wu**, *Peking University, China*

There are two parts to the book. In the first part a complete introduction of various kinds of a priori estimate methods for the Dirichlet problem of second order elliptic partial differential equations is presented. In the second part, the existence and regularity theories of the Dirichlet problem for linear and nonlinear second order elliptic partial differential systems are introduced. The book features appropriate materials and is an excellent textbook for graduate students. The volume is also useful as a reference source for undergraduate mathematics majors, graduate students, professors, and scientists.

Translations of Mathematical Monographs, Volume 174; 1998; 246 pages; Hardcover; ISBN 0-8218-0970-9; List $99; Individual member $59; Order code MMONO/174NT85

Lectures on Representation Theory and Knizhnik-Zamolodchikov Equations

Pavel I. Etingof, *Harvard University, Cambridge, MA*, **Igor B. Frenkel**, *Yale University, New Haven, CT*, and **Alexander A. Kirillov, Jr.**, *Massachusetts Institute of Technology, Cambridge*

This book is devoted to mathematical structures arising in conformal field theory and the q-deformations. The authors give a self-contained exposition of the theory of Knizhnik-Zamolodchikov equations and related topics. No previous knowledge of physics is required. The text is suitable for a one-semester graduate course.

Mathematical Surveys and Monographs; 1998; approximately 208 pages; Hardcover; ISBN 0-8218-0496-0; List $49; All AMS members $39; Order code SURV-ETINGOFNT85

Mathematical Aspects of Artificial Intelligence

Frederick Hoffman, *Florida Atlantic University, Boca Raton*, Editor

There exists a history of great expectations and large investments involving Artificial Intelligence (AI). There are also notable shortfalls and memorable disappointments. One major controversy regarding AI is just how mathematical a field it is or should be.

This text includes contributions that examine the connections between AI and mathematics, demonstrating the potential for mathematical applications and exposing some of the more mathematical areas within AI. The goal is to stimulate interest in people who can contribute to the field or use its results.

Included is work by M. Newborn on the famous Deep Blue chess match. He discusses highly mathematical techniques involving graph theory, combinatorics and probability and statistics. G. Shafer offers his development of probability through probability trees with some of the results appearing here for the first time. M. Golumbic treats temporal reasoning with ties to the famous Frame Problem. His contribution involves logic, combinatorics and graph theory and leads to two chapters with logical themes. H. Kirchner explains how ordering techniques in automated reasoning systems make deduction more efficient. Constraint logic programming is discussed by C. Lassez, who shows its intimate ties to linear programming with crucial theorems going back to Fourier. V. Nalwa's work provides a brief tour of computer vision, tying it to mathematics—from combinatorics, probability and geometry to partial differential equations.

All authors are gifted expositors and are current contributors to the field. The wide scope of the volume includes research problems, research tools and good motivational material for teaching.

Proceedings of Symposia in Applied Mathematics, Volume 55; 1998; approximately 288 pages; Hardcover; ISBN 0-8218-0611-4; List $49; All AMS members $39; Order code PSAPM/55NT85

Research in Collegiate Mathematics Education. III

Alan H. Schoenfeld, *University of California, Berkeley*, **Jim Kaput**, *University of Massachusetts, Dartmouth*, and **Ed Dubinsky**, *Georgia State University, Atlanta*, Editors

Volume III of *Research in Collegiate Mathematics Education* (RCME) presents state-of-the-art research on understanding, teaching and learning mathematics at the post-secondary level. This volume contains information on methodology and research concentrating on these areas of student learning:

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This series is published in cooperation with the Mathematical Association of America.

CBMS Issues in Mathematics Education, Volume 7; 1998; 316 pages; Softcover; ISBN 0-8218-0882-6; List $40; All individuals $24; Order code CBMATH/7NT85

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Allyn Jackson

The MPI in Bonn is one of the world's premier centers for mathematics research. Its upcoming move to a new building in the center of Bonn's old town provides an occasion for examining the MPI's history and future.

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Notices

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SUBSCRIPTION INFORMATION: Subscription prices for Volume 45 (1998) are \$300 list; \$240 institutional member; \$180 individual member. (The subscription price for members is included in the annual dues.) A late charge of 10% of the subscription price will be imposed upon orders received from nonmembers after January 1 of the subscription year. Add for postage: Surface delivery outside the United States and India—\$15; in India—\$36; expedited delivery to destinations in North America—\$35; elsewhere—\$70. Subscriptions and orders for AMS publications should be addressed to the American Mathematical Society, P.O. Box 5904, Boston, MA 02206-5904. All orders must be prepaid.

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[*Notices of the American Mathematical Society* is published monthly except bimonthly in June/July by the American Mathematical Society at 201 Charles Street, Providence, RI 02904-2213. Periodicals postage paid at Providence, RI, and additional mailing offices. POSTMASTER: Send address change notices to *Notices of the American Mathematical Society*, P.O. Box 6248, Providence, RI 02940-6248.] Publication here of the Society's street address and the other information in brackets above is a technical requirement of the U.S. Postal Service. All correspondence should be mailed to the post office box, not the street address. Tel: 401-455-4000; e-mail: notices@ams.org.

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From the AMS President

Grass Roots

Hypotheses: mathematics enables all the sciences and engineering; our future prosperity rests on new discoveries in science and mathematics; science evolves through a web of interdependent disciplines. Conclusion: the time is ripe to jump-start our federal investment in the future, to renew our commitments to research, to our mathematical and our scientific talent, and to our universities.

This message has been my hallmark. As cofounder of an ad-hoc coalition of presidents of scientific societies, I have helped to put in place a national pro-science movement. Commentator David Gergen christened our initial March 1997 proposal the "7 percent solution". Simply put, we asked that research funding in all fields of science increase by 7 percent in 1998. Our second, "unified" statement emerged last October. It focuses on a ten-year period beginning with fiscal 1999, is signed by over one hundred presidents, and asks for doubling of all science funding. This statement received considerable attention too. It coincided with the announcement of the bipartisan Gramm-Lieberman-Domenici-Bingaman bill, S.1305, to double civilian research funding. In February 1998 President Clinton asked in his budget for historic increases in science funding.

One year ago, whoever dared predict that the president and Congress would fight over who can do more for science and mathematics? Yet today this unlikely circumstance has arrived. It came about through the efforts of a small group of scientists and mathematicians and a handful of members of the Congress. It also received a strong push from prominent writers in the media. This initial success in affecting both appropriations and potential legislation has been no accident.

BUT we are at a watershed.

First: To sustain the pro-science movement, we must make it much broader. Rather than involving a few individuals, we need to generate a **grass-roots movement** in support of mathematics and science.

Second: We must work to ensure that the mathematics component remains central and that an appropriate share of funding goes both into our subject and **to investigators in an appropriate way.**

Some comments: I visited Paris recently and was overjoyed to learn that Claude Allègre, the new French minister of education, research, and technology, has launched a campaign to "debureaucratise scientific research" and to "leave more liberty to researchers." I later went to England and there heard a related story. The Royal Society aims to increase individual investigator-initiated "project grants" in all fields of science. Investigator-initiated projects lie at the heart of work in mathematics, so I take heart in their emphasis worldwide.

The initial success at home of the pro-science movement rested on a few scientists and mathematicians speaking with a few key legislators. But now our goal must be to engage every congressional representative and every senator, as well as the public. If we succeed, there is no question that science will actually remain a top priority of any U.S. president and of the Congress.

How can we take our message to schools and to our representatives? Here is a concrete recipe for the latter, home tested by the AMS. John Ewing organized a Providence town meeting, inviting Rhode Island Senator Jack Reed, along with local mathematicians and scientists from Brown, the University of Rhode Island, and local scientific industries. It worked wonderfully, stimulating interchange with the senator and a long discussion among the participants after Reed left! You too can do this at your universities: work together with a computer scientist, a physicist, a chemist, a biologist, and an engineer. Sam Rankin in the AMS Washington office can assist you. Afterwards, you can offer to advise the representatives or their staff.

Working together we can be a real political force. Over 3 million of us belong to the societies whose presidents form our coalition. With families and friends we comprise an important cross-section of the country; we also represent a relevant number of votes. Not only do we have allies in our universities, but we also find them in industry and in the financial community. Because our economic future depends on our innovation in science and mathematics, research and education are easy sells. The future is in our hands. We must not drop it. We need to remain visible!

—*Arthur Jaffe*

Commentary

In My Opinion

The Decline of Science

After a recent panel on "gender aspects of the science wars", someone persistently asked why such seemingly bad scholarship had attracted a following. I had no answer. Since then, the review (which appears in this issue) by Sandro Graffi of Russo's *The Forgotten Revolution* has given me new insight into this, and related, issues.

It is certainly important for the scientific community to be receptive to criticism, particularly regarding ethical issues. But I am concerned about those critiques which are based on the proposition that science itself is nothing more than a cultural construct—one that is white, male, and western. How, one wonders, can this be taken seriously? Is there any credible evidence that the force of gravitational attraction varies with gender or ethnicity? That electromagnetic phenomena in Africa are not in agreement with Maxwell's equations? Yet, Gross and Levitt's *Higher Superstition*[1], the hoax associated with the "Sokal affair"[1], and Bricmont and Sokal's recent *Impostures Intellectuelles*[2] leave little doubt that even some of the most preposterous cultural critiques have found a receptive audience. That this construct is suffused with male bias is a frequent theme in gender studies,[3] despite the lack of evidence that women prove different theorems. Indeed, those of us who participate in science and mathematics see so much evidence for its universal validity that we may forget that this is not obvious to others. However, among the general public a belief in the validity of science is being threatened by the appeal of alternative medicine, psychics, paranormal phenomena, etc.

Inadequacies of our educational system play a role. Consider, for example, the practice of trying to make physics attractive by eliminating even high school mathematics, depriving students of any possibility of seeing the logical development of physical principles. If, in addition, these students do not perform any simple experiments which illustrate basic phenomena, such as gravity, water pressure, magnetism, and the efficiency of pulleys, then listening to a (usually male) teacher lecture on such unfamiliar phenomena as black holes, relativity, strings, quarks, etc., is not likely to seem different from listening to a Druid priest. All connection with reality has been lost. With different motives, animal rights activists assert that the traditional dissection of frogs in biology can be replaced by computer simulations. But such simulations *are* unequivocally human constructs. Children are accustomed to using computer games which simulate a fantasy world of dungeons and dragons. A computer model may illustrate the location of the heart relative to the lungs, but it cannot teach students that real frogs have certain features in common, unaffected by whether or not those organs are included in a computer program. The role of dissection and animal experiments in education is a complex issue. But some experiments are necessary if students are to understand the notions of external world, "objective" reality, universality, scientific methodology, and "truth".

How can the public be expected to believe in scientific "truth" when supposedly "expert" witnesses present, under oath in court, absurdly divergent views as "scientific fact"? What is the public to make of the two video reconstructions with *different* trajectories that government bodies have presented of the 1996 crash of TWA flight 800? If this is truly a case in which an inverse problem does not have a unique solution, that should be admitted; if not, applied mathematicians with access to the data should set the record straight. Over twenty-five years ago almost half those surveyed believed that the moon landing they watched on television actually took place in Hollywood. Today, the credibility of science and engineering is reaching depths not experienced since the Dark Ages. Ethical responsibility alone should confine contradictory testimony to cases of bona fide ambiguity. Failure to do so undermines the very heart of science.

Experimental evidence can be used to counter the argument that science is a cultural construct. But what about mathematics? Despite its "unreasonable effectiveness" (as Eugene Wigner put it), mathematics *is* a human construct. We make definitions and examine their consequences. There is even a subjective human aspect to mathematical proof. Most number theorists were convinced of the essential validity of the Wiles strategy for proving Fermat's theorem before the details were available and even after a flaw was discovered. I would argue that the universality of mathematical truth is as valid and "unreasonable" a phenomenon as its widespread applicability. In a seminar, one previously math-phobic student wrote, "...the answers to *all* my questions are deep inside me. The problem isn't how to 'find' a solution, it's how to 'get it out' from within myself." Although this student had experienced the universal validity of mathematical truth, her words have been interpreted as supporting the notion[4] that "there are as many right answers as there are people listening to their own inner voices," i.e., that mathematical truth is a subjective personal construct. It may be tempting to dismiss this view as absurd. But it is a symptom of a serious and pervasive problem that merits our attention.

—Mary Beth Ruskai
Associate Editor

[1] *For reviews and commentary, see the articles by Sullivan and Harrell in the October 1996* Notices *or the Web site* http://www.physics.nyu.edu/faculty/sokal/index.html.

[2] *Planned for review in a future issue of the* Notices.

[3] *See, e.g., Allyn Jackson's article in the July/August 1989* Notices *or A. Koblitz's review of Claudia Henrion's* Women of Mathematics: The Addition of Difference *in the current* Notices.

[4] *M. F. Belenky et al.,* Epistemological development and the politics of talk in family life, *J. of Education* ***167*** *(1985), 9–27; see also M. F. Belenky, B. M. Clinchy, N. R. Goldberger, and J. Mattuck,* Women's ways of knowing, *Basic Books, 1986.*

Letters to the Editor

Comments on Sadosky's "Forum"

I was pleased to open my December issue of the *Notices* and see the article "On Issues of Immigration and Employment for Mathematicians" by Cora Sadosky in the "Forum". After a long silence from the *Notices* on the complex issues surrounding the current job market, I had hoped that Geoff Davis's excellent and thought-provoking article in the November issue marked the beginning of the *Notices* as a forum for thoughtful and frank discussion of these questions within the math community. I was particularly eager to hear considered arguments against changing current immigration law as it applies to scientists. I know many of the mathematicians advocating such changes and am familiar with their arguments, but have not heard much response to these arguments.

What I read was extremely disheartening. Sadosky speaks vaguely of "a few mathematicians" and makes brief reference to articles in the *Wall Street Journal* and the *Boston Globe* in which several mathematicians were interviewed and asserted that specific changes in immigration law as it pertains to scientists were largely responsible for the current job market crisis. Clearly she means to be responding to these people and these positions. Yet never in the entire article does she respond to any position I found remotely recognizable as being held by anyone I have heard speak on the subject. No mention is made of the recent changes in immigration law for scientists and engineers, nor are any arguments offered in favor of these changes. Instead, she creates a straw man of ridiculous and genuinely evil positions to argue against as a surrogate.

Those questioning the current status quo are compared to LePen's FNP and Nazis and caricatured by statements like "Now some would make foreigners rather than women the scapegoats." We are told that "surely mathematicians know better than to mistake correlation with causality in their efforts to deal with the current job crisis"; that "banning immigrant mathematicians" would create problems; that "asserting supposed birth rights of the U.S.-born in divisive chauvinistic quests, or with anti-immigration innuendo" is the wrong approach; and she concludes, "Let us work to eliminate the stereotype of foreigners as smart but unable to teach simply because they have accents." These assertions are inarguable, but if these are your only arguments against someone's position, you have in effect accused your opponent of racism, xenophobia, and the spreading of dangerous stereotypes.

Such accusations would require meticulous substantiation under any circumstances, and in an article solicited by the *Notices* in this close-knit and generally collegial community of mathematicians the standards should be far higher. This is all the more true since this is for the *Notices* a single isolated entry into the debate, and there appears to be no opportunity for those accused to defend themselves or state their positions. There was not a shred of substantiation for this smear. Even LePen was allowed to be damned by his own slogan rather than by having someone else's words put in his mouth, but no quotes or evidence of any kind were offered to condemn the accused racists and xenophobes.

Beyond being unsubstantiated, the accusations are also false: while I am sure somewhere in the world there are mathematicians who are racist, as in any profession, I have never heard any mathematician ever express any of the offensive sentiments Sadosky argues against.

I do not know what the *Notices*'s editorial policy is, but I expect and hope that making incendiary and unsubstantiated accusations against fellow mathematicians violates it and that the publication of this article is a mere oversight. I think an apology at least from the editorial board is called for. I also think that in an effort to undo some of the damage done here and to permit a productive discussion of what the *Notices* seems to feel is an important issue for mathematicians, it would be constructive to publish two pieces, making responsible and cogent cases on both sides of the immigration debate.

I should add that as disturbed as I was by the accusations of racism that seemed to me to be the centerpiece of Sadosky's argument, I felt there were also a number of valid points. In particular, she offered a number of plausible explanations for the job crisis, although I would have liked to see a real case made based on hard data that these can explain it. She also makes the important and often overlooked point that the place in all of this where mathematicians can probably have the most positive effect is in supporting the wealth of young research mathematicians who find themselves at places where little research has gone on. This does not, however, free us from the responsibility of considering all aspects of the crisis and all coherent arguments (even those which seem frightening) in the critical, open-minded, thoughtful, and collegial way that I believe characterizes our discipline.

Stephen Sawin
Fairfield University

(Received December 15, 1997, revised January 20, 1998)

Editor's Note: In the penultimate paragraph of his letter, Professor Sawin suggests that the *Notices* should publish two pieces representing both sides of the immigration debate. In fact, last year's Editorial Board attempted to do just that. Professor Sadosky's piece was to have been one of a pair of articles on immigration issues. The other author (whose offer to write on this topic led the Board to solicit the contrasting view from Professor Sadosky) produced a piece that was twice as long as the agreed-upon word limit and refused to shorten the piece. Out of fairness to Professor Sadosky, who had abided by the word limit, the Board decided to publish her piece alone. This year's *Notices* Editorial Board continues to look for ways to present various sides of the issues concerning immigration and employment.

Sadosky Replies

Professor Sawin is angry with my "Forum" piece on issues of immigration and employment. He expected an article countering arguments advocating restrictions to scientific immigration. Instead, in what I thought was going to be one of a pair of position pieces, I concentrated on the danger of substituting anti-immigrant rhetoric for the serious consideration of the unemployment crisis faced by mathematicians.

I mentioned Le Pen's slogan not to counter specific arguments against scientific immigration but to warn against the recurrence of foreigners as scapegoats. After WWI France had a great need of manpower sated by a flow of refugees; during the economic crisis of the thirties some professional associations reacted with xenophobia instead of confronting the causes of unemployment. Such attitudes are not uniquely French. My contention is that xenophobic reactions divert attention from the real causes of real problems.

Professor Sawin complains that my case on possible causes of the job crisis is not made because it is "not based on hard data." That is not so. The strict word limit of my article pushed the supporting material (all easily accessible to the *Notices* readership) to the references. For instance, I mentioned the decrease in calculus enrollment of more than 100,000 students in five years, which is quite hard data and comes from a survey published in the September 1997 *Notices*. The article "Changes in Mathematics Faculty Composition: Fall 1990 to Fall 1996" in the November 1997 *Notices* summarizes extensive data from past AMS-IMS-MAA Surveys: in the five-year period covered, total tenure-track faculty declined by 1,400 despite about 2,600 retirements—how can that be blamed on immigration?

On the other hand, the newspaper accounts to which I also referred reported efforts to lobby Congress against scientific immigration but did not present the substantiating arguments. While such arguments may be familiar to Professor Sawin, to my knowledge they have yet to appear in print. Making available through the *Notices* the text of the statement sent to Congress would facilitate an informed debate on their substance. If Professor Sawin knows of cogent arguments in support of restrictive immigration laws and feels so strongly that I overlooked or misrepresented them, why did he not use some of his letter to state them? How long are the purported powerful anti-immigrant arguments to remain mere rumors?

Professor Sawin calls in his letter for "considering all aspects of the [job] crisis and all coherent arguments (even those which seem frightening) in the critical, open-minded, thoughtful, and collegial way" that he believes "characterizes our discipline." In the same letter he calls for an apology from the *Notices* Editorial Board for having solicited and published my "incendiary" article. It is hard to reconcile both calls.

Cora Sadosky
Howard University

(Received February 11, 1998)

Hold Departments Accountable

Cora Sadosky's recent article on immigration makes an important point that bears repeating: immigration is *not* the real issue facing the mathematics community. Recent changes in immigration patterns are but one of a number of factors that have affected the balance of supply and demand for Ph.D.s. The real issue we must address as a community is that of how to adapt to the broad range of changes that are taking place in the environment in which we operate.

Sadosky's article evokes images of an idealized job market in which Ph.D.s engage in a Darwinian struggle for employment, a market in which survival is based purely on merit. While the evolutionary metaphor suggests that the ferocious competition amongst job-seeking doctorates leads to improvements in mathematics, there is a fallacy in this notion. It is *individuals* who feel and must respond to the selective pressures, not departments. The unfortunate reality is that many individuals are adapting to the present climate by leaving mathematics altogether. Departments, in contrast, have little incentive to change their ways.

A change in perspective is in order: consider what might happen if we were to expand the arena of competition to include departments. Suppose that not only would doctorates compete for jobs, their departments would also compete to ensure that their graduates obtained the best possible positions. Innovative initiatives such as the Preparing Future Faculty program and NSF's new VIGRE grants provide the means for departments to increase their graduates' chances of finding meaningful employment. Competitive pressures would give them the motivation to participate in these programs or to explore their own avenues of change. Some departments might add breadth to their doctoral curricula; others might create courses of study to prepare students for new, nonacademic careers; still others might hone teacher-training programs. The result would be an expansion of opportunities for new doctorates rather than the present contraction and retrenchment.

An annual departmental report card providing such information as placement rates for each department's recent graduates, attrition rates, and average times to degree would provide departments with incentives to adapt. Report cards would steer prospective students to the departments best suited to fulfilling their career goals. To attract the best students, departments would not only have to strive for excellence in research but also for excellence in their preparation of their students for their careers, be they inside or outside of academia. The Web site `http://www.phds.org/ratings/` illustrates how this data can be used.

The level of accountability embodied in departmental report cards is common in other professions. Detailed information on placement rates is readily available for business and law schools. Trials of hospital report cards have been so successful that the *Journal of the American Medical Association* has recently called for the provision of report cards for both hospitals and individual doctors. A March 3 workshop I am organizing with the AAAS Commission on Professionals in Science and Technology will lay the groundwork for the gathering of outcome data for doctorates in all of the sciences.

Holding ourselves to a higher standard through greater accountability is a first step towards alleviating the current labor market problems and preventing future ones. Increased accountability provides incentives to adapt without making any distinctions regarding nationality of doctorates and without mandating any cutbacks in enrollments. Prospective graduate students must invest years of their lives in a difficult course of study. These students are of tremendous benefit to faculty members: they help teach our classes and help us with our research. For the graduate students, however, the investment is a risky one. There are no guarantees that they will be able to fulfill their career goals upon obtaining a degree. It is the graduate student and not the department who ultimately pays the price for inappropriate training. Do we owe our students anything less than full information?

Geoff Davis
Dartmouth College

(Received January 20, 1998)

Vershik Work Needs Acknowledgement

I was astonished not to find in the paper "Random Combinatorial Structures and Prime Factorization" by R. Arratia, A. D. Barbour, S. Tavare (*Notices*, September 1997, 903–910) any reference to the works by A. M. Vershik (and his school) [i–iv] quoted below:

[i] A. Vershik and A. Schmidt, *Symmetric groups of higher degree*, Soviet Math. Dokl. **206** (1972), 269–272.

[ii] A. Vershik and A. Schmidt, *Limit measures that arise in the asymptotics of symmetric groups, I, II*, Theoret. Veroyatn. i Prim. **22** (1977), 72–88; **23** (1978), 42–54.

[iii] A. Vershik, *Asymptotic distribution of decompositions of natural numbers into prime divisors*, Soviet Math. Dokl. **289** (1986), 269–272.

[iv] A. Vershik, *Asymptotic combinatorics and algebraic analysis*, Proceedings Internat. Congr. Math., Zürich, Switzerland, 1994, vol. 2, Birkhäuser-Verlag, Basel, Switzerland, 1995, pp. 1383–1394.

The authors are wrong in attributing on pages 903–5 the results on the asymptotic distributions of normalized length of cycles of random permutations to [29, 7, 9] (their references) and others. The strongest and deepest results in this direction were announced in 1972 in [i], and the proof was published in two papers [ii].

I know that Vershik's ideas in this area were very fresh and were accepted by many mathematicians with enthusiasm and used by many others. In a sense Vershik has developed the pioneering ideas of the 1940s of a Russian mathematician, V. Goncharoff (who also is not quoted in the *Notices* article). Vershik thus called the crucial functional equation which he obtained "the Dickman-Goncharov equation".

Later Vershik found the link between that problem and the statistics of the prime factorization [iv]. The joint distribution of the prime divisors was found in the previous papers (unknown to Vershik), but the coincidence of the two statistics was mentioned first not in [1] as the authors have claimed but in [iii]. In his invited talk at ICM 94 in Zürich [iv] Vershik gave a survey on this and related topics and further references.

The results and papers of Vershik were undoubtedly known to the authors of the *Notices* paper.

The present situation is not the first case of the—I would say irresponsible—attitude of Western (especially American) mathematicians toward their helpless Russian colleagues. I have the impression that a segment of the Western mathematical community accepts the attitude of those mathematicians who quote results and ideas only of people who might invite them to their university (institution, conference, Congress, Prize) or might become the reviewers of their works for publication or might be useful in job hunting.

Since Russians have no money to pay them and are unlikely reviewers, it is safe not to quote Russians at all. In other domains of science and technology there exists a legal system of punishment for thieves (patents systems, courts, ...). In mathematics it is too easy to make a reputation just by repeating classical Russian results and by publicizing them under wrong names. I might list dozens of cases like the one provided by the disastrous *Notices* article.

People are still stealing the results of, say, my teachers, like Andronov, Kolmogorov, Pontryagin, Petrovskii, as well as those of my students (being, it seems, afraid to steal my own results, however).

I think that the main reason for this attitude is the tradition of an unfortunate tolerance of the mathematical community, especially in the USA, toward the unethical conduct of its members. If everyone would loudly protest whenever he sees the wrong attribution (as I am doing now), people would find it profitable to quote the correct references rather than to propagate unfair publicity.

V. Arnold
Steklov Mathematical Institute
and Université de Paris, Dauphine

(Received January 11,1998)

Comments on Arnold's Letter

I am grateful to Professor V. I. Arnold for his observation about the article of my old colleagues R. Arratia, A. Barbour, and S. Tavaré. Indeed, it is too bad that the authors forgot to mention the papers by V. Goncharoff and by my coauthors and me that have contained serious results in the area, especially papers [ii, iii], of which they definitely had knowledge.

But I am not in agreement with the sharp criticisms and terms that Professor Arnold used. My impression is that unfortunately such a gap in memory is common in different communities and is an ordinary lapse that occurs very often with many of us worldwide. On the other hand, it is true that the situation with authors from Russia is special because of the former long period of an absence of contacts.

Anatoly Vershik
Mathematical Institute of Russian
Academy of Science,
St. Petersburg branch

(Received February 1, 1998)

Reply to Arnold Letter

In response to Arnold's letter, we wish to make the following points. First, the *Notices* articles are intended as an introduction to a topic rather than as reviews, and editorial policy is that references should be designed as pointers to the immediately relevant literature and not as exhaustive lists. We mention this explicitly in the text. Our theme is the unified view deriving from the conditioning property and the logarithmic asymptotics; Vershik's approach is quite different and as such is not central to our theme.

To Arnold's specific points. The Poisson-Dirichlet approximation for the large prime factors we attribute, correctly, to Billingsley (1972). For combinatorial structures, our interest is precisely in the fact that the Poisson-Dirichlet approximation holds for a huge class of structures and not just for isolated instances, for which we cite the appropriate reference, Hansen (1994). It would have been polite to have mentioned Vershik's theorem for uniformly distributed random permutations at this juncture, but hardly essential. The fact that this limiting structure is common to primes and combinatorial structures we attribute not to ourselves, but to Knuth and Trabb Pardo (1976), a reference ten years earlier than that quoted by Arnold.

There seems little point in discussing the remainder of Arnold's letter. We should, however, mention that Vershik has been an honoured guest, not only in Zürich, but also at the University of Southern California, as have innumerable other Russian mathematicians. Also, that incorrect attribution does not work exclusively against Russians, as evidenced by continuing reference to that most useful and widely quoted probability inequality as Chebyshev's.

Richard Arratia, Andrew Barbour, Simon Tavaré
University of Southern California, University of Zürich, University of Southern California, respectively

(Received February 11, 1998)

How to Teach Limits and Continuity

In recent issues of the *Notices* (May 1997, pp. 559-563; September 1997, pp. 893 and 932-934; and January 1998, p. 6) there are interesting letters of David Mumford, Saunders Mac Lane, Leonard Gillman, and Peter D. Lax about ways of teaching limits, continuity, and uniform continuity. But I believe that the authors do not point their fingers at the root of the difficulty and how to overcome it.

The difficulty, I believe, comes from the fact that quantifiers constitute an advanced linguistic tool whose goal is to avoid the introduction of ad hoc names and symbols. The students whom we teach are not sufficiently used to this tool, and hence they find it difficult to overcome this linguistic barrier.

As always, the solution is to explain to the students what we have in mind. Thus when we claim that $a_n \to a$, we mean that we have a function $N(\epsilon)$ from positive reals to positive integers, such that

$$(*) \quad n > N(\epsilon) \text{ implies } |a_n - a| < \epsilon.$$

When we say that f is continuous, we mean that we have a function $\delta(x, \epsilon)$, where x is any element in the domain of f and ϵ is any positive real, such that

$$(**) \quad |x - y| < \delta(x, \epsilon) \text{ implies } |f(x) - f(y)| < \epsilon.$$

After all, the only way to prove $a_n \to a$ or to prove that f is continuous is to build the appropriate functions $N(\epsilon)$ or $\delta(x, \epsilon)$ respectively and to prove (*) or (**) for those functions. And I believe that a student who is not able to prove that, say, $1/n^{1/2} \to 0$ or that $x^{1/2}$ is continuous does not understand convergence or continuity. On the other hand, a student who is able to prove a few theorems of that kind does understand those concepts.

One final remark: A naive interpretation of quantifiers accepts Platonism or physicalism, namely, a Platonic or a physical existence of all the elements of the domains to which the quantifiers are referring. Operations such as $N(\epsilon)$ and $\delta(x, \epsilon)$, which are called Skolem functions, justify the use of quantifiers without forcing us to accept Platonism or physicalism. Indeed, we construct those operations in our brains, but we do not (and cannot) build all the elements of their domains or ranges, since, as a rule, those sets are too large. Thus quantifiers are mere abbreviations by means of which we can avoid (but not always) naming or denoting some Skolem functions.

Jan Mycielski
University of Colorado

(Received February 2, 1998)

Keep Young Scholars Programs Running

The NSF's decision to cut the funding for the Young Scholars program ("The Demise of the Young Scholars Program", *Notices*, March 1998) is a tragic mistake. The total cost of these programs, \$10 million a year, is relatively small, yet the potential benefit to society is enormous. The argument that "these students are already highly talented and motivated and such programs simply add to their advantages" badly misses the mark. In fact, many of these youngsters are intellectually and socially isolated in their school environments, and it is by no means certain that they will, without help, fulfill their potential. These programs affirm that what they are interested in is worthwhile and valued and not merely "weird". My daughter, Lenore, who is a mathematician, was in David Kelly's fine program at Hampshire, and I am by no means certain that she would be in our profession if it weren't for that experience.

If NSF funding cannot be restored, other sources should be pursued. (Bill Gates, are you listening?) Also, those of us who can afford to do so should contemplate making donations to those programs which are still in existence. It is money well spent!

Robert Cowen
Queens College, C.U.N.Y.

(Received February 13, 1998)

AMERICAN MATHEMATICAL SOCIETY

Announcing searches for

TWO ASSOCIATE SECRETARIES

of the American Mathematical Society

Positions

The American Mathematical Society is seeking applications and nominations for candidates for two positions: Associate Secretary of the Southeastern Section and Associate Secretary of the Western Section. Robert Daverman, currently Associate Secretary of the Southeastern Section, has been elected Secretary and will assume that office on 01 February 1999. William Harris, Associate Secretary of the Western Section, passed away suddenly in early January.

An Associate Secretary is an officer of the Society and is appointed by the Council to a two-year term, beginning on 01 February. In the case of the Associate Secretary for the Southeastern Section, the term would begin on 01 February 1999. In the case of the Associate Secretary of the Western Section, the term would begin immediately and end on 31 January 2000. Reappointments are possible and desirable. All necessary expenses incurred by an Associate Secretary in performance of duties for the Society are reimbursed, including travel and communications.

Duties

The primary responsibility of an Associate Secretary is to oversee scientific meetings of the Society in the section. Once every four years an Associate Secretary has primary responsibility for the Society's Annual Meetings program at the January Joint Mathematics Meeting. An Associate Secretary is a member of the Secretariat, a committee consisting of all Associate Secretaries and the Secretary. The Secretariat approves all applications for membership in the Society and approves all sites and dates of meetings of the Society. Frequently an Associate Secretary is in charge of an international joint meeting. Associate Secretaries are the principal contact between the Society and its members in the various sections. They are invited to all Council meetings and have a vote on the Council on a revolving basis.

Applications

An Associate Secretary is appointed by the Council upon recommendation by the Executive Committee and Board of Trustees. Applications and nominations should be sent to: Professor Robert M. Fossum, Secretary, American Mathematical Society, Department of Mathematics, University of Illinois, 1409 W. Green Street, Urbana, IL 61801-2975, e-mail: `r-fossum@uiuc.edu`.

Applications received by 30 April 1998 will be assured full consideration.

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A Guide to Entropy and the Second Law of Thermodynamics

Elliott H. Lieb and Jakob Yngvason

This article is intended for readers who, like us, were told that the second law of thermodynamics is one of the major achievements of the nineteenth century—that it is a logical, perfect, and unbreakable law—but who were unsatisfied with the "derivations" of the entropy principle as found in textbooks and in popular writings.

A glance at the books will inform the reader that the law has "various formulations" (which is a bit odd, as if to say the Ten Commandments have various formulations), but they all lead to the existence of an entropy function whose reason for existence is to tell us which processes can occur and which cannot. We shall abuse language (or reformulate it) by referring to the existence of entropy as *the* second law. This, at least, is unambiguous. The entropy we are talking about is that defined by thermodynamics (and *not* some analytic quantity, usually involving expressions such as $-p \ln p$, that appears in information theory, probability theory, and statistical mechanical models).

There are three laws of thermodynamics (plus one more, due to Nernst, which is mainly used in low-temperature physics and is not immutable—as are the others). In brief, these are:

The Zeroth Law, which expresses the transitivity of thermal equilibrium and which is often said to imply the existence of temperature as a parametrization of equilibrium states. We use it below but formulate it without mentioning temperature. In fact, temperature makes no appearance here until almost the very end.

The First Law, which is conservation of energy. It is a concept from mechanics and provides the connection between mechanics (and things like falling weights) and thermodynamics. We discuss this later on when we introduce simple systems; the crucial usage of this law is that it allows energy to be used as one of the parameters describing the states of a simple system.

The Second Law. Three popular formulations of this law are:

> *Clausius:* No process is possible, the sole result of which is that heat is transferred from a body to a hotter one.
>
> *Kelvin (and Planck):* No process is possible, the sole result of which is that a body is cooled and work is done.
>
> *Carathéodory:* In any neighborhood of any state there are states that cannot be reached from it by an adiabatic process.

All three formulations are supposed to lead to the entropy principle (defined below). These steps can be found in many books and will not be trod-

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den again here. Let us note in passing, however, that the first two use concepts such as hot, cold, heat, cool that are intuitive but have to be made precise before the statements are truly meaningful. No one has seen "heat", for example. The last (which uses the term "adiabatic process", to be defined below) presupposes some kind of parametrization of states by points in $\mathbf{R}^n$, and the usual derivation of entropy from it assumes some sort of differentiability; such assumptions are beside the point as far as understanding the meaning of entropy goes.

Why, one might ask, should a mathematician be interested in this matter, which historically had something to do with attempts to understand and improve the efficiency of steam engines? The answer, as we perceive it, is that the law is really an interesting mathematical theorem about an ordering on a set, with profound physical implications. The axioms that constitute this ordering are somewhat peculiar from the mathematical point of view and might not arise in the ordinary ruminations of abstract thought. They are special but important, and they are driven by considerations about the world, which is what makes them so interesting. Maybe an ingenious reader will find an application of this same logical structure to another field of science.

The basic input in our analysis is a certain kind of ordering on a set, and denoted by

$$\prec$$

(pronounced "precedes"). It is transitive and reflexive, as in A1, A2 below, but $X \prec Y$ and $Y \prec X$ do not imply $X = Y$, so it is a "preorder". The big question is whether $\prec$ can be encoded in an ordinary, real-valued function, denoted by S, on the set, such that if X and Y are related by $\prec$, then $S(X) \leq S(Y)$ if and only if $X \prec Y$. The function S is also required to be additive and extensive in a sense that will soon be made precise.

A helpful analogy is the question: When can a vector-field, $V(x)$, on $\mathbf{R}^3$ be encoded in an ordinary function, $f(x)$, whose gradient is V? The well-known answer is that a necessary and sufficient condition is that $\operatorname{curl} V = 0$. Once V is observed to have this property, one thing becomes evident and important: it is necessary to measure the integral of V only along some curves—not all curves—in order to deduce the integral along *all* curves. The encoding then has enormous predictive power about the nature of future measurements of V. In the same way, knowledge of the function S has enormous predictive power in the hands of chemists, engineers, and others concerned with the ways of the physical world.

Our concern will be the existence and properties of S, starting from certain natural axioms about the relation $\prec$. We present our results without proofs, but full details and a discussion of related previous work on the foundations of classical thermodynamics are given in [7]. The literature on this subject is extensive, and it is not possible to give even a brief account of it here, except for mentioning that the previous work closest to ours is that of [6] and [2] (see also [4], [5], and [9]). These other approaches are also based on an investigation of the relation $\prec$, but the overlap with our work is only partial. In fact, a major part of our work is the derivation of a certain property (the "comparison hypothesis" below), which is taken as an axiom in the other approaches. It was a remarkable and largely unsung achievement of Giles [6] to realize the full power of this property.

Let us begin the story with some basic concepts.

1. *Thermodynamic system:* Physically this consists of certain specified amounts of certain kinds of matter, e.g., a gram of hydrogen in a container with a piston, or a gram of hydrogen and a gram of oxygen in two separate containers, or a gram of hydrogen and two grams of hydrogen in separate containers. The system can be in various states which, physically, are *equilibrium states.* The space of states of the system is usually denoted by a symbol such as Γ and states in Γ by X, Y, Z, etc.

Physical motivation aside, a state-space, mathematically, is just a set to begin with; later on we will be interested in embedding state-spaces in some convex subset of some $\mathbf{R}^{n+1}$; i.e., we will introduce coordinates. As we said earlier, however, the entropy principle is quite independent of coordinatization, Carathéodory's principle notwithstanding.

2. *Composition and scaling of states:* The notion of Cartesian product, $\Gamma_1 \times \Gamma_2$, corresponds simply to the two (or more) systems being side by side on the laboratory table; mathematically it is just another system (called a *compound system*), and we regard the state-space $\Gamma_1 \times \Gamma_2$ as being the same as $\Gamma_2 \times \Gamma_1$. Points in $\Gamma_1 \times \Gamma_2$ are denoted by pairs (X, Y), as usual. The subsystems comprising a compound system are physically independent systems, but they are allowed to interact with each other for a period of time and thereby to alter each other's state.

   The concept of scaling is crucial. It is this concept that makes our thermodynamics inappropriate for microscopic objects like atoms or cosmic objects like stars. For each state-space Γ and number $\lambda > 0$ there is another state-space, denoted by $\Gamma^{(\lambda)}$, with points denoted by λX. This space is called a *scaled copy* of Γ. Of course we identify $\Gamma^{(1)} = \Gamma$ and $1X = X$. We also require $(\Gamma^{(\lambda)})^{(\mu)} = \Gamma^{(\lambda\mu)}$ and $\mu(\lambda X) = (\mu\lambda)X$. The physical interpretation of $\Gamma^{(\lambda)}$ when Γ is the space of one gram of hydrogen is simply the state-space of λ grams of hydrogen. The state λX is the state of λ grams of hydrogen with the same "intensive" properties as X, e.g., pressure, while "extensive" properties like energy, volume, etc., are scaled by a factor λ (by definition).

For any given Γ we can form Cartesian product state-spaces of the type $\Gamma^{(\lambda_1)} \times \Gamma^{(\lambda_2)} \times \cdots \times \Gamma^{(\lambda_N)}$. These will be called *multiple-scaled copies* of Γ.

The notation $\Gamma^{(\lambda)}$ should be regarded as merely a mnemonic at this point, but later on, with the embedding of Γ into $\mathbf{R}^{n+1}$, it will literally be $\lambda\Gamma = \{\lambda X : X \in \Gamma\}$ in the usual sense.

3. *Adiabatic accessibility:* Now we come to the ordering. We say $X \prec Y$ (with X and Y possibly in *different* state-spaces) if there is an *adiabatic process* that transforms X into Y.

What does this mean? Mathematically, we are just given a list of pairs $X \prec Y$. There is nothing more to be said, except that later on we will assume that this list has certain properties that will lead to interesting theorems about this list and will lead, in turn, to the existence of an *entropy function*, S, characterizing the list.

The physical interpretation is quite another matter. In textbooks a process is usually called adiabatic if it takes place in "thermal isolation", which in turn means that "no heat is exchanged with the surroundings". Such statements appear neither sufficiently general nor precise to us, and we prefer the following version (which is in the spirit of Planck's formulation of the second law [8]). It has the great virtue (as discovered by Planck) that it avoids having to distinguish between work and heat—or even having to define the concept of heat. We emphasize, however, that the theorems do not require agreement with our physical definition of adiabatic process; other definitions are conceivably possible.

> *A state Y is adiabatically accessible from a state X, in symbols $X \prec Y$, if it is possible to change the state from X to Y by means of an interaction with some device consisting of some auxiliary system and a weight in such a way that the auxiliary system returns to its initial state at the end of the process, whereas the weight may have risen or fallen.*

The role of the "weight" in this definition is merely to provide a particularly simple source (or sink) of mechanical energy. Note that an adiabatic process, physically, does not have to be gentle, or "static" or anything of the kind. It can be arbitrarily violent! (See Figure 1.)

An example might be useful here. Take a pound of hydrogen in a container with a piston. The states are describable by two numbers, energy and volume, the latter being determined by the position of the piston. Starting from some state X, we can take our hand off the piston and let the volume increase explosively to a larger one. After things have calmed down, call the new equilibrium state Y. Then $X \prec Y$. Question: Is $Y \prec X$ true? Answer: No. To get from Y to X we would have to use some machinery and a weight, with the machinery returning to its initial state, and there is no way this can be done. Using a weight, we can indeed recompress the gas to its original volume, but we will find that the energy is then larger than its original value.

On the other hand, we could let the piston expand very, very slowly by letting it raise a carefully calibrated weight. No other machinery is involved. In this case, we can reverse the process (to within an arbitrarily good accuracy) by adding a tiny bit to the weight, which will then slowly push the piston back. Thus, we could have (in principle, at least) both $X \prec Y$ and $Y \prec X$, and we would call such a process a *reversible adiabatic process.*

Let us write

$$X \prec\prec Y \quad \text{if} \quad X \prec Y$$

but not

$$Y \prec X \quad \text{(written } Y \not\prec X\text{)}.$$

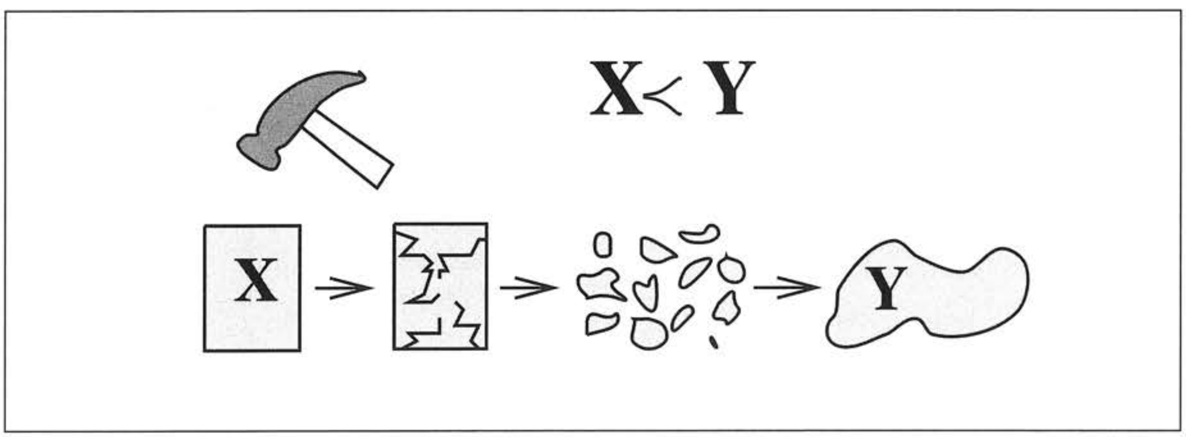

Figure 1. A violent adiabatic process connecting equilibrium states *X* and *Y*.

In this case we say that we can go from X to Y by an *irreversible adiabatic process.* If $X \prec Y$ and $Y \prec X$ (i.e., X and Y are connected by a reversible adiabatic process), we say that X and Y are *adiabatically equivalent* and write

$$X \overset{A}{\sim} Y.$$

Equivalence classes under $\overset{A}{\sim}$ are called *adiabats.*

4. *Comparability:* Given two states X and Y in two (same or different) state-spaces, we say that they are comparable if $X \prec Y$ or $Y \prec X$ (or both). This turns out to be a crucial notion. Two states are not always comparable; a necessary condition is that they have the same material composition in terms of the chemical elements. Example: Since water is H_2O and the atomic weights of hydrogen and oxygen are 1 and 16 respectively, the states in the compound system of 2 grams of hydrogen and 16 grams of oxygen are comparable with states in a system consisting of 18 grams of water (but not with 11 grams of water or 18 grams of oxygen).

Actually, the classification of states into various state-spaces is done mainly for conceptual convenience. The second law deals only with states, and the only thing we really have to know about any two of them is whether or not they are comparable. Given the relation $\prec$ for all possible states of all possible systems, we can ask whether this relation can be encoded in an entropy function according to the following:

Entropy principle: *There is a real-valued function on all states of all systems (including compound systems) called* **entropy**, *denoted by S, such that*

a) Monotonicity: *When X and Y are comparable states, then*

$$(1) \qquad X \prec Y \quad \text{if and only if} \quad S(X) \leq S(Y)\,.$$

b) Additivity and extensivity: *If X and Y are states of some (possibly different) systems and if (X, Y) denotes the corresponding state in the compound system, then the entropy is additive for these states; i.e.,*

$$(2) \qquad S(X, Y) = S(X) + S(Y)\,.$$

S is also extensive; i.e., for each $\lambda > 0$ and each state X and its scaled copy $\lambda X \in \Gamma^{(\lambda)}$ (defined in 2, above)

$$(3) \qquad S(\lambda X) = \lambda S(X)\,.$$

A formulation logically equivalent to (a), not using the word "comparable", is the following pair of statements:

$$(4) \qquad \begin{aligned} &X \overset{A}{\sim} Y \Longrightarrow S(X) = S(Y) \quad \text{and} \\ &X \prec\prec Y \Longrightarrow S(X) < S(Y). \end{aligned}$$

The last line is especially noteworthy. It says that entropy must increase in an irreversible adiabatic process.

The additivity of entropy in compound systems is often just taken for granted, but it is one of the startling conclusions of thermodynamics. First of all, the content of additivity, (2), is considerably more far-reaching than one might think from the simplicity of the notation. Consider four states, X, X', Y, Y', and suppose that $X \prec Y$ and $X' \prec Y'$. One of our axioms, A3, will be that then $(X, X') \prec (Y, Y')$, and (2) contains nothing new or exciting. On the other hand, the compound system can well have an adiabatic process in which $(X, X') \prec (Y, Y')$ but $X \not\prec Y$. In this case, (2) conveys much information. Indeed, by monotonicity there will be many cases of this kind, because the inequality $S(X) + S(X') \leq S(Y) + S(Y')$ certainly does not imply that $S(X) \leq S(Y)$. The fact that the inequality $S(X) + S(X') \leq S(Y) + S(Y')$ tells us *exactly* which adiabatic processes are allowed in the compound system (among comparable states), independent of any detailed knowledge of the manner in which the two systems interact, is astonishing and is at the *heart of thermodynamics.* The second reason that (2) is startling is this: From (1) alone, restricted to one system, the function S can be replaced by $29S$ and still do its job, i.e., satisfy (1). However, (2) says that it is possible to calibrate the entropies of all systems (i.e., simultaneously adjust all the undetermined multiplicative constants) so that the entropy $S_{1,2}$ for a compound $\Gamma_1 \times \Gamma_2$ is $S_{1,2}(X, Y) = S_1(X) + S_2(Y)$, even though systems 1 and 2 are totally unrelated!

We are now ready to ask some basic questions.

Q1: Which properties of the relation $\prec$ ensure existence and (essential) uniqueness of S?

Q2: Can these properties be derived from simple physical premises?

Q3: Which convexity and smoothness properties of S follow from the premises?

Q4: Can temperature (and hence an ordering of states by "hotness" and "coldness") be defined from S, and what are its properties?

The answer to question Q1 can be given in the form of six axioms that are reasonable, simple, "obvious", and unexceptionable. An additional, crucial assumption is also needed, but we call it a hypothesis instead of an axiom because we show later how it can be derived from some other axioms, thereby answering question Q2.

A1. Reflexivity. $X \overset{A}{\sim} X$.

A2. Transitivity. If $X \prec Y$ and $Y \prec Z$, then $X \prec Z$.

A3. Consistency. If $X \prec X'$ and $Y \prec Y'$, then $(X, Y) \prec (X', Y')$.

A4. Scaling Invariance. If $\lambda > 0$ and $X \prec Y$, then $\lambda X \prec \lambda Y$.

A5. Splitting and Recombination. $X \overset{A}{\sim}$

$((1-\lambda)X, \lambda X)$ for all $0 < \lambda < 1$. Note that the state-spaces are not the same on both sides. If $X \in \Gamma$, then the state-space on the right side is $\Gamma^{(1-\lambda)} \times \Gamma^{(\lambda)}$.

A6. Stability. If $(X, \varepsilon Z_0) \prec (Y, \varepsilon Z_1)$ for some Z_0, Z_1, and a sequence of ε's tending to zero, then $X \prec Y$. This axiom is a substitute for continuity, which we cannot assume because there is no topology yet. It says that "a grain of dust cannot influence the set of adiabatic processes".

An important lemma is that (A1)–(A6) imply the *cancellation law*, which is used in many proofs. It says that for any three states X, Y, Z

$$(5) \qquad (X, Z) \prec (Y, Z) \implies X \prec Y .$$

The next concept plays a key role in our treatment.

CH. Definition: We say that the *Comparison Hypothesis* (CH) holds for a state-space Γ if all pairs of states in Γ are comparable.

Note that A3, A4, and A5 automatically extend comparability from a space Γ to certain other cases; e.g., $X \prec ((1-\lambda)Y, \lambda Z)$ for all $0 \le \lambda \le 1$ if $X \prec Y$ and $X \prec Z$. On the other hand, comparability on Γ alone does not allow us to conclude that X is comparable to $((1-\lambda)Y, \lambda Z)$ if $X \prec Y$ but $Z \prec X$. For this, one needs CH on the product space $\Gamma^{(1-\lambda)} \times \Gamma^{(\lambda)}$, which is not implied by CH on Γ.

The significance of A1–A6 and CH is borne out by the following theorem:

Theorem 1 (Equivalence of entropy and A1–A6, given CH). *The following are equivalent for a state-space Γ:*

i) The relation $\prec$ between states in (possibly different) multiple-scaled copies of Γ, e.g., $\Gamma^{(\lambda_1)} \times \Gamma^{(\lambda_2)} \times \cdots \times \Gamma^{(\lambda_N)}$, is characterized by an entropy function, S, on Γ in the sense that

$$(6) \qquad (\lambda_1 X_1, \lambda_2 X_2, \ldots) \prec (\lambda_1' X_1', \lambda_2' X_2', \ldots)$$

is equivalent to the condition that

$$(7) \qquad \sum_i \lambda_i S(X_i) \le \sum_j \lambda_j' S(X_j')$$

whenever

$$(8) \qquad \sum_i \lambda_i = \sum_j \lambda_j'.$$

ii) The relation $\prec$ satisfies conditions (A1)–(A6), and (CH) holds for every multiple-scaled copy of Γ.

This entropy function on Γ is unique up to affine equivalence; i.e., $S(X) \to aS(X) + B$, with $a > 0$.

That (i) $\implies$ (ii) is obvious. The proof of (ii) $\implies$ (i) is carried out by an explicit construction of the entropy function on Γ, reminiscent of an old definition of heat by Laplace and Lavoisier in terms of the amount of ice that a body can melt.

Basic Construction of S (Figure 2): Pick two reference points X_0 and X_1 in Γ with $X_0 \prec\prec X_1$. (If such points do not exist, then S is the constant function.) Then define for $X \in \Gamma$

$$(9) \qquad S(X) := \sup\{\lambda : ((1-\lambda)X_0, \lambda X_1) \prec X\}.$$

Remarks: As in axiom A5, two state-spaces are involved in (9). By axiom A5, $X \overset{A}{\sim} ((1-\lambda)X, \lambda X)$, and hence, by CH in the space $\Gamma^{(1-\lambda)} \times \Gamma^{(\lambda)}$, X is comparable to $((1-\lambda)X_0, \lambda X_1)$. In (9) we allow $\lambda \le 0$ and $\lambda \ge 1$ by using the convention that $(X, -Y) \prec Z$ means that $X \prec (Y, Z)$ and $(X, 0Y) = X$. For (9) we need to know only that CH holds in twofold scaled products of Γ with itself. CH will then automatically be true for all products. In (9) the reference points X_0, X_1 are fixed and the supremum is over λ. One can ask how S changes if we change the two points X_0, X_1. The answer is that the change is affine; i.e., $S(X) \to aS(X) + B$, with $a > 0$.

Theorem 1 extends to products of multiple-scaled copies of different systems, i.e., to general *compound* systems. This extension is an immediate consequence of the following theorem, which is proved by applying Theorem 1 to the product of the system under consideration with some standard reference system.

Theorem 2 (Consistent entropy scales). *Assume that CH holds for all compound systems. For each system Γ let S_Γ be some definite entropy function on Γ in the sense of Theorem 1. Then there are constants a_Γ and $B(\Gamma)$ such that the function S, defined for all states of all systems by*

$$(10) \qquad S(X) = a_\Gamma S_\Gamma(X) + B(\Gamma)$$

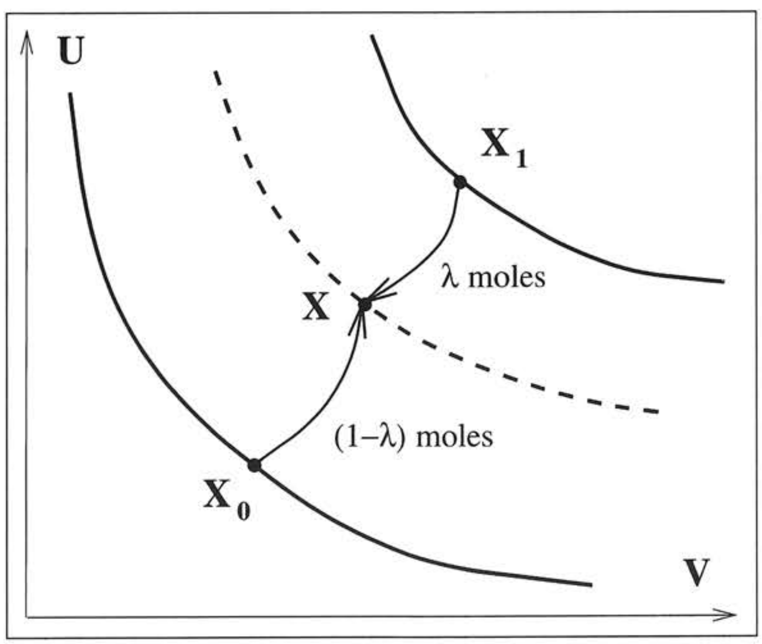

Figure 2. The entropy of X is determined by the largest amount of X_1 that can be transformed adiabatically into X, with the help of X_0.

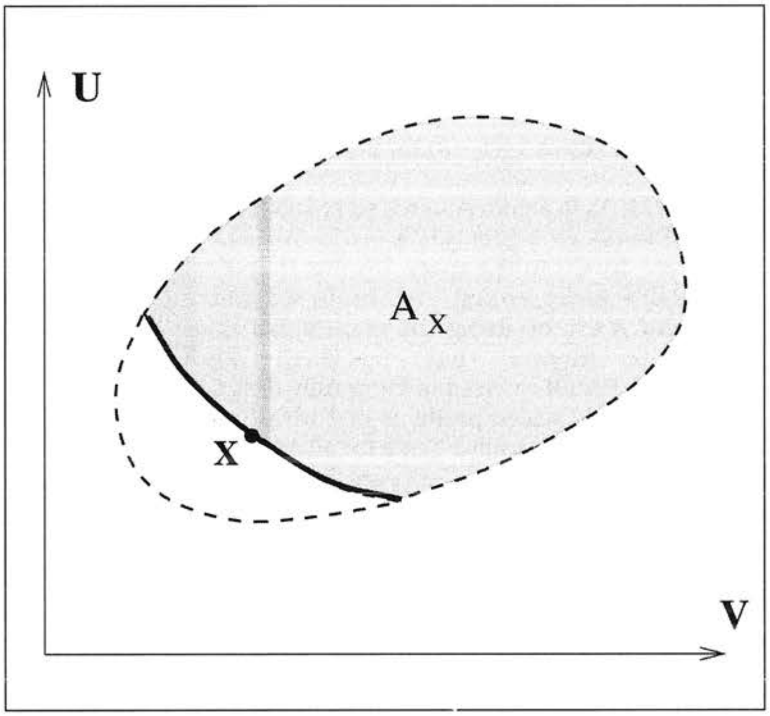

Figure 3. The coordinates U and V of a simple system. The state-space (bounded by dashed line) and the forward sector A_X (shaded) of a state X are convex, by axiom A7. The boundary of A_X (full line) is an adiabat.

for $X \in \Gamma$, satisfies additivity (2), extensivity (3), and monotonicity (1) in the sense that whenever X and Y are in the same state-space, then

$$(11) \qquad X \prec Y \quad \text{if and only if} \quad S(X) \leq S(Y).$$

Theorem 2 is what we need, except for the question of mixing and chemical reactions, which is treated at the end and which can be put aside at a first reading. In other words, as long as we do not consider adiabatic processes in which systems are converted into each other (e.g., a compound system consisting of a vessel of hydrogen and a vessel of oxygen is converted into a vessel of water), the entropy principle has been verified. If that is so, what remains to be done? the reader may justifiably ask. The answer is twofold: First, Theorem 2 requires that CH hold for *all* systems, and we are not content to take this as an axiom. Second, important notions of thermodynamics such as "thermal equilibrium" (which will eventually lead to a precise definition of temperature) have not appeared so far. We shall see that these two points (i.e., thermal equilibrium and CH) are not unrelated.

As for CH, other authors—[6], [2], [4], and [9]—essentially *postulate* that it holds for all systems by making it axiomatic that comparable states fall into equivalence classes. (This means that the conditions $X \prec Z$ and $Y \prec Z$ always imply that X and Y are comparable; likewise, they must be comparable if $Z \prec X$ and $Z \prec Y$). By identifying a state-space with an equivalence class, the comparison hypothesis then holds in these other approaches *by assumption* for all state-spaces. We, in contrast, would like to derive CH from something that we consider more basic. Two ingredients will be needed: the analysis of certain special but commonplace systems called "simple systems" and some assumptions about thermal contact (the "zeroth law") that will act as a kind of glue holding the parts of a compound system in harmony with each other. The simple systems are the building blocks of thermodynamics; all systems we consider are compounds of them.

Simple Systems

A **Simple System** is one whose state-space can be identified with some open convex subset of some $\mathbf{R}^{n+1}$ with a distinguished coordinate denoted by U, called the *energy*, and additional coordinates $V \in \mathbf{R}^n$, called *work coordinates*. The energy coordinate is the way in which thermodynamics makes contact with mechanics, where the concept of energy arises and is precisely defined. The fact that the amount of energy in a state is independent of the manner in which the state was arrived at is, in reality, the first law of thermodynamics. A typical (and often the only) work coordinate is the volume of a fluid or gas (controlled by a piston); other examples are deformation coordinates of a solid or magnetization of a paramagnetic substance.

Our goal is to show, with the addition of a few more axioms, that CH holds for simple systems and their scaled products. In the process we will introduce more structure, which will capture the intuitive notions of thermodynamics; thermal equilibrium is one.

First, there is an axiom about convexity:

A7. Convex combination. If X and Y are states of a simple system and $t \in [0, 1]$, then

$$(tX, (1-t)Y) \prec tX + (1-t)Y,$$

in the sense of ordinary convex addition of points in $\mathbf{R}^{n+1}$. A straightforward consequence of this axiom (and A5) is that the **forward sectors** (Figure 3)

$$(12) \qquad A_X := \{Y \in \Gamma : X \prec Y\}$$

of states X in a simple system Γ are *convex* sets.

Another consequence is a connection between the existence of irreversible processes and Carathéodory's principle [3, 1] mentioned above.

Lemma 1. *Assume (A1)–(A7) for $\Gamma \subset R^{n+1}$ and consider the following statements:*

a) Existence of irreversible processes: For every $X \in \Gamma$ there is a $Y \in \Gamma$ with $X \prec\prec Y$.

b) Carathéodory's principle: In every neighborhood of every $X \in \Gamma$ there is a $Z \in \Gamma$ with $X \not\prec Z$.

Then (a) $\Longrightarrow$ (b) always. If the forward sectors in Γ have interior points, then (b) $\Longrightarrow$ (a).

We need three more axioms for simple systems, which will take us into an analytic detour. The first of these establishes (a) above.

A8. Irreversibility. For each $X \in \Gamma$ there is a point $Y \in \Gamma$ such that $X \prec\prec Y$. (This axiom is implied by A14, below, but is stated here separately because important conclusions can be drawn from it alone.)

A9. Lipschitz tangent planes. For each $X \in \Gamma$ the *forward sector* $A_X = \{Y \in \Gamma : X \prec Y\}$ has a *unique* support plane at X (i.e., A_X has a *tangent plane* at X). The tangent plane is assumed to be a *locally Lipschitz continuous* function of X, in the sense explained below.

A10. Connectedness of the boundary. The boundary ∂A_X (relative to the open set Γ) of every forward sector $A_X \subset \Gamma$ is connected. (This is technical and conceivably can be replaced by something else.)

Axiom A8 plus Lemma 1 asserts that every X lies on the boundary ∂A_X of its forward sector. Although axiom A9 asserts that the convex set A_X has a true tangent at X only, it is an easy consequence of axiom A2 that A_X has a true tangent everywhere on its boundary. To say that this tangent plane is locally Lipschitz continuous means that if $X = (U^0, V^0)$, then this plane is given by

(13) $$U - U^0 + \sum_1^n P_i(X)(V_i - V_i^0) = 0$$

with locally Lipschitz continuous functions P_i. The function P_i is called the generalized *pressure* conjugate to the work coordinate V_i. (When V_i is the volume, P_i is the ordinary pressure.)

Lipschitz continuity and connectedness are well known to guarantee that the coupled differential equations

(14) $$\frac{\partial U}{\partial V_j}(V) = -P_j(U(V), V) \quad \text{for } j = 1, \dots, n$$

not only have a solution (since we know that the surface ∂A_X exists) but this solution must be unique. Thus, if $Y \in \partial A_X$, then $X \in \partial A_Y$. In short, the surfaces ∂A_X foliate the state-space Γ. What is less obvious but very important because it instantly gives us the comparison hypothesis for Γ is the following.

Theorem 3 (Forward sectors are nested). *If A_X and A_Y are two forward sectors in the state-space Γ of a simple system, then exactly one of the following holds.*

a) $A_X = A_Y$; i.e., $X \overset{A}{\sim} Y$.

b) $A_X \subset$ Interior (A_Y); i.e., $Y \prec\prec X$.

c) $A_Y \subset$ Interior (A_X); i.e., $X \prec\prec Y$.

It can also be shown from our axioms that the orientation of forward sectors with respect to the energy axis is the same for *all* simple systems. By convention we choose the direction of the energy axis so that the energy always *increases* in adiabatic processes at fixed work coordinates. When temperature is defined later, this will imply that temperature is always positive.

Theorem 3 implies that Y is on the boundary of A_X if and only if X is on the boundary of A_Y. Thus the adiabats, i.e., the $\overset{A}{\sim}$ equivalence classes, consist of these boundaries.

Before leaving the subject of simple systems let us remark on the connection with Carathéodory's development. The point of contact is the fact that $X \in \partial A_X$. We assume that A_X is convex and use transitivity and Lipschitz continuity to arrive even-

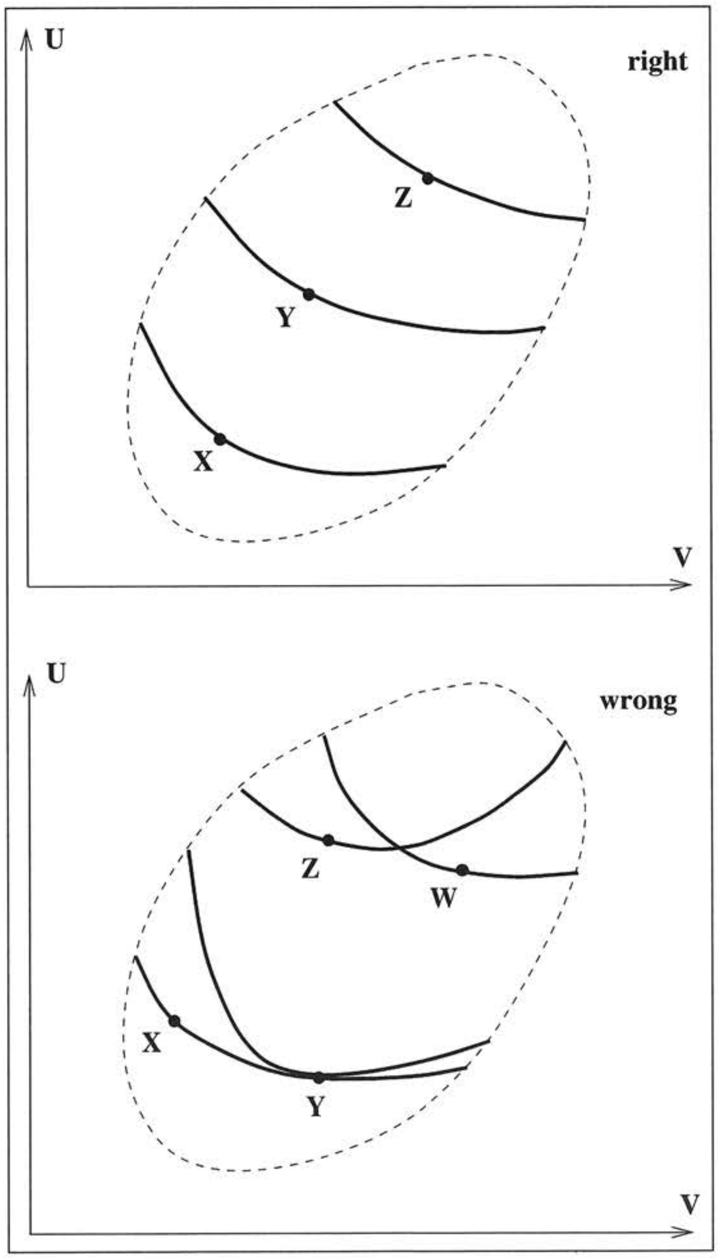

Figure 4. The forward sectors of a simple system are nested. The bottom figure shows what could, in principle, go wrong but does not.

tually at Theorem 3. Carathéodory uses Frobenius's theorem plus assumptions about differentiability to conclude the existence locally of a surface containing X. Important *global* information, such as Theorem 3, is then not easy to obtain without further assumptions, as discussed, e.g., in [1].

Thermal Contact

Thermal contact and the zeroth law entail the very special assumptions about $\prec$ that we mentioned earlier. It will enable us to establish CH for products of several systems and thereby show, via Theorem 2, that entropy exists and is additive. Although we have established CH for a simple system, Γ, we have not yet established CH even for a product of two copies of Γ. This is needed in the definition of S given in (9). The S in (9) is determined up to an affine shift, and we want to be able to calibrate the entropies (i.e., adjust the multiplicative and additive constants) of all systems so that they work together to form a global S satisfying the entropy principle. We need five more axioms. They might look a bit abstract, so a few words of introduction might be helpful.

In order to relate systems to each other in the hope of establishing CH for compounds and thereby an additive entropy function, some way must be found to put them into contact with each other. Heuristically we imagine two simple systems (the same or different) side by side and fix the work coordinates (e.g., the volume) of each. Connect them with a "copper thread", and wait for equilibrium to be established. The total energy U will not change, but the individual energies U_1 and U_2 will adjust to values that depend on U and the work coordinates. This new system (with the thread per-

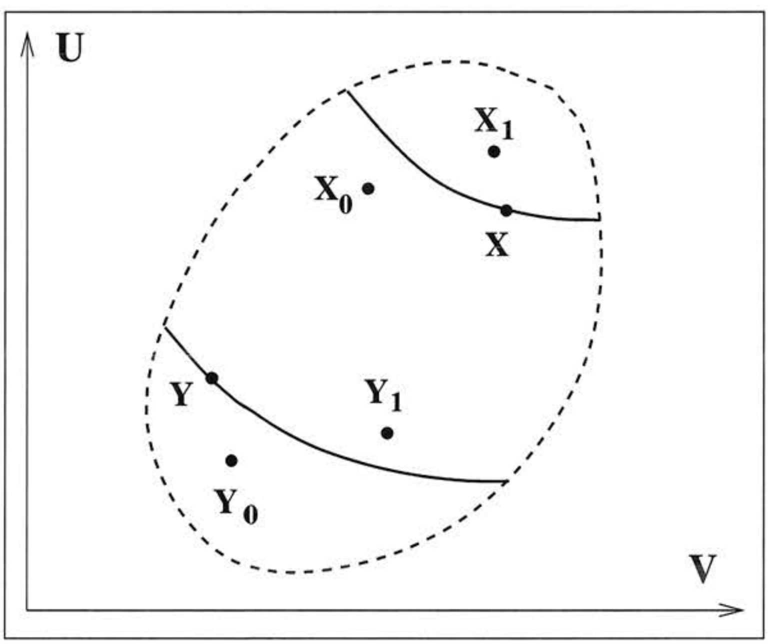

Figure 5. Transversality, A14, requires that each X have points on each side of its adiabat that are in thermal equilibrium.

manently connected) then behaves like a simple system (with one energy coordinate) but with several work coordinates (the union of the two work coordinates). Thus, if we start initially with $X_1 = (U_1, V_1)$ for system 1 and $X_2 = (U_2, V_2)$ for system 2 and if we end up with $X = (U, V_1, V_2)$ for the new system, we can say that $(X_1, X_2) \prec X$. This holds for every choice of U_1 and U_2 whose sum is U. Moreover, after thermal equilibrium is reached, the two systems can be disconnected, if we wish, to once more form a compound system, whose component parts we say are in thermal equilibrium. That this is transitive is the zeroth law.

Thus, we cannot only make compound systems consisting of independent subsystems (which can interact, but separate again), we can also make a new simple system out of two simple systems. To do this an energy coordinate has to disappear, and thermal contact does this for us. All of this is formalized in the following three axioms.

A11. Thermal contact. For any two simple systems with state-spaces Γ_1 and Γ_2 there is another *simple* system, called the *thermal join* of Γ_1 and Γ_2, with state-space

$$\Delta_{12} = \{(U, V_1, V_2) : U = U_1 + U_2 \text{ with } (U_1, V_1) \in \Gamma_1, (U_2, V_2) \in \Gamma_2\}. \tag{15}$$

Moreover,

$$\Gamma_1 \times \Gamma_2 \ni ((U_1, V_1),\ (U_2, V_2)) \prec (U_1 + U_2, V_1, V_2) \in \Delta_{12}. \tag{16}$$

A12. Thermal splitting. For any point $(U, V_1, V_2) \in \Delta_{12}$ there is at least one pair of states, $(U_1, V_1) \in \Gamma_1$, $(U_2, V_2)) \in \Gamma_2$, with $U = U_1 + U_2$, such that

$$(U, V_1, V_2) \overset{A}{\sim} ((U_1, V_1), (U_2, V_2)). \tag{17}$$

If $(U, V_1, V_2) \overset{A}{\sim} ((U_1, V_1), (U_2, V_2))$, we say that the states $X = (U_1, V_1)$ and $Y = (U_2, V_2))$ are in *thermal equilibrium* and write

$$X \overset{T}{\sim} Y.$$

A13. Zeroth law of thermodynamics. If $X \overset{T}{\sim} Y$ and if $Y \overset{T}{\sim} Z$, then $X \overset{T}{\sim} Z$.

A11 and A12 together say that for each choice of the individual work coordinates there is a way to divide up the energy U between the two systems in a stable manner. A12 is the stability statement, for it says that joining is reversible; i.e., once the equilibrium has been established, one can cut the copper thread and retrieve the two systems back again, but with a special partition of the energies.

This reversibility allows us to think of the thermal join, which is a simple system in its own right, as a special subset of the product system $\Gamma_1 \times \Gamma_2$, which we call the *thermal diagonal*. In particular, A12 allows us to prove easily that $X \overset{T}{\sim} \lambda X$ for all X and all $\lambda > 0$.

A13 is the famous zeroth law, which says that the thermal equilibrium is transitive and hence an equivalence relation. Often this law is taken to mean that the equivalence classes can be labeled by an "empirical" temperature, but we do not want to mention temperature at all at this point. It will appear later.

Two more axioms are needed.

A14 requires that for every adiabat (i.e., an equivalence class w.r.t. $\overset{A}{\sim}$) there exists at least one isotherm (i.e., an equivalence class w.r.t. $\overset{T}{\sim}$) containing points on both sides of the adiabat. Note that, for each given X, only two points in the entire state-space Γ are required to have the stated property. This assumption essentially prevents a state-space from breaking up into two pieces that do not communicate with each other. Without it, counterexamples to CH for compound systems can be constructed. A14 implies A8, but we listed A8 separately in order not to confuse the discussion of simple systems with thermal equilibrium.

A15 is technical and perhaps can be eliminated. Its physical motivation is that a sufficiently large copy of a system can act as a heat bath for other systems. When temperature is introduced later, A15 will have the meaning that all systems have the same temperature range. This postulate is needed if we want to be able to bring every system into thermal equilibrium with every other system.

A14. Transversality. If Γ is the state-space of a simple system and if $X \in \Gamma$, then there exist states $X_0 \overset{T}{\sim} X_1$ with $X_0 \prec\prec X \prec\prec X_1$.

A15. Universal temperature range. If Γ_1 and Γ_2 are state-spaces of simple systems, then, for every $X \in \Gamma_1$ and every V belonging to the projection of Γ_2 onto the space of its work coordinates, there is a $Y \in \Gamma_2$ with work coordinates V such that $X \overset{T}{\sim} Y$.

The reader should note that the concept "thermal contact" has appeared, but not temperature or hot and cold or anything resembling the Clausius or Kelvin-Planck formulations of the second law. Nevertheless, we come to the main achievement of our approach: *With these axioms we can establish CH for products of simple systems* (each of which satisfies CH, as we already know). First, the thermal join establishes CH for the (scaled) product of a simple system with itself. The basic idea here is that the points in the product that lie on the thermal diagonal are comparable, since points in a simple system are comparable. In particular, with X, X_0, X_1 as in A14, the states $((1-\lambda)X_0, \lambda X_1)$ and $((1-\lambda)X, \lambda X)$ can be regarded as states of the *same* simple system and are therefore comparable. *This is the key point needed for the construction of S, according to (9).* The importance of transversality is thus brought into focus.

With some more work we can establish CH for multiple-scaled copies of a simple system. Thus, we have established S within the context of one system and copies of the system, i.e., condition (ii) of Theorem 1. As long as we stay within such a group of systems there is no way to determine the unknown multiplicative or additive entropy constants. The next task is to show that the multiplicative constants can be adjusted to give a universal entropy valid for copies of *different* systems, i.e., to establish the hypothesis of Theorem 2. This is based on the following.

Lemma 2 (Existence of calibrators). *If Γ_1 and Γ_2 are simple systems, then there exist states $X_0, X_1 \in \Gamma_1$ and $Y_0, Y_1 \in \Gamma_2$ such that*

$$X_0 \prec\prec X_1 \quad \text{and} \quad Y_0 \prec\prec Y_1$$

and

$$(X_0, Y_1) \overset{A}{\sim} (X_1, Y_0).$$

The significance of Lemma 2 is that it allows us to fix the *multiplicative* constants by the condition

$$S_1(X_0) + S_2(Y_1) = S_1(X_1) + S_2(Y_0). \tag{18}$$

The proof of Lemma 2 is complicated and really uses all the axioms A1 to A14. With its aid we arrive at our chief goal, which is CH for compound systems.

Theorem 4 (Entropy principle in products of simple systems). *The comparison hypothesis CH is valid in arbitrary scaled products of simple systems. Hence, by Theorem 2, the relation $\prec$ among states in such state-spaces is characterized by an entropy function S. The entropy function is unique, up to an overall multiplicative constant and one additive constant for each simple system under consideration.*

At last we are ready to define *temperature*. Concavity of S (implied by A7), Lipschitz continuity of the pressure, and the transversality condition, together with some real analysis, play key roles in the following, which answers questions Q3 and Q4 posed at the beginning.

Theorem 5 (Entropy defines temperature). *The entropy S is a concave and continuously differentiable function on the state-space of a simple system. If the function T is defined by*

$$\frac{1}{T} := \left(\frac{\partial S}{\partial U}\right)_V, \tag{19}$$

then $T > 0$ and T characterizes the relation $\overset{T}{\sim}$ in the sense that $X \overset{T}{\sim} Y$ if and only if $T(X) = T(Y)$. Moreover, if two systems are brought into thermal contact with fixed work coordinates, then, since the total entropy cannot decrease, the energy flows from the system with the higher T to the system with the lower T.

The temperature need not be a strictly monotone function of U; indeed, it is not so in a "multiphase region". It follows that T is not always capable of specifying a state, and this fact can cause some pain in traditional discussions of the second law if it is recognized, which usually it is not.

Mixing and Chemical Reactions

The core results of our analysis have now been presented, and readers satisfied with the entropy principle in the form of Theorem 4 may wish to stop at this point. Nevertheless, a nagging doubt will occur to some, because there are important adiabatic processes in which systems are not conserved, and these processes are not yet covered in the theory. A critical study of the usual textbook treatments should convince the reader that this subject is not easy, but in view of the manifold applications of thermodynamics to chemistry and biology it is important to tell the whole story and not ignore such processes.

One can formulate the problem as the determination of the additive constants $B(\Gamma)$ of Theorem 2. As long as we consider only adiabatic processes that preserve the amount of each simple system (i.e., such that Eqs. (6) and (8) hold), these constants are indeterminate. This is no longer the case, however, if we consider mixing processes and chemical reactions (which are not really different, as far as thermodynamics is concerned). It then becomes a nontrivial question whether the additive constants can be chosen in such a way that the entropy principle holds. Oddly, this determination turns out to be far more complex mathematically and physically than the determination of the multiplicative constants (Theorem 2). In traditional treatments one usually resorts to *gedanken* experiments involving strange, nonexistent objects called "semipermeable membranes" and "van t'Hofft boxes". We present here a general and rigorous approach which avoids all this.

What we already know is that every system has a well-defined entropy function—e.g., for each Γ there is S_Γ—and we know from Theorem 2 that the multiplicative constants a_Γ can be determined in such a way that the sum of the entropies increases in any adiabatic process in any compound space $\Gamma_1 \times \Gamma_2 \times \dots$. Thus, if $X_i \in \Gamma_i$ and $Y_i \in \Gamma_i$, then

$$(X_1, X_2, \dots) \prec (Y_1, Y_2, \dots) \quad \text{if and only if} \quad \sum_i S_i(X_i) \le \sum_j S_j(Y_j), \tag{20}$$

where we have denoted S_{Γ_i} by S_i for short. The additive entropy constants do not matter here, since each function S_i appears on both sides of this inequality. It is important to note that this applies even to processes that, in intermediate steps, take one system into another, provided the total compound system is the same at the beginning and at the end of the process.

The task is to find constants $B(\Gamma)$, one for each state-space Γ, in such a way that the entropy defined by

$$S(X) := S_\Gamma(X) + B(\Gamma) \quad \text{for} \quad X \in \Gamma \tag{21}$$

satisfies

$$S(X) \le S(Y) \tag{22}$$

whenever

$$X \prec Y \quad \text{with} \quad X \in \Gamma,\ Y \in \Gamma'.$$

Moreover, we require that the newly defined entropy satisfy scaling and additivity under composition. Since the initial entropies $S_\Gamma(X)$ already satisfy them, these requirements become conditions on the additive constants $B(\Gamma)$:

$$B(\Gamma_1^{(\lambda_1)} \times \Gamma_2^{(\lambda_2)}) = \lambda_1 B(\Gamma_1) + \lambda_2 B(\Gamma_2) \tag{23}$$

for all state-spaces Γ_1, Γ_2 under consideration and $\lambda_1, \lambda_2 > 0$. Some reflection shows us that consistency in the definition of the entropy constants $B(\Gamma)$ requires us to consider all possible chains of adiabatic processes leading from one space to another via intermediate steps. Moreover, the additivity requirement leads us to allow the use of a "catalyst" in these processes, i.e., an auxiliary system that is recovered at the end, although a state change *within* this system might take place. With this in mind we define quantities $F(\Gamma, \Gamma')$ that incorporate the entropy differences in all such chains leading from Γ to Γ'. These are built up from simpler quantities $D(\Gamma, \Gamma')$, which measure the entropy differences in one-step processes, and $E(\Gamma, \Gamma')$, where the catalyst is absent. The precise definitions are as follows. First,

$$D(\Gamma, \Gamma') := \inf\{S_{\Gamma'}(Y) - S_\Gamma(X) \,:\, X \in \Gamma,\ Y \in \Gamma',\ X \prec Y\}. \tag{24}$$

If there is no adiabatic process leading from Γ to Γ', we put $D(\Gamma, \Gamma') = \infty$. Next, for any given Γ and Γ', we consider all finite chains of state-spaces $\Gamma = \Gamma_1, \Gamma_2, \dots, \Gamma_N = \Gamma'$ such that $D(\Gamma_i, \Gamma_{i+1}) < \infty$ for all i, and we define

$$E(\Gamma, \Gamma') := \inf\{D(\Gamma_1, \Gamma_2) + \cdots + D(\Gamma_{N-1}, \Gamma_N)\}, \tag{25}$$

where the infimum is taken over all such chains linking Γ with Γ'. Finally we define

$$F(\Gamma, \Gamma') := \inf\{E(\Gamma \times \Gamma_0, \Gamma' \times \Gamma_0)\}, \tag{26}$$

where the infimum is taken over all state-spaces Γ_0. (These are the catalysts.)

The importance of the F's for the determination of the additive constants is made clear in the following theorem:

Theorem 6 (Constant entropy differences). *If Γ and Γ' are two state-spaces, then for any two states*

$X \in \Gamma$ *and* $Y \in \Gamma'$

$$(27) \qquad \begin{aligned} &X \prec Y \quad \text{if and only if} \\ &S_\Gamma(X) + F(\Gamma,\Gamma') \le S_{\Gamma'}(Y). \end{aligned}$$

An essential ingredient for the proof of this theorem is Eq. (20).

According to Theorem 6 the determination of the entropy constants $B(\Gamma)$ amounts to satisfying the inequalities

$$(28) \qquad -F(\Gamma',\Gamma) \le B(\Gamma) - B(\Gamma') \le F(\Gamma,\Gamma')$$

together with the linearity condition (23). It is clear that (28) can only be satisfied with finite constants $B(\Gamma)$ and $B(\Gamma')$ if $F(\Gamma,\Gamma') > -\infty$. To exclude the pathological case $F(\Gamma,\Gamma') = -\infty$, we introduce our last axiom, A16, whose statement requires the following definition.

Definition. A state-space Γ is said to be *connected* to another state-space Γ' if there are states $X \in \Gamma$ and $Y \in \Gamma'$, and state-spaces $\Gamma_1, \ldots, \Gamma_N$ with states $X_i, Y_i \in \Gamma_i$, $i = 1, \ldots, N$, and a state-space Γ_0 with states $X_0, Y_0 \in \Gamma_0$, such that

$$(X, X_0) \prec Y_1, \qquad X_i \prec Y_{i+1},\ i = 1, \ldots, N-1,$$
$$X_N \prec (Y, Y_0).$$

A16. Absence of sinks: If Γ is connected to Γ', then Γ' is connected to Γ.

This axiom excludes $F(\Gamma,\Gamma') = -\infty$ because, on general grounds, one always has

$$(29) \qquad -F(\Gamma',\Gamma) \le F(\Gamma,\Gamma').$$

Hence $F(\Gamma,\Gamma') = -\infty$ (which means, in particular, that Γ is connected to Γ') would imply $F(\Gamma',\Gamma) = \infty$, i.e., that there is no way back from Γ' to Γ. This is excluded by axiom 16.

The quantities $F(\Gamma,\Gamma')$ have simple subadditivity properties that allow us to use the Hahn-Banach theorem to satisfy the inequalities (28), with constants $B(\Gamma)$ that depend linearly on Γ, in the sense of Eq. (23). Hence we arrive at

Theorem 7 (Universal entropy). *The additive entropy constants of all systems can be calibrated in such a way that the entropy is additive and extensive and* $X \prec Y$ *implies* $S(X) \le S(Y)$, *even when* X *and* Y *do not belong to the same state-space.*

Our final remark concerns the remaining nonuniqueness of the constants $B(\Gamma)$. This indeterminacy can be traced back to the nonuniqueness of a linear functional lying between $-F(\Gamma',\Gamma)$ and $F(\Gamma,\Gamma')$ and has two possible sources: one is that some pairs of state-spaces Γ and Γ' may not be connected; i.e., $F(\Gamma,\Gamma')$ may be infinite (in which case $F(\Gamma',\Gamma)$ is also infinite by axiom A16). The other is that there might be a true gap; i.e.,

$$(30) \qquad -F(\Gamma',\Gamma) < F(\Gamma,\Gamma')$$

might hold for some state-spaces, even if both sides are finite.

In nature only states containing the same amount of the chemical elements can be transformed into each other. Hence $F(\Gamma,\Gamma') = +\infty$ for many pairs of state-spaces, in particular, for those that contain different amounts of some chemical element. The constants $B(\Gamma)$ are, therefore, never unique: For each equivalence class of state-spaces (with respect to the relation of connectedness) one can define a constant that is arbitrary except for the proviso that the constants should be additive and extensive under composition and scaling of systems. In our world there are 92 chemical elements (or, strictly speaking, a somewhat larger number, N, since one should count different isotopes as different elements), and this leaves us with at least 92 free constants that specify the entropy of one gram of each of the chemical elements in some specific state.

The other possible source of nonuniqueness, a nontrivial gap (30) for systems with the same composition in terms of the chemical elements, is, as far as we know, not realized in nature. (Note that this assertion can be tested experimentally without invoking semipermeable membranes.) Hence, once the entropy constants for the chemical elements have been fixed and a temperature unit has been chosen (to fix the multiplicative constants), the universal entropy is completely fixed.

We are indebted to many people for helpful discussions, including Fred Almgren, Thor Bak, Bernard Baumgartner, Pierluigi Contucci, Roy Jackson, Anthony Knapp, Martin Kruskal, Mary Beth Ruskai, and Jan Philip Solovej.

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Bonn's Max Planck Institute: A New Building and a New Era

Allyn Jackson

Since its founding in 1982, the Max Planck Institute for Mathematics (MPI) in Bonn has become a major international center for mathematics research. With the money and effort that have poured into eastern Germany since the fall of Communism, mathematical enterprises are blooming in places like Leipzig and Berlin, the latter of which is the site of the International Congress of Mathematicians (ICM) in August of this year (the first time since 1904 that the ICM will be in Germany). Nevertheless, the MPI in Bonn retains its role as the top research institute for pure mathematics in Germany. Much of the credit for the success of the MPI goes to its founding director, Friedrich Hirzebruch, who has made enormous contributions to rebuilding mathematics research in Germany after World War II. With Hirzebruch's retirement from the directorship in 1995 and the Institute's imminent move to fine new quarters smack in the center of Bonn's old town, the MPI seems poised to enter a new era.

Roots of the MPI

Although Germany has historically produced some of the best and most prolific mathematicians, many of its top researchers fled the country during the Nazi period. German mathematics never quite recovered from the loss. The slow process of rebuilding the field has been aided in no small part by Hirzebruch, who is in many respects the most important German mathematician of the postwar era. He brought to German mathematics just what it needed after the war: scientific leadership of the highest quality combined with the administrative skill needed to rebuild the field's infrastructure. He is well known not only for his mathematics—which includes the proof of the Hirzebruch-Riemann-Roch theorem and many other important contributions to topology and algebraic geometry—but also for acting as something of an ambassador for German mathematics. For example, he has worked on behalf of the Minerva Foundation, a German organization that has established a number of small scientific research institutes in Israel. Last year he received the Lomonosov Medal, the highest honor of the Russian Academy of Sciences, partly for his research achievements and partly for his work on building greater cooperation among scientists in Germany and Russia. This year he is serving as Honorary President of the Organizing Committee of the ICM.

After receiving his Ph.D. from Münster in 1950 Hirzebruch spent time at the Institute for Advanced Study (IAS) in Princeton and was for a year on the faculty of Princeton University. When he was offered a professorship at the University of Bonn in 1956, he wanted to continue the international contacts that he had developed while abroad. Thus the now-famous *Arbeitstagung* was born in 1957. The word literally means "working meeting". The hallmark of the *Arbeitstagung* was that speakers were not arranged in advance, even when the meeting grew to as many as 200 participants and lasted a week. The method of choosing the speakers became known as "guided democracy": participants gathered together for a "program discussion" in which they threw out suggestions for whom they would like to hear speak, and Hirzebruch acted as master of ceremonies, writing names on the blackboard and gauging the level of interest in the various suggestions. The one exception to this spur-of-the-moment scheduling was that the opening talk was always set in advance. For many years running, Michael Atiyah presented the first talk of the *Arbeitstagung*. Later on, this task was taken up by his student, Simon Donaldson, and others.

Selecting the speakers took mathematical taste as well as diplomacy, and Hirzebruch's choices were not always popular. "People claimed that if I didn't like a particular suggestion, then my ears got worse and I didn't hear it," he recalls. Nevertheless,

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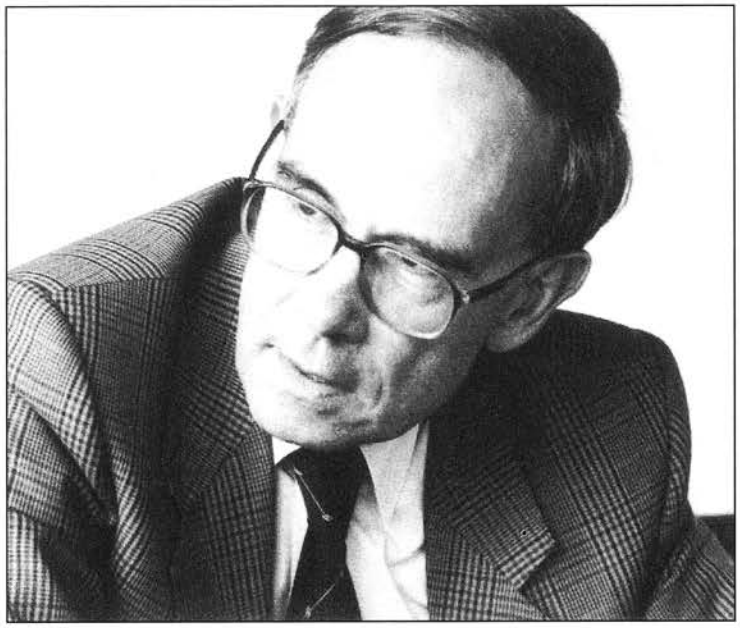
there was always a sense of excitement and anticipation at the *Arbeitstagung* that could not be matched by a planned-ahead meeting. Other places have emulated the model of the *Arbeitstagung*, but it seems it was invented by Hirzebruch. He is modest about the innovation, saying that he did it in part "to save some energy, not to worry about negotiating before the meeting with many people what they will talk about." And, he confesses, "There is also some laziness involved."

MPI's Precursor: SFB Theoretische Mathematik

In addition to starting the *Arbeitstagung*, Hirzebruch wanted to set up a way of insuring a steady flow of international contacts year-round. His time at the IAS, as well as the establishment in 1958 of the Institut des Hautes Études Scientifiques (IHES) outside Paris, became the inspiration for the idea of establishing a permanent mathematics institute in Germany. Soon after Hirzebruch came to Bonn, German mathematicians began discussing this idea in connection with attempts to secure permanent funding for the mathematics research institute at Oberwolfach. Located in the seclusion of Germany's Black Forest, Oberwolfach was founded in 1944 as a refuge for a small group of mathematicians and later became a mathematical conference center. The discussions about Oberwolfach mingled with the idea of establishing a new institute along the lines of IHES or IAS, with Hirzebruch as director. Around 1960 a formal application for funding was made to the Max-Planck-Gesellschaft (MPG, Max Planck Society), a private foundation that funds scientific research. The federal and all of the state governments provide nearly all of the funding for the MPG, but it operates independently of the government. Currently the MPG funds about eighty Max Planck Institutes all over Germany in all areas of science.

This first proposal for a Max Planck Institute in mathematics foundered for three main reasons. First, the application discussed both a new institute as well as Oberwolfach, thereby creating some confusion over the differences and priorities between the two. Second, the reviews of the application were mixed. One of the most negative was from Carl Ludwig Siegel, who not only was unenthusiastic about the institute model—he spent some time at the IAS himself after fleeing Nazi Germany—but also disliked the abstract direction that many mathematicians were taking, Hirzebruch being a prime example.[1] Finally, as with many programs for funding science, mathematics did not fit the mold. Generally, Max Planck Institutes are centered around a particular individual and his or her research, a system that is well suited to laboratory sciences but does not work so easily for mathematics.[2]



Photograph courtesy of the Max Planck Institute, Bonn.

Friedrich Hirzebruch

Soon after this application was rejected, the Deutsche Forschungsgemeinschaft (DFG, the German equivalent of the National Science Foundation in the U.S.), started providing funding to universities for research programs called *Sonderforschungsbereiche* (SFB, special research areas). Mathematicians in Bonn applied to the DFG and in 1969 formed the SFB Theoretische Mathematik under the leadership of Hirzebruch. (The following year Bonn got a second SFB in the area of approximation theory and optimization, led by Walter Vogel). With the SFB, Hirzebruch was able to bring a higher international profile to the Bonn mathematics department by bringing in each year about forty visitors from abroad for long-term stays of a year or two. The university covered the "overhead", from offices to supplies to secretarial assistance, while the SFB paid salaries for the visitors.

In addition to the improvement provided by the SFB, the Bonn mathematics department expanded from three full professors to six, hiring such well-known people as Jacques Tits, Wilhelm Klingenberg, Günter Harder, and Egbert Brieskorn. Also attracted to Bonn in 1970 was Don B. Zagier, a brilliant graduate student then just nineteen years old. He had spent two years at Oxford studying under Atiyah. When Atiyah went on leave and it was unclear whether he would return, Zagier looked around for a place to finish his dissertation

[1] *Part of Siegel's letter appears in the article "Mordell's Review, Siegel's Letter to Mordell, Diophantine Geometry, and 20th Century Mathematics", by Serge Lang,* Notices, *March 1995, pages 339–350; see in particular footnote 8 on page 347.*

[2] *For an excellent account of this story, see "Max-Planck-Institut für Mathematik: Historical Notes on the New Research Institute at Bonn", by Norbert Schappacher,* The Mathematical Intelligencer, *vol. 7, no. 2, 1985.*

Photograph by Ingrid von Kruse, Freibildnerische Photographie.

Don B. Zagier

and ended up with Hirzebruch in Bonn. It was not an obvious choice: "From the war until about 1970 you could count on your fingers the number of top leaders in mathematics in Germany," Zagier notes. As he explains, "I came to Germany uniquely because of Hirzebruch's personality." Not only was Hirzebruch a warm and welcoming presence, it was "just so exciting mathematically" to work with him. Zagier has now been in Bonn for about twenty-five years, having turned down offers to go elsewhere (for some years he retained joint appointments in Bonn and at the University of Maryland, and now he has a part-time appointment in Utrecht).

SFB Phased Out, MPI Phased In

The SFB was from the outset temporary: DFG rules stipulated reapplications every three years and closure after a maximum of fifteen years. So by the late 1970s there were renewed discussions between mathematicians in Bonn and the Max Planck Society about establishing a permanent Max Planck Institute in mathematics when the SFB ran out. The problems and confusion that had arisen in the first application were not present this time, and the MPG was very receptive to the idea. By 1980 it had been decided in principle to found such an institute in Bonn with Hirzebruch as director. The usual model of building a Max Planck Institute around the work of an individual was set aside; instead, the role of the director was to attract high-quality mathematicians working in all areas. The success of the SFB was proof that this mode of operation worked, and the establishment of the MPI was more a matter of making the SFB permanent and independent from the university than of creating an institute from scratch. The plan was that the MPI would begin partially operating in 1982 during the phase-out of the SFB, which was scheduled to end in 1985.

In January 1982 the MPI moved into its present quarters on Gottfried-Claren-Strasse in Beuel, a section of Bonn across the river from the old city. Zagier and Harder were appointed as scientific members of the MPI, though in somewhat different roles, with Zagier keeping only loose ties to the University of Bonn and Harder retaining his full-time professorship there. Hirzebruch retired from the directorship of the MPI in late 1995, though he still retains the title of retired scientific member and is still based at the Institute. In 1993, Gerd Faltings, then at Princeton University, accepted a position as permanent scientific member of the MPI. Also hired in the same capacity that year was Yuri Manin, who in 1991 had left positions at the Steklov Institute and Moscow State University. Faltings, Harder, Manin, and Zagier run the MPI jointly, with the position of "managing director" rotating among the four every two years.

The MPI bears more similarity to IHES or IAS than to the Mathematical Sciences Research Institute (MSRI) in Berkeley, the Institute for Mathematics and its Applications (IMA) in Minneapolis, or the Isaac Newton Institute in Cambridge, England. MSRI, IMA, and the Newton Institute run programs that focus on specific mathematical areas, and mathematicians interested in those areas apply to participate. These programs typically run from a few months to a year and are fixed about two years ahead of time. By contrast the MPI does not run programs; it takes applications from mathematicians in all areas and chooses whom to invite according to the quality of the applicants. Efforts are made to coordinate invitations so that there are people in the same or related areas who can interact. If there are a number of applications in a certain area, the MPI might organize a special concentration of people all working in the same area and perhaps suggest to some in that area who have not applied that they do so. Sometimes these activities can grow to be quite large; for example, during a two-and-a-half-month period last year about forty topologists came to the MPI for stays of varying lengths. This activity culminated in a small conference of forty to fifty people.

At any one time the MPI has about eighty visitors. Of these about half are young mathematicians, ranging from fresh Ph.D.s to those who are five to eight years past the Ph.D. From the beginning the MPI has favored longer stays (usually a one-year sabbatical) over shorter ones in order to foster deeper interactions among the visitors. Occasionally there are special three-year visiting positions, usually for senior mathematicians. Sometimes a mini-research group springs up around a three-year visitor, with the visitor making suggestions of people to invite for stays at the MPI. In recent years, with the difficult job market for mathematicians in many countries, the number of applications to the MPI has leaped to around twice what it was in the early 1990s. As a result the MPI has brought in more people for shorter stays, usually three to six months. Because of limitations on the number of visitors the building can accommodate, there has not been an increase in the number of people in the Institute at any one time, but there has been an increase in the number coming through the Institute per year, up from perhaps 200 to about 270 over the past several years.

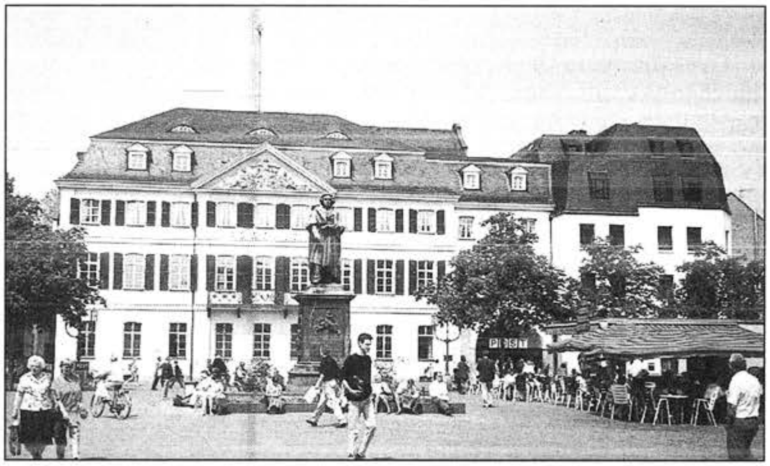
Since the MPI began it has overseen the organization of the *Arbeitstagung*, but the lack of a sufficiently large lecture room at the MPI building has meant that all of the lectures are held at the University of Bonn. At the thirtieth *Arbeitstagung* in 1991 Hirzebruch announced that that would be his last time organizing the meeting. Since then the four permanent members of the MPI have organized the *Arbeitstagung* of the Second Series. It is held in odd-numbered years and has taken place three times so far, with the next one scheduled for the spring of 1999. With the growth in the size of the meeting and perhaps in the absence of Hirzebruch's inimitable skill in organizing it, there have been some changes in the Second Series, the most notable being that a few of the talks can be set in advance. Still, it remains an exciting event: the 1997 *Arbeitstagung* featured talks by a number of outstanding young mathematicians, including Vladimir Voevodsky, who will present a Plenary Lecture at the ICM in August.

Life at the MPI

One of the most important roles of the MPI is to provide mathematicians with time to do research away from the distraction of their usual duties at their home institutions. But the MPI also has a broader function, that of disseminating new ideas. Within the first couple of years of its existence the MPI organized a seminar on Gerd Faltings's then-recent work on the Mordell Conjecture while Faltings was a visitor there. Later on in the 1980s it held a seminar on the new theory about four-manifolds that had been developed by Simon Donaldson. Such activities have helped to expose mathematicians from all over the world to important developments in their subject. In this way the MPI benefits mathematical life in institutions all over the world, as its visitors carry away new ideas to work on back home. It also plays a special role in Germany, for many young mathematicians from German universities get their first taste of international-level research through a postdoc at the MPI.

Over the years the MPI has been the site where much important research in mathematics has been carried out. Some recent examples include research by Maxim Kontsevich on a conjecture of Witten about intersection numbers of moduli spaces of curves, and the work of Vladimir Voevodsky on a conjecture of Milnor in algebraic K-theory. Kenneth Ribet worked on his celebrated result that the Taniyama-Shimura conjecture implies Fermat's Last Theorem while at the MPI in 1986 and spoke about his ideas at the *Arbeitstagung*. In fact, it was an episode involving Fermat that drew perhaps the greatest public attention to the MPI. In 1988 the algebraic geometer Yoichi Miyaoka announced at the MPI that he believed he could extend to arithmetic surfaces the Miyaoka-Yau inequality that had been proven for complex surfaces years before. A. N. Parshin had suggested that such an extension would prove Fermat. Word of a purported proof leaked out to the press, and Zagier recalls that for five days he managed to keep a lid on the story in the hope that the details of the proof could be checked. But when the story finally was reported in the *Los Angeles Times*, other publications followed suit, and for two weeks Zagier found himself on the phone every half hour with newspapers all over the world. Within two weeks Faltings, who was still at Princeton at the time, found a problem in the proof, and life at the MPI returned to normal.

While research at the MPI covers all fields of pure mathematics, there are some areas of special strength. Hirzebruch's activities in algebraic geometry always attracted many visitors, particularly mathematicians from Japan. Today this theme has found a natural continuation in Manin's activities in quantum cohomology, which have also attracted a lot of visitors, especially Russians. Manin runs a weekly seminar on topics at the interface of mathematics and theoretical physics. With Zagier and Harder as permanent members, number theory has always been strong at the MPI, and the hiring of Faltings increased this strength. One of their organized activities is a weekly number theory lunch and seminar. The traditional emphasis on topology begun by Hirzebruch has continued through the permanent position of homotopy theorist Hans Baues and through three-year appointments of topologists (two examples are Matthias Kreck of the University of Mainz and Ian Hambleton of McMaster University) as well as a weekly seminar. In fact Hirzebruch himself has organized an MPI activity on the topology of algebraic varieties, to be held this summer in memory of Boris Moishezon, who died in 1993 at the age of fifty-six. There is also the "Oberseminar", in which visitors speak about their work in a way that is accessible to all MPI visitors, even those who are not in the same area. The directors usually attend the Oberseminar and sometimes engage in banter and verbal



A famous statue of Beethoven overlooks the square in front of the facade of the new Max Planck Institute building in Bonn.

sparring that contributes a convivial, informal spirit.

For a mathematics institute, creating this kind of open and stimulating scientific atmosphere is paramount. But there are also other, more practical aspects in the running of an institute that can influence the quality of a visitor's experience. One of these is office space, which at the MPI is in short supply. Very few visitors get offices to themselves, many professors are 2 or 3 to an office, postdocs might be 4 or 5 to an office, and graduate students as many as 7. Some MPI visitors have perceived a sense of hierarchy in the way office space is distributed. The MPI administration says that hierarchy does not come into play and that they distribute office space according to such practical considerations as how many people are likely to come to a given visitor's office for discussions.

Another major consideration is funding for visitors. The MPI does not pay salaries to regular visitors but instead provides a certain amount per month that (usually generously) covers expenses. Postdocs are given an amount more like a full salary, on the expectation that they do not yet have permanent positions. Apart from postdocs, there are two categories of pay, one for assistant and associate professors, and one for full professors. The fact that there are variations in the amounts paid within each category has led some visitors to perceive here too a sense of hierarchy in the workings of the MPI. Although it produces some grumbles, this system of paying visitors can offer more flexibility than is found at other institutes. For example, because senior visitors at MSRI typically get only funds to cover living expenses, high profile mathematicians who have organized MSRI programs have sometimes not shown up to participate in the programs because the pay was so low.

In addition to office space and pay, the quality of the library is an important aspect of institute life. A common problem for institute libraries is that the holdings do not go back very far: The MPI's library began in 1982 and holds complete sets of all of the major mathematics journals from that time forward. Faltings has used research funds he received by winning the Leibniz Prize to fill in back issues of some journals. Thus the main difficulty the MPI library has faced is not lack of money but lack of space; for want of any other option, it has expanded into the basement of the MPI building. As with many institutes, visitors are permitted use of the university mathematics library, which in the case of the University of Bonn is excellent (though budget cuts have in recent years diminished its quality).

The MPI has quite good computing facilities. Zagier is a prodigious calculator, and it was his love of computing that led the MPI early on to purchase computers. Today it has a network of Unix workstations accessible in offices and in some public areas. Some visitors have found the rules of the computing administration at the MPI rather rigid, with especially specific instructions about how computer accounts must be organized and how the computers can be used. On the other hand, the MPI administration says the institute has received many comments about how helpful and flexible their computer administrators are. There are also other aspects of MPI operations that some visitors have felt are too restrictive, such as the rules governing telephone use, which have caused many to head, phone card in hand, for the one pay phone in the MPI building.

When it comes to visitor housing, the MPI does not have an easy job. Unlike, for example, the IAS, which has its own on-campus housing, the MPI must rely on a network of rental properties around Bonn. The quality of apartments is uneven, with some visitors being placed in somewhat rundown but well located apartments and others assigned to apartments in Tannenbusch, a set of highrises far from the institute. The city of Bonn is quite safe, though some visitors have found it dull and the citizens less than hospitable. Some appreciate the peacefulness of Beuel, the section of town that is home to the MPI's current building. The location of the MPI's new building, on a bustling central square in Bonn, will be livelier though less serene.

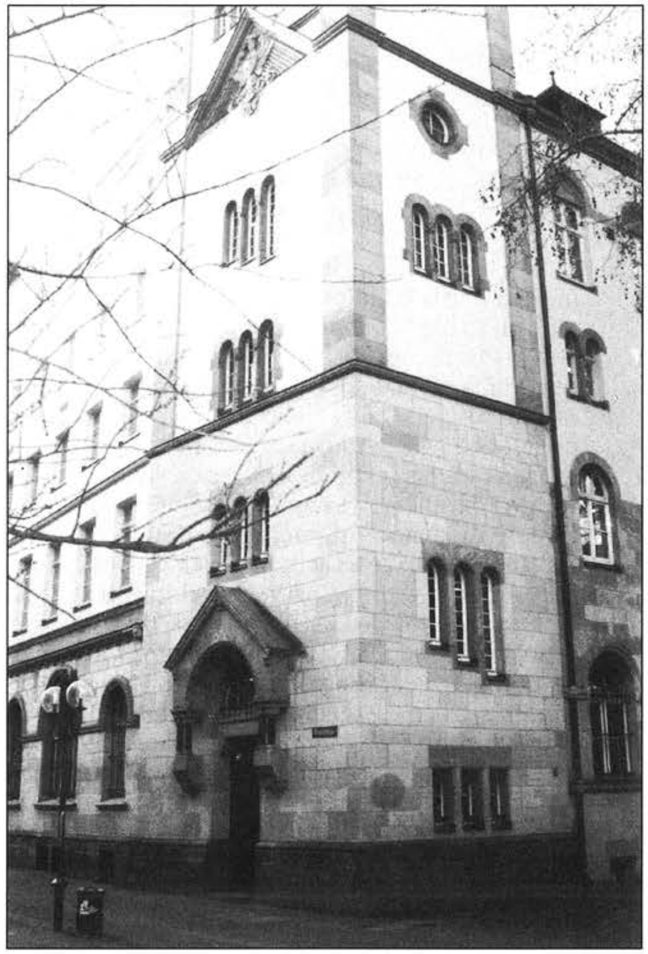
MPI Finds a New Home

Don Zagier served as managing director of the MPI from Hirzebruch's retirement in 1995 to late 1997 (currently Gerd Faltings is the managing director). One of Zagier's main goals was to secure a new building for the MPI. Asked about this effort, Zagier laughs, "That was a big battle!" He cannot conceal his glee over the outcome: quarters that are larger, more centrally located, and closer to the University of Bonn. And although the MPI does not wish to advertise the fact, their new home is an elegant listed building in the center of town, with the words "Postamt" running in gilt letters across the facade (it used to be a post office), a wrought iron balcony, and a bas-relief set into a central pediment.

When the MPI started in 1982, many different buildings were considered. In his 1985 *Intelligencer* article on the MPI, Norbert Schappacher commented that, among the possible homes for the MPI, "a Los Angeles like project of having the institute riding on a bridge across a freeway has already been turned down." Nothing suitable could be found close to the university, so the MPI chose the building on Gottfried-Claren-Strasse, which was ideal in other ways and which had a reasonable rent. As the MPI grew, the building became more and more crowded. So many people have had to share offices that it just became "ridiculous," says Zagier. "You can't do this like a youth hostel." At one point the space became physically smaller when the owners of the building needed to use one wing, forcing the library into the larger of the two lecture rooms. As the administrative staff grew, some had to relocate to a separate building about a quarter of a mile away.

Seven or eight years ago the MPI appealed to the Max Planck Society for additional money to rent a larger building. The MPG turned down the request because, with the reunification of Germany, it was concentrating its efforts on the eastern part of the country.[3] Still, the MPG agreed that the Bonn institute needed a new building and suggested that it raise the issue again in about five years, when the situation in eastern Germany would presumably have settled. But during that period Germany entered a recession, and the MPG was forced to cut back. The pressure has been so severe that it recently closed four Max Planck Institutes, purely for financial reasons. "They sometimes closed one because it was considered that it was no longer doing enough good scientific work," Zagier notes. "But they never before closed one because they ran out of money." It was not an auspicious time to ask the MPG for more money for a new building.

Coincidentally, it was the political situation that opened the door on negotiations for a new building. In 1995 the MPG offered the MPI a couple of floors in a skyscraper that had been vacated because of the moving of Germany's capital from Bonn to Berlin. The move has become a politically sensitive issue in Bonn. The hope was that getting prestigious organizations like the MPI to move into the vacant buildings would lessen the loss in property values. But the particular building suggested by the MPG was not suitable. "You couldn't imagine a worse place for a math institute," says



Entrance to the new Max Planck Institute building.

Zagier. "It was very fancy, of course, but extremely cold, with huge rooms and long corridors," rather than areas in which people can circulate and gather together to talk. This episode had one bright spot: the MPG's offer meant that it agreed in principle to finding a better home for the MPI (the government building would have been triple the rent on Gottfried-Claren-Strasse). So over the course of the ensuing two years Zagier and the other scientific members looked at about thirty buildings in Bonn, aiming to find a handful to propose to the MPG.

All along they were searching for rented quarters; the MPG's budget prohibited the construction of a new building. At one point the University of Bonn offered a plot of land to the MPI on very good terms, and a sponsor was found to construct a building that would be rented to the Institute. While the location was excellent, there were other problems: the plot of land was too small, and the rent would have been too high. In the end three or four existing buildings were proposed to the MPG, one of them being the old post office in a central square in Bonn called the Münsterplatz. The post office was the best choice in many respects, including location, size, and proximity to the university, and it was not the most expensive. Never-

[3]*For example, the MPG established the Max Planck Institute for Mathematics in the Sciences in Leipzig, which began operations in October 1996; see "A New Max-Planck Institute for Mathematics in the Sciences in Leipzig", by Jürgen Jost, Stefan Müller, and Eberhard Zeidler,* Notices, *November 1996, pages 1125–1126.*

theless, the beauty of the building made it a tough sell: Could the MPG, so strapped for money it was closing institutes, be seen renting such fine quarters for the mathematicians?

At one point the negotiations reached an impasse, but Zagier persisted, and he and Faltings flew to Munich to discuss the matter with MPG officials. There was no disagreement that the Institute needed a new building; the problem was the pressure on the MPG's funds. "All of the Max Planck Institutes have come up with very good projects, and many of them have stories about how rough life is," Zagier explains. "So we had to convince them that our life is rougher. And in the end most anybody who has visited this institute now agrees that although we are doing okay, we really are living in a shoebox." He says that one of his most persuasive arguments was that the MPG was actually getting a poor return on its money with the present building. If the visitors are too crowded in their offices, they find they cannot work, so they give up on coming into the Institute and work at home instead. "And if people are working at home, you might as well not have a Max Planck Institute," says Zagier. "The whole idea is that we bring people together and they work together.... But it only happens if people actually use their offices." In the end the trip to Munich paid off: the MPG agreed in principle to let the MPI rent the postal building, and two or three months later they got the final okay.

If the MPI's new home seems to have a noble flourish, that is because it was at one time a palace, the Fürstenberg Palais, home of canon Radermacher of the cathedral chapter and later in the 19th century of the noble family Fürstenberg-Stammheim. It was built in 1798, and greatly expanded in 1926, when it was converted into the main post office. The building features in many postcards from Bonn, for it stands just behind a famed, larger-than-life statue of Beethoven (who was born in Bonn). In 1845 Queen Victoria stood on the balcony of the Fürstenberg Palais during the inauguration of the statue.

Present plans call for the MPI to move into the new building in November of this year. The building is in a U-shape, and the "U" will be closed up to form a courtyard in the center. There will be a subterranean level of shops and restaurants. The MPI will occupy the third, fourth, and fifth floors of the building, together with the second floor that faces the Münsterplatz. The MPI entrance will not be on the square, but around the corner on a side street. One of the biggest problems with the old MPI building is the lack of a good lecture hall. After the larger of the two seminar rooms was taken over by the library, the MPI was left with one that could seat only thirty-five to forty people, and uncomfortably at that. The new building has an enormous room that once housed 400 telephone switchboard operators; this will be the MPI auditorium. There is also much more room for the library, which will be on two stories, with tables and chairs on the second level. The architects who were designing the interior proposed an efficient, central location for such necessities as the computer room, administrative offices, fax machine, and so on. "We explained we wanted exactly the opposite," says Zagier. The idea is to have the facilities spread out so that visitors have to circulate around the Institute. There will be small niches around the building with blackboards and tables so that it is easy to find places to talk. (These touches bear some resemblance to the Newton Institute, which has blackboards in every conceivable spot and some inconceivable ones, like the restrooms.)

One of the changes that the MPI is looking forward to in the new building is more interaction with mathematicians at the University of Bonn. In addition it is planning two new activities that are made possible by the extra space afforded by the new building. Both aim at improving support for young mathematicians in Europe, who often have difficulty securing permanent, full professor positions. One of these is the European Postdoctoral Institute (EPDI), a joint effort by MPI, IHES, and the Newton Institute. The EPDI provides two years of funding to postdoctoral mathematicians, who then spend one year at one of the three institutes and the second year elsewhere in Europe at a university or research institute or even in industry. The three institutes have started the EPDI on a very small scale and are hoping to secure funding for twenty postdocs a year from the European Union. The other new effort at MPI is called *Nachwuchsgruppen*. These would be small groups of perhaps three people, led by a young person who is several years past the Ph.D. but who has a sufficiently strong research program that he or she could supervise Ph.D. students. While this person would be given a five-year appointment at the MPI, the expectation would be that before that time ran out he or she would secure a permanent job. The other members of the *Nachwuchsgruppe* would be graduate students or postdocs who would work directly with the group leader.

This summer, as the mathematical world turns its attention to Berlin for the ICM, at the other end of Germany the MPI will be in the midst of preparations for its move to the new building in November. With the retirement of Hirzebruch the building has become emblematic of a new era for the MPI. Many would agree with Matthias Kreck, director of the mathematics institute at Oberwolfach, who commented that, with his charming personality and willingness to listen, Hirzebruch "was and is central for the atmosphere at the Max Planck Institute." The challenge for the MPI is to chart a course for the future while retaining the great traditions that have made it one of the world's leading centers for mathematics research.

Mathematicians and the National Eighth-Grade Test

Hyman Bass

The committee to develop specifications for the Voluntary National Mathematics Test included three mathematicians: Don Kreider, Jim Lewis, and me. I offer here some reflections on our work with that committee and on some larger educational issues encountered in that work. I thank Deborah Ball for helpful discussion of these issues.

First Reception of the Idea

In his 1997 State of the Union address President Clinton proposed an audacious education agenda. One of its highlights was an unprecedented Voluntary National Mathematics Test (VNMT), to be administered to eighth-grade students, as well as a fourth-grade test in reading. The VNMT was to be designed to provide individual students, families, and teachers with an indicator of what each student knows and is able to do with respect to challenging but appropriate tasks in mathematics at the eighth-grade level. Just as the fourth grade marks a passage from "learning to read" to "reading to learn", the eighth grade is seen as a critical gateway toward future mathematical and scientific study and achievement.

I think it is fair to say that first reactions to this proposal were mixed, often hesitant, in all of the current camps of educational debate. My first disposition was that this was not the best place to put top political priority. Professional preparation and development of teachers and improvement of curricula seemed to be much more urgent and central concerns. Moreover, given the inequity in opportunities to learn in this country, a national test might aggravate rather than support correction of these disparities by highlighting poor performance of students in underserved schools without providing the resources needed to change this inequity. At the same time, the existence of such a test seemed at first like a political given, and it would come with the highest presidential backing. On that premise, discussion shifted to how one might make this high profile VNMT an instrument to help advance these other agendas. Before describing that train of thought, let me say something about the debates on National Standards, debates which impinged on the VNMT.

There has been widespread and often confused and nonproductive debate about the NCTM Standards. The generality of their language, partly imposed by the current political inadmissibility of prescribing anything resembling a national curriculum in this country, leaves them open to diverse (often misguided) interpretations and implementations. Moreover, even persons most philosophically committed to the Standards recognize that they must inherently be viewed as a document subject to ongoing review and improvement. (In fact, a very substantial revision process, enlisting the views of many communities, including mathematicians, is currently under way.) The most virulent foes of the Standards often cite misguided implementations or misreadings of them and take these to be authoritative representations of what the Standards are or were intended to be. Adding confusion to this discourse is the lack of consensus about what constitutes appropriate and well-grounded evidence for claims. For example, among the unfortunate outcomes of these debates is a false antagonism proposed between the nature and acquisition of basic skills on the one hand and conceptual understanding and problem-solving skills

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on the other. I know of no one who has reflected seriously on the improvement of mathematical education who does not believe that all of these things are to be desired. Indeed, most mathematicians believe that they are mutually dependent. To elevate this discussion and make it more grounded and constructive, how can we, in a national framework, give a more concrete, unambiguous, and consensual indicator of high curricular expectations for all students?

This was a possibility that some of us saw for the VNMT, provided that it was well designed and developed. If established, then the collection of mathematical tasks presented on this test would, de facto, represent over time a concrete and ample sampling of what informed professional thinking deemed to be challenging and appropriate mathematical expectations at the eighth-grade level. Moreover, the publication of the tests and supporting materials and the prompt feedback to students, families, and teachers could afford a rich source of diagnostic information and guidance for curriculum design by teachers. If the test were subscribed to by a large number of states and perhaps later extended to more grade levels, then, some argued, it could become a powerful resource for curricular and textbook improvement, as well as a resource for professional development of teachers focused more on curriculum, children's understandings, content, and the pedagogy of that content.

It was with these admittedly very speculative and optimistic hopes that some of us agreed to work in support of the VNMT, being vigilant about the quality controls in its development. The mathematics community felt that it would be crucial, in order to help assure the mathematical quality of the test items, to have professional mathematicians involved throughout the development and oversight processes, much more so than has been the pattern in development of other national educational policy documents and programs. A letter addressed to U.S. Secretary of Education Riley from the AMS Committees on Education and Science Policy expressed this concern. When Don Kreider and I were appointed to the Mathematics Committee (to develop specs for the mathematics test, a parallel committee being named for the reading test), I reiterated this concern to the Committee itself, and so Jim Lewis was added to our ranks.

The Composition and Guidelines of the Mathematics Committee

The mathematics and reading tests were under the jurisdiction of the Department of Education (DOE). To develop item and test specifications, DOE contracted MPR Associates (to handle administrative and logistical matters) and the Council of Chief State School Officers (CCSSO), a natural choice, since these would be key agents in decisions by the states on whether to adopt the voluntary national tests. A National Test Panel provided overall policy guidance and review for the project. Two content committees reporting to the test panel—one for math (to which this article refers) and one for reading—were constituted to draft specifications for the assessment, make recommendations regarding scoring and reporting, and contribute to the development of an ongoing research agenda. A Technical Advisory Group consisting of experts in educational measurement supported the work of both the panel and the content committees. The recommendations of the content committees, once approved by the panel, would guide the contractor named to develop, administer, evaluate, and update the actual tests.

The work of the content committees was bounded by some fundamental policy constraints, the principal one being that the tests be based on the framework of the DOE's National Assessment of Educational Progress (NAEP). For twenty-five years NAEP has been measuring national performance in mathematics and reading. It has a well-developed educational measurement methodology on which the Voluntary National Test development could rely. Also, the alignment with the NAEP framework affords the possibility to predict NAEP performance from VNT results. In the case of mathematics, correlation can also be made with TIMSS, because TIMSS was already designed to be linked to NAEP for U.S. students.

At the same time, NAEP and the VNMT are fundamentally different, in that NAEP is based on a modest sample of students and measures system performance, whereas the VNMT is designed to be taken by every student, with test results promptly shared with individual students, parents, and teachers. The VNMT will be not only an evaluation tool but, more importantly, a resource meant to support improved teaching and learning by promptly returning student work, publishing the tests, and providing booklets with sample test items accompanied by hypothetical student work and scoring rubrics.

Further initial conditions given to the Mathematics Committee required that the tests:

- assess the same high standards for all students;
- take place every spring;
- be 90 minutes in length;
- include approximately 80% machine-scored items and 20% non-machine-scored, including one extended written response item;
- call for students to spend approximately equal amounts of time on machine-scored and non-machine-scored items;
- allow for reliable and valid linking of individual student performance to the NAEP and TIMSS achievement levels;

- be scorable within three weeks;
- allow the results to be returned to students, families, and teachers within two months of test administration; and
- be released in its entirety following each administration.

Since concerns were expressed about the membership of the Mathematics Committee, I list here its members: John Dossey (chair) (Distinguished Univ. Prof. of Math., Illinois State U.), Hyman Bass (prof. math., Columbia U.), Gail Burrill (vice chair) (pres., NCTM, secondary teacher and associate researcher, U. Wisconsin), Bettye Forte (program dir. math., Ft. Worth Indepen. Sch. Dist.), Ana Maria Golan (regional dir., Renaissance Proj., Fountain Valley, CA), Joan Grampp (math/science resource teacher, Milwaukee USI), Ann Kahn (past pres., National PTA), Edward Kifer (prof. and chair, Educ. Policy Studies and Evaluation, U. Kentucky), Donald Kreider (prof. math. and CS, Dartmouth Coll.), Steven Leinwand (math. consultant, Conn. State DOE), William James Lewis (chair, Dept. Math. and Stat., U. Nebraska), Debra Paulson (math. chair, Dr. Hornedo Middle Sch., El Paso, TX), Marjorie Petit (deputy commissioner, Vermont DOE), Edward Silver (prof., Cognitive Studies and Math. Educ., Learning R&D Center, U. Pittsburgh), Kris Warloe (teacher, Cheldelin Middle Sch., Corvallis, OR), Patricia Wilson (assoc. prof., Math. Educ., U. Georgia). Several support staff from MPR Associates and CCSSO also attended the meetings.

The Committee first met in Washington in late May, and after an intense series of summer meetings and public hearings around the country delivered the final draft of its report on schedule in early September.

The Working Culture of the Committee and Some Sources of Tension

This was not the first time since working in the world of education that I found myself at a table of mostly unfamiliar faces from professional communities with which I had very limited acquaintance. I came with concerns about the mathematical level and quality of the test items and quickly learned that this was but one, albeit very important, aspect of what goes into the construction of a large-scale test. Myriad important considerations first occupied our attention: the number and distribution of item types (machine- or non-machine-scored, multiple choice, gridded, drawn, short- or long-extended response), scoring rubrics, accessibility issues, reporting, scheduling, venue, administration, etc. The initial meetings focused on these technical, logistical, and administrative issues and featured sophisticated discussions by people whose professional lives they occupy.

I was impressed by the professionalism of this work and by this rapid exposure to the technology of assessment that I had not before closely witnessed. At the same time, I was worried that the attention to such concerns might subordinate the issues of mathematical quality of content, which were paramount in the minds of mathematicians like me. Moreover, I suspected that the knowledge of and sensitivity to such content issues were significantly higher among the few mathematicians present than among most of the other Committee members, and so I was concerned that these priorities enjoy a receptive hearing across the boundaries of the professional cultures represented on the Committee.

I was therefore gratified to see a very open, generous, and respectful working ethos develop within this Committee. Everyone became intellectually engaged with all of the work, both critiquing and learning from the work of the other professionals. A number of issues, particularly the position on use of calculators, were vigorously debated. But the debates were thoughtful and nonconfrontational. Moreover, the views expressed by mathematicians on matters of mathematical substance and quality were generally received with respect and generosity.

I have learned that most important agendas in mathematics education require multidisciplinary perspectives and resources, yet we have few good models of deeply probing collaborative work across the different professional cultures involved. The work of the Mathematics Committee provided for me a gratifying example of what can be achieved when such collaboration is effectively mobilized.

The specifications imposed on our work—adherence to the NAEP framework, the 90-minute test length, the large number of machine-scored items, etc.—were a source of frustration to many of us (mathematicians, teachers, educators), who felt that it would be difficult to represent sufficiently ambitious learning expectations under those constraints. Moreover, with due attention to considerations of accessibility, we intended that the VNMT be designed to express growing expectations over time. So, while honoring the specifications, we pushed their envelope toward allowance for more complex and higher-order problem-solving items and toward content coverage that creatively interpreted the content strands that govern NAEP. These efforts were supported by a broad consensus in the Committee.

A couple of (related) issues precipitated some lively debate within the Committee. These had to do with the allowance for use of calculators on the test and with the amount (and nature) of attention given to "basic skills" on the test. Consensual resolutions of both issues were achieved. In the case of basic skills, the inclination favored designing more complex or multistep problems whose solutions demonstrably entail various basic skills, computational and other, rather than directly posing routine computational tasks.

External Input and Public Response

The Mathematics Committee was instructed to solicit broad input from the public, and it aggressively sought to do so. Two full-day public hearings were held, one in Denver in June, the other in San Francisco in August. Moreover, John Dossey disseminated e-mail requests to many interested parties, including a broad solicitation to mathematicians, for suggestions of candidates for exemplar test items. Richard Askey was among several contributors of very valuable resource material, and he strongly urged attention to the practices of other high-performance countries, notably Japan.

At the time of the Denver meeting there was little available documentation to react to at the public hearing, and the public notice was regrettably short. I personally had to miss that meeting because of a family illness. It was at that time that the first cut on the selection of exemplar items was made, the process with which I was most concerned. These were submitted in the first publicly distributed draft, to which people responded at the San Francisco hearing. When I first saw the selections, I was dismayed at the poor quality, in my opinion, of several of them, and I was eager to help correct this.

The San Francisco hearing was, in many ways, a remarkable event. It was an open and dignified occasion, with the Committee very receptive and responsive to a wide range of opinions and concerns expressed there. A substantial and diverse group of persons, many representing important organizations, came to testify. Some were school system administrators expressing their concerns and hopes for the VNMT. Others made passionate appeals for sensitivity to the potential for aggravating inequities in opportunities to learn in this country. Some of them pleaded for multilingual versions of the test.

Notable among those testifying were several distinguished mathematicians. John Ewing, executive director of the AMS, eloquently expressed the concerns in the mathematical community that the test represent substantial and high-standard mathematical expectations and that mathematicians remain engaged with the development and oversight of the test. Richard Schoen and James Milgram from Stanford presented very detailed and forceful but constructive critiques of several of the items in the then current draft report from the Committee. In fact, they focused on many of the same characteristics with which I had been concerned. Their views were gratefully received. When Schoen suggested that he knew many mathematicians who could construct very good test items, John Dossey eagerly invited him to have such materials submitted to the Committee.

I for one paid great heed to the critiques offered by Schoen, Milgram, and others. Their analyses were detailed and carefully reasoned, and they accorded pretty much with my own earlier reactions to the draft items. I made an express effort to address them in the redesign and, in some cases, reselection of the exemplar test items. I strongly urged inclusion of some items from TIMSS and from other sources, such as the Japanese. And the Committee adopted many of these recommendations. A review of the final report from the Committee will show that the test items selected come from a great diversity of sources and that many of them call for substantial computational skills, often embedded in more complex tasks. The point that I wish to emphasize here is not only the substance of the final report but the fact that the process for its generation, with substantial public feedback, in fact worked very effectively. The Committee did not have a preordained agenda, apart from the overall goals of the test described in the introduction above and the framework for its work imposed by the DOE, and it represented with integrity the constructive views transmitted to it by the public.

Politics

California was then and now remains the site of some volatile and highly polarized backlash to educational reform initiatives. Surprisingly little of this was in direct evidence at the San Francisco hearing, apart from the testimony of Madalyn McDaniel, a parent from Atascadero, CA, who was greatly displeased by IMP (the Interactive Mathematics Program) that had been adopted in her son's school. She had joined forces with anti-reform organizations and was even featured in a widely cited *Weekly Standard* article by Lynne Cheney. Her testimony was emotionally charged, and she flatly accused the Committee of being beholden to the support of IMP and other educational agendas, which she described in almost conspiratorial terms. Following her testimony, several Committee members raised their hands to ask what IMP was.

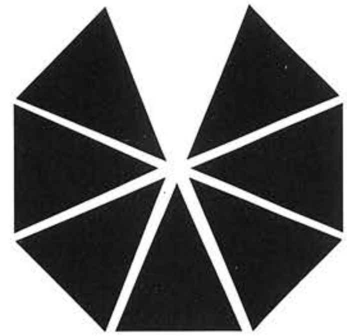
This was an admittedly extreme example of condemnation of the VNMT based on a priori judgments of the Committee members, insinuating either incompetence or misguided philosophies of education or conflict of interest. This was quite interesting to me, for I was an inside observer who had met many of the Committee members for the first time in this work. They represented a wide range of professional knowledge that seemed necessary for our task. And through direct participation and observation, I gained a great respect for the professionalism and constructive collaboration that the Committee achieved. Further, I found it ironic that concerned observers would condemn an activity expressly designed for generous and open feedback from the public, to which some of them contributed, before they had seen the final product of that process.

This protest found one public expression in the form of an open letter to President Clinton composed in August 1997—before the final draft of the Committee report was prepared—by Mike McKeown and Paul Clopton, founders of Mathematically Correct, a San Diego-based organization opposed to many of the current mathematics reform efforts in California. This letter advanced several claims that I know to be groundless, and it asserted many things about the inevitable design of the test before the final report was even written and which were demonstrably at variance with what was finally produced. Attacks were made on the integrity of the Committee members. I found the letter to be irresponsible and destructive in both tone and substance. I was therefore saddened to find among those enlisted to sign it some of the very people who offered criticism and guidance to the Committee and whose suggestions were incorporated in the final version of the report.

Not everything in our report is what I personally might have chosen, but it represents a thoughtful and intelligently negotiated design that had to accommodate many conflicting realities and ambitions in current U.S. education. Having entered this effort with considerable skepticism, I stand now firmly in support of the report that we have produced and, equally importantly, in support of the process of cross-disciplinary collaboration and receptivity to community feedback that produced it.

There remain, I recognize, good reasons for caution and skepticism about the wisdom of having such a national test at all. Can we be fully assured that its design and development will be well aligned with appropriate educational goals? Will it support or undermine the ongoing efforts to improve teaching and learning in classrooms and the production of high-quality curricular materials? Will such a test further aggravate the unequal opportunities to learn that characterize U.S. education? The desirability of the test is contingent on its effect on all of these other issues, and that is ultimately the context in which it should be judged.

Get the slice of cake you want!



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Sarvadaman Chowla (1907–1995)

Raymond G. Ayoub, James G. Huard, and Kenneth S. Williams

Sarvadaman Chowla

Sarvadaman Chowla was an extremely talented mathematician who was internationally known for his research in number theory and related topics. His name is associated with several important theorems. His mathematical output was impressive and reflected his special gift for expressing complex ideas simply. One of the best-known number theorists from India who followed in the tradition of Ramanujan, Chowla's fertile and creative imagination justified the title "poet of mathematics" given to him by his associates.

Chowla was born in London, England, on October 22, 1907, the son of Gopal and Shankuntala Chowla. His father, Gopal, was a professor of mathematics from Lahore in India who had gone to Cambridge University in England for further studies. Chowla was reared in India and showed an early aptitude for mathematics. His first published papers appeared when he was only eighteen. In 1928 he received a master's degree from Government College in Lahore. Between 1929 and 1931 Chowla studied at Trinity College, Cambridge, where he received his doctorate under the guidance of J. E. Littlewood. Following his return to India, Chowla held professorships at St. Stephen's College in Delhi, at Benares Hindu University in Benares, at Andhra University in Waltair, and lastly at Government College of Punjab University in Lahore, where he was head of the Department of Mathematics from 1936 to 1947. While at St. Stephen's College, he met and married a student, Himani Mozoomdar. Their only child, Paromita, also became a number theorist and is now a retired professor from Pennsylvania State University.

Upon the partition of India in 1947 Chowla fled from Lahore with his family first to Delhi and then to the United States, where he visited the Institute for Advanced Study in Princeton until the fall of 1949, when he assumed a professorship at the University of Kansas in Lawrence. In 1952 he moved to the University of Colorado in Boulder. Then in 1963 he accepted the offer of a position as research professor at Pennsylvania State University, where he remained until his retirement in 1976. After his retirement Chowla spent several years at the Institute for Advanced Study. From there Chowla eventually moved to Laramie, Wyoming, to work with his former doctoral student Mary Jane Cowles. Chowla died in Laramie on December 10, 1995.

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Those who knew Chowla were always struck by his enthusiasm for and love of his subject. One of Chowla's doctoral students referred to him as a "perpetual ambassador for number theory," and this reflects accurately Chowla's great capacity to stimulate and excite others about the theory of numbers. Chowla's lectures were both interesting and inspiring. He introduced students to the main ideas of the subject by means of illuminating examples and by giving proofs of important special cases of more general theorems. He taught by suggestion and encouragement, confident that his doctoral students would find their own interesting problems to work on. This approach brought out the best in his students, who often made progress with minimal assistance.

Chowla was a lively, friendly, and good-humored person who was extremely modest about his accomplishments. He was engaged in mathematics to such an extent that he had few outside interests. Mrs. Chowla was a constant source of support and freed him from the more mundane matters of everyday life. Though the death of his wife in 1970 was a tremendous loss to Chowla, after her death he managed reasonably well on his own with the assistance of friends.

Chowla was a member of the Indian National Academy of Sciences (from which he received a Padmabhushan Award) and an honorary foreign member of the Royal Norwegian Society of Sciences and Letters.

Chowla's first paper appeared in 1925 and his last in 1986. During this period of sixty-two years he wrote about 350 papers. His papers encompassed a wide variety of interests. He wrote on additive number theory (lattice points, partitions, Waring's problem), analysis (Bernoulli numbers, class invariants, definite integrals, elliptic integrals, infinite series, the Weierstrass approximation theorem), analytic number theory (Dirichlet L-functions, primes, Riemann and Epstein zeta functions), binary quadratic forms and class numbers, combinatorial problems (block designs, difference sets, Latin squares), diophantine equations and diophantine approximation, elementary number theory (arithmetic functions, continued fractions, and Ramanujan's tau function), and exponential and character sums (Gauss sums, Kloosterman sums, trigonometric sums). This list is not intended to be exhaustive. Among his coauthors are such well-known mathematicians as N. C. Ankeny, T. M. Apostol, E. Artin, R. P. Bambah, P. T. Bateman, B. C. Berndt, B. J. Birch, R. C. Bose, R. Brauer, H. Davenport, B. Dwork, P. Erdős, R. J. Evans, J. B. Friedlander, D. M. Goldfeld, H. Gupta, M. Hall Jr., H. Hasse, I. N. Herstein, B. W. Jones, D. J. Lewis, H. B. Mann, W. E. Mientka, L. J. Mordell, M. B. Nathanson, S. S. Pillai, K. Ramanchandra, C. R. Rao, H. J. Ryser, A. Schinzel, A. Selberg, G. Shimura, Th. Skolem, E. G. Straus, J. Todd, A. Walfisz, A. L. Whiteman, and H. Zassenhaus. Here we can do no more than touch upon some of Chowla's results. The selection will of course reflect the tastes of the authors.

Chowla's name is identified with a number of mathematical results, including the Bruck-Chowla-Ryser theorem that gives a criterion for the nonexistence of certain block designs, the Ankeny-Artin-Chowla congruence for the class number of a real quadratic field, the Chowla-Mordell theorem on Gauss sums, and the Chowla-Selberg formula relating special values of the Dedekind eta function. We now describe each of these briefly.

Let ν, k, and λ be positive integers. A (ν, k, λ)-*design* is a set of ν elements arranged into ν sets such that every set contains exactly k distinct elements and every pair of sets has exactly $\lambda = k(k-1)/(\nu-1)$ elements in common.

Bruck-Chowla-Ryser Theorem [1]. If a (ν, k, λ)-design exists, then $k-\lambda$ is a square when ν is even, and the diophantine equation $x^2-(k-\lambda)y^2-(-1)^{(\nu-1)/2}\lambda z^2=0$ has a nontrivial solution when ν is odd.

Let $h(d)$ denote the class number of the real quadratic field K of discriminant d, and let $(t+u\sqrt{d})/2$ be the fundamental unit (>1) of K. Let p be an odd prime divisor of d.

Ankeny-Artin-Chowla Theorem [2]. If $3<p<d$, then

$$-2\frac{u}{t}h(d) \equiv \sum_{0<n<d} \frac{p}{dn}\left(\frac{d}{n}\right)\left[\frac{n}{p}\right] \pmod{p},$$

where (d/n) is the Kronecker symbol for discriminant d and $[x]$ denotes the greatest integer less than or equal to x.

Let p be an odd prime, and let χ be a nonprincipal character (mod p). The Gauss sum $G(\chi)$ is defined by

$$G(\chi)=\sum_{n=1}^{p-1}\chi(n)e^{2\pi i n/p}.$$

We set $\varepsilon(\chi)=G(\chi)/\sqrt{p}$. It is well known that $|\varepsilon(\chi)|=1$. Chowla and Mordell proved the following result independently in 1962.

Chowla-Mordell Theorem [3]. $\varepsilon(\chi)$ is a root of unity if and only if $\chi(n)$ is the Legendre symbol (n/p).

Let d be a negative integer with $d \equiv 0$ or 1 (mod 4). The equivalence classes of positive-definite, primitive, integral binary quadratic forms $(a,b,c)=ax^2+bxy+cy^2$ of discriminant $d=b^2-4ac$ form a finite abelian group under Gaussian composition denoted by $H(d)$. Denote the class containing the form (a,b,c) by $[a,b,c]$ and the number of classes by $h(d)$.

In 1967 Selberg and Chowla discovered a beautiful formula, now known as the Chowla-Selberg formula, giving explicitly the value of the product of $|\eta((b+\sqrt{d})/2a)|$ as $[a,b,c]$ runs through the classes of $H(d)$ where d is a fundamental discriminant and $\eta(z)$ is the Dedekind eta function defined by

$$\eta(z) = e^{2\pi i z/24} \prod_{m=1}^{\infty} (1 - e^{2\pi i m z})$$

for $z = x + iy$, $y > 0$.

Chowla-Selberg Formula [4].

$$\prod_{[a,b,c]\epsilon H(d)} a^{-1/4} \left| \eta\left((b+\sqrt{d})/2a \right) \right| =$$

$$(2\pi|d|)^{-h(d)/4} \left\{ \prod_{m=1}^{|d|} (\Gamma(m/|d|))^{(d/m)} \right\}^{w(d)/8},$$

where $\Gamma(z)$ is the gamma function, (d/m) is the Kronecker symbol for discriminant d, and $w(d)$ is the number of roots of unity in the ring of integers of the quadratic field $\mathbf{Q}(\sqrt{d})$.

The Chowla-Selberg formula has been extended recently to nonfundamental discriminants as well as to genera of $H(d)$.

The study of class numbers from an analytic point of view is a recurring theme throughout Chowla's work. We describe briefly another of Chowla's results in this area.

Heilbronn showed in 1934 that $h(d) \to \infty$ as $d \to -\infty$. Upon learning of this result, Chowla [8] showed the stronger result that $h(d)/2^{t(d)} \to \infty$ as $d \to -\infty$, where $t(d)$ denotes the number of distinct prime divisors of d.

A number of Chowla's papers show that he was a master of the methods of analytic number theory. We mention briefly two examples. The first concerns the representation of a positive integer as the sum of four squares and a prime; the second, the behavior of the error term in the asymptotic formula for the summatory function of Euler's phi function.

Let $N_{r,s}(n)$ denote the number of representations of the positive integer n as the sum of r squares and s primes. By making use of the Brun-Titchmarsh Theorem, Chowla [5] showed in 1935 that

$$N_{4,1}(n) \sim \frac{\pi^2 n^2}{2\log n} \prod_{\substack{p|n \\ p>2}} \frac{(p-1)^2(p+1)}{(p^3-p^2+1)} \times \prod_{p>2} \left(1 + \frac{1}{p^2(p-1)}\right),$$

as $n \to \infty$, where p denotes a prime, thereby establishing a conjecture made by Hardy and Littlewood in 1922 in their famous work on *Partitio Numerorum.*

Next let $\phi(n)$ denote Euler's phi function; that is, $\phi(n)$ counts the number of positive integers not exceeding n that are coprime to n. It has long been known that

$$\sum_{n \le x} \phi(n) \sim \frac{3}{\pi^2} x^2$$

as $x \to \infty$. It was shown by Mertens in 1874 that the error term

$$E(x) = \sum_{n \le x} \phi(n) - \frac{3}{\pi^2} x^2$$

satisfies

$$E(x) = O(x \log x).$$

In 1930 in joint work with Pillai, Chowla [6] considered the sum

$$S(x) = \sum_{n \le x} E(n)$$

and showed that

$$S(x) \sim \frac{3}{2\pi^2} x^2$$

as $x \to \infty$. He also established that

$$E(x) \ne o(x \log\log\log x).$$

In 1932 Chowla returned to the subject of the behavior of $E(x)$ and proved in a long paper [7] that the integral

$$I(x) = \int_1^x E^2(u) du$$

satisfies

$$I(x) \sim \frac{1}{6\pi^2} x^3,$$

as $x \to \infty$.

Chowla's work was also characterized by a large number of short papers, many of them mathematical gems, others interesting conjectures. We give six examples.

1. Let p be a prime with $p > 3$. In 1862 Wolstenholme showed that

$$1 + \frac{1}{2} + \cdots + \frac{1}{p-1} \equiv 0 (\text{mod } p^2),$$

where $1/i$ denotes the inverse of i modulo p^2. There are many generalizations of Wolstenholme's theorem. In 1934 Chowla [9] gave a very short elegant proof of one of these due to Leudesdorf; namely, if n is a positive integer coprime with 6, then

$$\sum_{\substack{m=1 \\ (m,n)=1}}^{n} \frac{1}{m} \equiv 0 (\text{mod } n^2).$$

2. Quintic equations that are solvable by radicals have attracted a great deal of attention in recent years since the publication of Dummit's important paper (*Solving solvable quintics*, Math.

Comp. **57** (1991), 387–401). Chowla in conjunction with Bhalotra wrote on this subject in 1942 [10]. Let $x^5 + ax^3 + bx^2 + cx + d$ be irreducible in $\mathbf{Z}[x]$. They showed that if a and b are even and c and d are odd, then the quintic equation

$$x^5 + ax^3 + bx^2 + cx + d = 0$$

is not solvable by means of radicals. In particular, the quintic trinomial equation

$$x^5 + cx + d = 0$$

is not solvable by radicals when c and d are both odd. They also showed that this last equation is not solvable by radicals if c is odd and not divisible by any prime p with $p \equiv 3 \pmod 4$.

3. Let $p(n)$ denote the number of partitions of the positive integer n into integer parts. In joint work with A. M. Mian, Chowla [11] showed that the function

$$y(x) = \sum_{n=1}^{\infty} p(n)x^n \quad (|x| < 1)$$

satisfies an algebraic differential equation.

4. The Bernoulli numbers $B_n (n = 1, 2, \ldots)$ can be defined by

$$\frac{x}{e^x - 1} = 1 - \frac{x}{2} + \sum_{n=1}^{\infty} \frac{(-1)^{n-1} B_n x^{2n}}{(2n)!}.$$

There is a vast literature devoted to the properties of these numbers. In 1972 Chowla together with P. Hartung [12] considered the problem of determining an exact closed-form formula for B_n. They proved that

$$B_n = \frac{1}{2(2^{2n}-1)}\left(1 + \left[\frac{2(2^{2n}-1)(2n)!}{2^{2n-1}\pi^{2n}} \sum_{m=1}^{3n} \frac{1}{m^{2n}}\right]\right).$$

5. Let p be a prime with $p \equiv 1 \pmod 4$. It is well known that there are integers a and b such that $p = a^2 + b^2$, where a is odd and b is even. Indeed a is uniquely determined by this equation and the condition that $a \equiv 1 \pmod 4$. Gauss showed that the binomial coefficient

$$A = \binom{(p-1)/2}{(p-1)/4}$$

satisfies the congruence $A \equiv 2a \pmod p$. In one of his last papers Chowla, in joint work with Dwork and Evans [13], proved, using the Gross-Koblitz formula, the congruence

$$A \equiv \left(1 + \frac{2^{p-1}-1}{2}\right)\left(2a - \frac{p}{2a}\right) \pmod{p^2},$$

which had been conjectured by Beukers.

6. For a positive integer N the continued fraction expansion of $\sqrt{N}$ is of the form

$$\sqrt{N} = [a_0; \overline{a_1, a_2, \cdots, a_\ell}],$$

where $a_0 = [\sqrt{N}]$ and $a_l = 2a_0$. It was shown by T. Vijayaraghavan (Proc. London Math. Soc. **26** (1927), 403–414) that the length l of the period $a_1 a_2 \ldots a_l$ satisfies

$$l = O(N^{1/2} \log N).$$

He also showed that if $\delta > 0$, then there are infinitely many values of the positive integer N for which

$$l > N^{1/2-\delta}.$$

The estimation of l is an important problem in number theory, and it was a problem that interested Chowla. In 1929 he [14] showed that if N is squarefree and exceeds a certain bound depending on $\delta > 0$, then

$$l < \left(\frac{6}{\pi^2} + \delta\right) N^{1/2} \log N.$$

This inequality should be compared with that of R. G. Stanton, C. Sudler Jr., and H. C. Williams (*An upper bound for the period of the simple continued fraction for* $\sqrt{D}$, Pacific J. Math. **67** (1976), 525–536), who showed that

$$l < 0.72\, N^{1/2} \log N$$

for all squarefree $N > 7$. In joint work with Pillai in 1931 Chowla [15] showed that under a certain condition

$$l = O(N^{1/2} \log\log N)$$

and without the condition that there are positive constants C_1 and C_2 such that the inequalities

$$C_1 N^{1/2} < l < C_2 N^{1/2}$$

hold for infinitely many positive integers N. They showed further that l is "on the average" of order $N^{1/2}$.

The first author wrote an article on Chowla and his work on the occasion of Chowla's seventieth birthday. This article, which contained a list of Chowla's publications up to that point and a list of Chowla's twenty-three doctoral students in the United States, appeared in a special issue of the *Journal of Number Theory* dedicated to Professor Chowla [J. Number Theory **11** (1979), 286–301; erratum, ibid. **12** (1980), 139.] The other two authors are in the process of preparing Chowla's collected papers for publication.

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Singular Perturbations in Elasticity Theory

Volume 1 in Analysis and its Applications
Published by: IOS Press
Edited by: L.S. Frank (University of Reims, France)
1997, 384 pp., hardcover
ISBN: 90 5199 307 2
Price: US$82

Singular perturbations appear in different fields of Pure and Applied Mathematics. The most striking examples come from Fluid Dynamics (Navier-Stokes equations with large Reynolds numbers), Elasticity Theory (Equations for the buckling plates), Diffraction Theory and other branches of Applied Mathematics. Singular perturbations appearing in Elasticity and Diffraction Theories and also in some problems in Fluid Dynamics, as, for instance, the spectral Stokes problem, belong to the class of the operators with small or large parameters, which satisfy the algebraic condition of coerciveness. The coerciveness concept for one parameter families of singular perturbations was introduced in 1976 and is a necessary and sufficient algebraic condition for the stability of singularly perturbed boundary value problems, i.e. the coerciveness is a necessary and sufficient condition for the validity of two-sided a priori estimates for the solutions to singularly perturbed problems uniformly with respect to the small (or large) parameter. It turns out that the same coerciveness condition guarantees that any coercive singular perturbation can be reduced in a constructive way to a regular perturbation. As some direct applications of the constructive reduction procedure for the coercive singular perturbations to problems in Elasticity Theory, one should mention the following ones:

1) Simple derivation of asymptotic formulae for their solutions with smooth and non-smooth data;
2) Asymptotics for their eigenvalues and eigenfunctions;
3) Asymptotic analysis of the bifurcation phenomenon for Coercive Singular Perturbations;
4) Construction of efficient and robust algorithms for numerical treatment of Coercive Singular Perturbations.

Appendices are devoted, respectively to general Coercive Singular Perturbations, travelling waves in shallow water, one parameter families of finite difference Toeplitz' type operators and some quasilinear second order Elliptic and Parabolic singular perturbations.

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Eventually

Marianne Freundlich

Rick Norwood's letter (December 1997), which I read with enthusiastic agreement, prompts me to enlarge on his comments about δ and ϵ to talk about my personal experiences with them. In a sense I have been reflecting on the matter since at least my junior year in college, when I had a first course in analysis from S. S. Cairns, then at Queens College. I just simply didn't get it! I probably went to all his office hours and recall how patiently he said, over and over, what Norwood now says "...is crystal clear, and in plain language says this: a function has a limit at an (input)[1] number x if and only if, etc. etc."—and I, too, now see it with crystal clarity. But in my junior year I didn't, though even then I had the sophistication to know that this "it" was crucial, while I also knew that I didn't get "it" or have any idea how to use "it". Professor Cairns kindly gave me a C, and on I went to grad school at Illinois, where an Intro to Analysis was again required. It was "déjà vu all over again," this time with a wonderful instructor named Ralph Fox, who had red hair, worked in Knotentheorie, and told a funny story about how he married his Quaker wife. (He also put me in touch with a chess player named Marseille, who was investigating baking ragweed pollen into bread for people like me with hayfever.)

I still had no idea and turned in a bluebook final in which I wrote only my name. Fox gave me an A, so I went to see him and complained bitterly: "How could you do that? I didn't even pretend. I don't get it. How could you give me an A?" He said that he hadn't wanted to spoil my record and anyone with the ___ (none of the words now coming to the reader's mind were then current, so I truly don't recall how he put it!) would be sure to get it "eventually." I was more baffled than ever but gamely said, "Well, what do I do next?" And he said, "Take the graduate course!" And he sent me down the hall to David Bourgin. [I think Laurie Snell may recall the class also. Also Jewell Schubert, Frankie Morfoot (Mrs. M. M. Day), and Roger Livesay were there.]

So now I'm in the grad course in analysis with Bourgin, and that man *made* me a mathematician, I guess. Or else I was just finally "ready"? The numbers ϵ and δ actually never came up, but there were gorgeous theorems. And as he never had any notes (just odd bits of old envelopes), I took on the job of writing up his lectures for the class, including complete proofs. Somehow I learned to *do*

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[1] *This word "input" is not in Cauchy's classic formulation and makes the definition of limit unnecessarily a whole word longer, without actually adding meaning.*

math. With a *lot* of talking to him.[2] Anyway, one day, maybe halfway through what was now my second year of grad school, I said, "Wow, I get it! Eureka, aha," or words like that. I'm sure I never found it either obvious or trivial, though, yes, crystal clear finally!

There are several interesting sequels here. Perhaps the reader should be informed that in that second year I switched from physics to math; and, who knows, "getting it" about δ and ϵ may well have been a part of that switch, though that behavior too was, like most important life choices, overdetermined. Another couple of years later Professor Cairns was invited to become the Illinois math department's chairman; I was by then the apple of a lot of people's eyes, and when I went to the party given for him, he saw me walking in and reacted with "What are *you* doing here?" I think I explained that I now understood about δ and ϵ!

But I never stopped wondering about it and eventually decided, while clinging to "ontogeny recapitulates phylogeny", that sometime near the middle of the nineteenth century Cauchy figured out a way to tame infinity (years later, for my students, I worked this into a metaphor of a lion tamer handling a large and dangerous animal using nothing but a small wooden stool while inside the lion's cage) and that this simple, crystal-clear definition in fact represents an enormous step in intellectual history: humanity's victory over difficulties that baffled the Greeks, as we learn from Plato, not to mention church fathers puzzling over angels dancing on pinheads and infinite sums that could be added up and others that couldn't. I've always felt that we, all of us Thinking Reeds, really held our collective breath from the time Plato's Socrates had a ten-year-old slave boy prove $\sqrt{2}$ irrational and Zeno's turtle beat Achilles until Cauchy, armed only with that wooden stool, tamed infinity. An intellectual development incubated for over two thousand years could well take me three.

Eventually I came to think my slowness was "developmental": after I had a lot of children and watched who did what when, I saw that the "when" seemed to matter less and less compared to the "what". (Maybe Ralph Fox knew something like that.) For a while I had wondered if perhaps my slowness might have to do with sex-linked traits, but two of my sons had similar experiences in junior-level analysis.

As a calculus teacher I was, with all this personal experience, always on the side of "wait and see", though I never gave an A for a blank final, maybe because no such paper was ever turned in to me! A lot of students have experiences similar to mine in junior-level analysis, and of course many sail right on through there and never find it hard. Them I've never really understood! What got me through and out the other side was *desire*—I cared and stayed in there, and one day I "got it". I doubt whether anyone who hasn't had to wait for that clear light really appreciates those two little words the way I do, but of course that may be envy speaking! I don't think we can *teach* students such mysteries; time and, alas, patience and some will to learn (to power?) are what are needed. The New Math had to fail because it jumped students into logical simplicities, skipping over at least five hundred years of phylogeny.

This is becoming too long. Let me end with an example from my proverb collection: "If it isn't logical, then it's psychological!"

[2] *Fifty years later, hindsight whispers that Bourgin may have been using the Moore method. (The writer regrets the mixing of metaphor.)*

La Rivoluzione Dimenticata (The Forgotten Revolution)

Reviewed by Sandro Graffi

La Rivoluzione Dimenticata
(The Forgotten Revolution)
Lucio Russo
Feltrinelli, Milan, 1996
380 pages
Hardcover $30.00

The conquests of Alexander the Great superimposed the Greek culture over the older Middle Eastern ones of Egypt, Mesopotamia, and Persia. The consequent cross-fertilization was epoch-making and gave rise to Hellenistic civilization. Its main center was Alexandria, with its Museum and its Library, in many aspects comparable to the present-day advanced research institutes.

In *The Forgotten Revolution* the author, a probabilist at the University of Rome II and a professional classical philologist as well, sets out to reconstruct Hellenistic science between the foundation of Alexandria in 331 B.C. and the first closure of the Museum in 145 B.C., the golden age of science in antiquity.[1]

The book is a comprehensive and in-depth review of Hellenistic science. Its first conclusion represents an innovation, even with respect to classics such as Otto Neugebauer's *Exact Sciences in the Antiquity* or Sir Thomas Heath's *A History of Greek Mathematics*: the Hellenistic scientists were no simple "forerunners" or "anticipators" of modern science and technology, able maybe to go far on particular issues through sophisticated arguments but basically amateurish, unlike the present-day professionally trained scientists and technologists. On the contrary, they were real pros: the Hellenistic civilization was largely based on a scientific revolution amounting to the introduction of today's scientific method and scientific technology, including much of today's mathematics, *in today's formulation* (Euclidean geometry, real numbers, limits, definite integrals) and of solid and fluid mechanics (whence civil, mechanical, naval engineering), optics, astronomy, anatomy, physiology, scientific medicine, even psychoanalysis.

The second conclusion goes even further: in the same way that the Renaissance was based on the recovery of classical culture,[2] the post-Renaissance scientific revolution of the seventeenth century was basically due to the conscious recovery of the Hellenistic science (not even to its full extent, reached only in the second half of the nineteenth century with Dedekind's and Weierstrass's isolation of the real number concept directly out of Euclid's definition of proportion). Unlike artists and humanists, however, the scientists (e.g., New-

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[1] *Those active in Alexandria include the mathematicians and physicists Euclid and Heratosthenes, the physician Herophilos, and many others; elsewhere, the mathematician, physicist, and engineer Archimedes of Syracuse, the mathematician Apollonius of Perge, the astronomers Aristarchus of Samos and Hipparchus of Nicea, etc.*

[2] *Including Euclid's* Elements *and* Optics, *the basis of Hellenistic perspective rediscovered in the early fifteenth century. The annotated Latin translation of the* Elements *belonging to Leon Battista Alberti (1401-1478), one of the first and foremost Renaissance architects and painters, still exists in Florence (Biblioteca Laurenziana).*

ton) and their popularizers (e.g., Voltaire), being probably more insecure in their achievements and thus more anxious to take credit, did not pay the debt due to their true sources.

The novelty of these conclusions is such that one might be tempted to react with plain disbelief, if not with a shrug. The reader should, however, avoid such a reaction, because the scholarly support is unquestionably impressive. It includes a methodological novelty, this time in the examination of the original sources. Thanks to his dual competence in science and philology, Russo does away with a time-honored habit among scholars of antiquity—namely, that humanists only deal with "literary" sources and historians of science with the "scientific" ones. The scarcity of the extant sources on science in antiquity forces the modern scholar to look for all second- or third-hand information scattered and interspersed through the literary ones. The examination of many more sources than the traditional ones not only adds to the historical perspective but yields new findings in the history of science. One of the two most interesting, in my opinion—the discovery of the inverse square law of gravitation in Hellenistic times (the other being the philological deduction that Euclid's definitions are not in the original text)—comes mainly from reading historians or philosophers such as Plutarch or Seneca with the eye of a scientist.

The second conclusion is even more daring. Here again, however, the examination of the original literature (Galileo, Kepler, Descartes, and especially Newton) and of the related matters of historical relevance,[3] particularly in relation to the Hellenistic sources, is so careful that, to say the least, it cannot be easily dismissed.

The topic is covered in ten chapters, an epilogue, and a mathematical appendix. Chapters 1-7 cover in detail the birth, rise, decline, and fall of Hellenistic science and technology: mathematics, mechanics of solids and fluids, topography and geodesy, optics, astronomy; civil, mechanical, naval, and military engineering; anatomy, physiology, biology, and medicine; economics and mass production techniques; architecture and urban development; psychoanalysis and cognitive sciences. In Chapter 1 the isolation of today's concept of "exact science", both theoretical and experimental, is reconstructed, comparing the quantum jump between the arguments on mechanical advantage of gears of Aristoteles (d. 331 B.C.), negating their feasibility, and Archimedes (d. 212 B.C.), first asserting the contrary theoretically and later supervising their construction.

From Chapter 2 on Hellenistic mathematics I give an example of a recurrent argument in the book: to assess Hellenistic science, and especially its modern aspects, commonplace opinions should be reevaluated. One of these states: in Greek science the concept of infinity is poorly understood and openly avoided.[4] The view of the Hellenistic mathematicians is instead much the same as that, for instance, of G. H. Hardy[5]: "There is no number infinity: such an equation as $n = \infty$ is as it stands *meaningless*. A number n cannot be equal to ∞ because 'equal to ∞' means nothing." To prove his case, the author simply reproduces in full Archimedes' famous computation of the area of the parabolic segment by the exhaustion method. Archimedes, it is true, does not use the word "limit". If this word is, however, replaced by its present-day definition, his statement is exactly reproduced, and, again, replacing a word by its definition results in a Riemann integral. Actually, the author's main point about Hellenistic mathematics is its methodological nature: even more important than what Euclid, Archimedes, and Heratosthenes actually discovered is the method they introduced, namely, the axiomatic, deductive way of argumentation which characterizes mathematics. More generally, the deductive approach, coupled to the experimental method also introduced by the Hellenistic scientists, is our own approach to exact sciences. The Hellenistic scientific revolution was forgotten precisely because that scientific method was abandoned in antiquity and its recovery was exceedingly slow. For example, coming back to mathematics, Newton was still far below the Hellenistic level of rigor, as evident from comparing his argument about the ratio of infinitesimal quantities (*Principia*, I.I) with Archimedes' work *On Spirals*, where infinitesimals of different orders are introduced: in essence, Newton lacked the limit concept which Archimedes possessed. The full recovery of the Hellenistic way of doing mathematics had to wait for Cauchy and Weierstrass.

The two subsequent chapters deal mainly with optics, mechanics and astronomy, and engineering. Their purpose is to show how the main achievements of Hellenistic technology, whose memory is still alive today (the Colossus of Rhodes; the lighthouse of Alexandria, whose rays could be seen from a distance of more than thirty miles; Archimedes' machines; ships with metal-protected hulls and up to thirty orders of rows, etc.) were made possible by the sound scientific ground on which the engineering was based.

The same scientific method characterizes the investigations in biomedical sciences (here the main

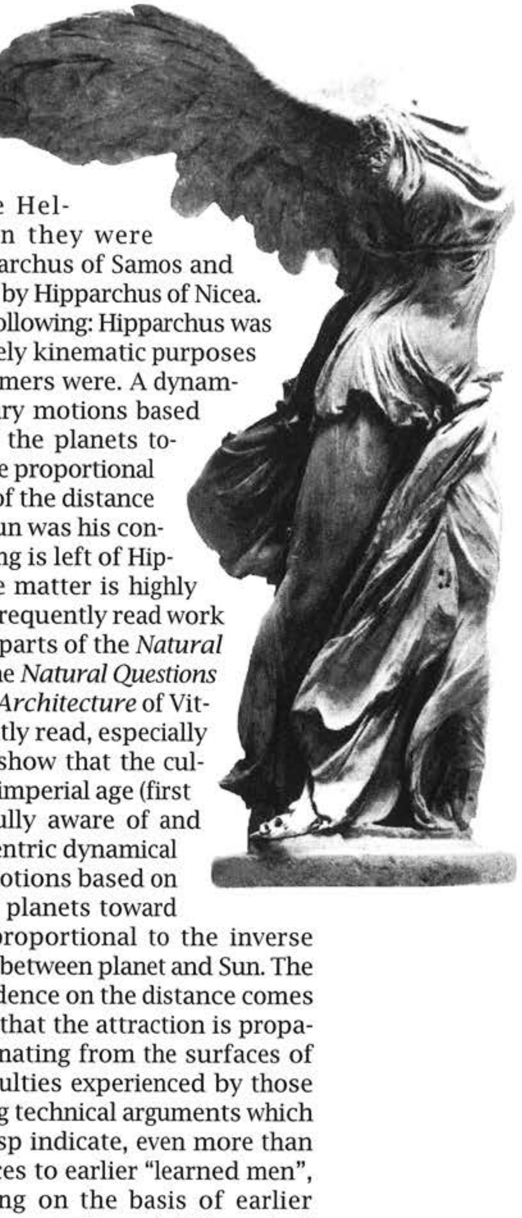
[3] *For example,* Scholia, *related to the various writing stages of* Philisophiae Naturalis Principia Mathematica; *list of books in Newton's library; etc.*

[4] *See, e.g., M. Kline,* Mathematics in Western Culture, *Oxford, 1953, or C. Boyer,* A History of Mathematics, *New York, 1968.*

[5] A Course of Pure Mathematics, *Cambridge, 1963, §55.*

figure is Herophilus of Chalcedon,[6] who developed a theory, very much like our modern ones, of human anatomy and physiology, discovered the nervous system, and made a distinction between sensors and motors), in economics and mass production techniques, in architecture and urban development, and in cognitive sciences. Taken as a whole, the scientific methods characterized Hellenistic civilization, which underwent a major crisis in 145–144 B.C. (under Roman pressure after the subjugation of Macedonia and the destruction of Carthage) and later a slow but steady decline during its forced integration into the Roman state, concluded in 30 B.C. with the reduction of Egypt to a Roman province. However, Alexandria maintained its role as the scientific capital of antiquity (with a partial recovery in the second century A.D., the time of the mathematician and mechanical engineer Heron, the physician Galenus, and the astronomer Claude Ptolemy) well into the fifth century A.D. To fix the time scale, note that the rise, decline, partial recovery, and fall of Alexandrine science took more than seven centuries.

Before turning to the question of the decline of Hellenistic science, I come back to the new light shed by the book on Euclid's *Elements* and on pre-Ptolemaic astronomy. Euclid's definitions of the elementary geometric entities—point, straight line, plane—at the beginning of the *Elements* have long presented a problem.[7] Their nature is in sharp contrast with the approach taken in the rest of the book, and continued by mathematicians ever since, of refraining from defining the fundamental entities explicitly but limiting themselves to postulating the properties which they enjoy. Why should Euclid be so hopelessly obscure right at the beginning and so smooth just after? The answer is: the definitions are not Euclid's. Toward the beginning of the second century A.D. Heron of Alexandria found it convenient to introduce definitions of the elementary objects (a sign of decadence!) in his commentary on Euclid's *Elements*, which had been written at least 400 years before. All manuscripts of the *Elements* copied ever since included Heron's definitions without mention, whence their attribution to Euclid himself. The philological evidence leading to this conclusion is quite convincing.[8]



Heliocentric theories of planetary motions were known long before Hellenistic times, when they were reelaborated by Aristarchus of Samos and then one century later by Hipparchus of Nicea. The point here is the following: Hipparchus was not motivated by purely kinematic purposes as the earlier astronomers were. A dynamical theory of planetary motions based on the attractions of the planets toward the Sun by a force proportional to the inverse square of the distance between planet and Sun was his contribution. Since nothing is left of Hipparchus's works,[9] the matter is highly debatable. Now an infrequently read work of Plutarch,[10] several parts of the *Natural History* of Plinius, of the *Natural Questions* of Seneca, and of the *Architecture* of Vitruvius, also infrequently read, especially by scientists, clearly show that the cultural elite of the early imperial age (first century A.D.) were fully aware of and convinced of a heliocentric dynamical theory of planetary motions based on the attractions of the planets toward the Sun by a force proportional to the inverse square of the distance between planet and Sun. The inverse square dependence on the distance comes from the assumption that the attraction is propagated along rays emanating from the surfaces of the bodies. The difficulties experienced by those authors in reproducing technical arguments which they did not fully grasp indicate, even more than their indirect references to earlier "learned men", that they were writing on the basis of earlier sources. An accurate examination of all the extant related literature strongly supports the opinion that the true source must have been Hipparchus.[11]

How much of the above was known to Newton? We learn that Definition 5 (centripetal force) of the

[6]*Active in Alexandria in the beginning of the third century B.C. On this point the author acknowledges his debt to H. von Staden,* Herophilus. The Art of Medicine in Early Alexandria, *Cambridge, 1989.*

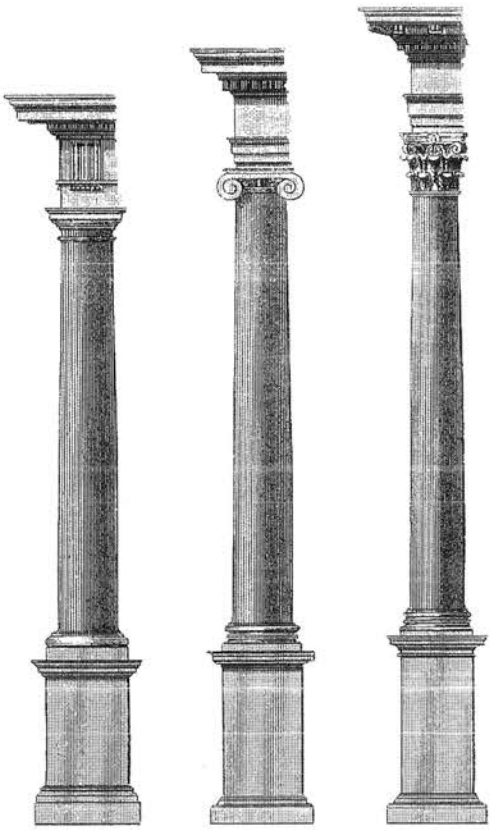
[7]*"The language thus seen is hopelessly obscure" is the comment of T. L. Heath,* op.cit., *after the definition of straight line.*

[8]*The book reproduces the original argument of L. Russo,* "On the non-authenticity of the definitions of the fundamental geometric entities in Euclid's *Elements*", *Bolletino dei Classici, Accademia Nazionale dei Lincei (Rome) XIII, 1992, pp. 25-44. An enlarged English version of the argument is in press: L. Russo,* The definition of fundamental geometric entities contained in Book I of Euclid's *Elements, to appear in* Archive for History of Exact Sciences.

[9]*The most important of them were lost after only 300 years. Claude Ptolemy had the complete list of publications of Hipparchus, but not the main astronomical works themselves.*

[10]De facie quae in orbe lunae apparet *(On the light glowing on the Moon). The complete works of Plutarch were present in Newton's library.*

[11]*An English version of the argument can be found in: L. Russo,* The astronomy of Hipparchus and his time: a study on pre-Tolemaic sources, *Vistas in Astronomy **38** (1994), 207–248.*



Principia is almost the translation of Plutarch's rendering of the same concept. Likewise, the illustration (Comment after Definition 5) of centrifugal force through the example of the stone put in rotation through a sling is in Plutarch's *De facie*. Moreover, in the *Scholia*[12] of the *Principia* (published only in 1981!) Newton had inserted, without quotation, several chosen passages of *De facie*, including the full development of the above-mentioned ones, in which Plutarch argues that the Moon keeps going along its circular orbit and does not fall on the Earth by compensation between centripetal attraction and centrifugal force. The passage of Seneca in which Plutarch's theory of the motion of the Moon around the Earth is applied to explain the planetary motions—the center being this time the Sun—also appears, again without quotation, in the fragments, as well as another passage about the motions of the comets in *De mundi systemate Liber I*. What about the inverse square law? Again in the *Scholia* Newton gives credit for its discovery to Pythagoras (while in the *De mundi systemate Liber I* he credits the second king of Rome, the legendary Numa Pompilius, for the introduction of heliocentrism, suggesting, however, that he may have had it from the Egyptians). Hooke thought of deducing Kepler's laws out of the inverse square law before Newton and communicated his idea in a letter[13] to him. We learn then that the inverse square law can be traced back, through Boulliau, Kepler, Roger Bacon, to the above-mentioned *Architecture* of Vitruvius. The Hellenistic sources were thus forgotten by a kind of "double censorship" mechanism: first by Newton himself and second by his followers, who never published those of his works which could make clear his dependence on them.[14] Voltaire's invention of the tale of Newton's apple put the final seal to the matter.

[12]Scholia = *annotations on the original manuscript not appearing in the printed version.*

[13]*Whence the well-known controversy between the two.*

[14]*The* Scholia *related to the* Principia *were published only in 1981, and the* Treatise on Apocalypse *in 1994.*

Why then did Hellenistic science decline under the Roman empire and eventually disappear? Why, to begin with, did many Hellenistic works, even those among the most important, cease being copied well before Claude Ptolemy was writing the *Almagest* around 150 A.D.? Why did the selection process work in reverse, saving some of the worst and throwing away much of the best? This question is considered in Chapter 8. An example illustrates the author's argument. Imagine a slow but steady impoverishment of the deductive and quantitative contents of scientific culture, so that in time mathematics courses are no longer offered in colleges. Imagine also such a shortage of space that just a small fraction of the printed books can be conserved. Now take orbit theory and spacecraft navigation, namely, dynamical systems and celestial mechanics. What books would be selected after, say, 200 years? Poincaré's *Méthodes Nouvelles* and Siegel-Moser's *Lectures on Celestial Mechanics*, or just some descriptive book of today, richly illustrated with color pictures of fractals and coming with some (usually already outdated) software for computing orbits?

What about the general and steady (on the average) impoverishment of Hellenistic science under the Roman empire? This is a major historical problem, strongly tied to the even bigger one of the decline and fall of the antique civilization itself. I would summarize the author's argument by saying that it basically represents an application to science of a widely accepted general theory on decadence of antique civilization going back to Max Weber. Roman society, mainly based on slave labor, underwent an ultimately unrecoverable crisis as the traditional sources of that labor force, essentially wars, progressively dried up. To save basic farming, the remaining slaves were promoted to be serfs, and poor free peasants reduced to serfdom, but this made trade disappear. A society in which production is almost entirely based on serfdom and with no trade clearly has very little need of culture, including science and technology. As Max Weber pointed out, when trade vanished, so did the marble splendor of the ancient towns, as well as the spiritual assets that went with it: art, literature, science, and sophisticated commercial laws. The recovery of Hellenistic science then had to wait until the disappearance of serfdom at the end of the Middle Ages. To quote Max Weber: "Only then with renewed vigor did the old giant rise up again."

This book shows how complex and unstable the preservation of science is when the unit of time of historical observation is the millennium. The epilogue contains the (rather pessimistic) views of the author on the future of science, threatened by the apparent triumph of today's vogue of irrationality even in leading institutions (e.g., an astrology professorship at the Sorbonne). He looks at today's ever-increasing tendency to teach science more on a fideistic than on a deductive or experimental basis as the first sign of a decline which could be analogous to the post-Hellenistic one. I quote:

> As in the Roman empire age, the theoretical concepts, taken out of the theories assigning their meaning and considered instead real objects, whose existence can be apparent only to the initiated people, are used to amaze the public. In physics courses the student (now unaware of the experimental basis of heliocentrism or of atomic theory, accepted on the sole basis of the authority principle) gets addicted to a complex and mysterious mythology, with *orbitals* undergoing *hybridization*, elusive *quarks*, voracious and disquieting *black holes* and a creating *Big Bang*: objects introduced, all of them, in theories totally unknown to him and having no understandable relation with any phenomenon he may have access to.

If this concern is justified, then the present scientific revolution will in time be forgotten, and new Dark Ages are awaiting our descendants. In the words of Francis Bacon, quoted at the beginning of J. L. Borges' *The Immortal*:

> Solomon saith: there is no new thing upon the earth. So that as Plato had an imagination, that all knowledge was but remembrance; so Solomon giveth his sentence, that all novelty is but oblivion.

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Book Review

Women in Mathematics: The Addition of Difference

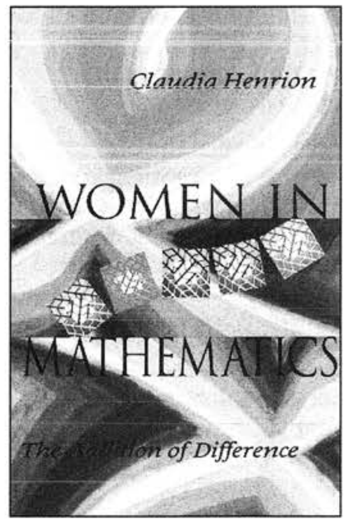
Reviewed by Ann Hibner Koblitz

Women in Mathematics: The Addition of Difference
Claudia Henrion
Indiana University Press, 1997
293 pages
Hardcover $39.95 (ISBN 0-253-33279-6)
Softcover $16.95 (ISBN 0-253-21119-0)

According to Claudia Henrion's introduction, this book is the product of years of research and has undergone many transformations during those years. At first, Henrion envisioned her work as a more or less straightforward depiction of the lives of a dozen or so successful women mathematicians. The message was essentially to be: "Since all of these women have created a niche for themselves in mathematics, other women can do the same" (p. xvii). Gradually, however, Henrion decided that:

> ...this approach to the book was only half the work. Two interrelated questions continued to surface, and were not adequately addressed by this initial vision. First, why is it that women continue to be significantly underrepresented in mathematics, particularly at the highest levels of accomplishment? And second, why is it that even the most successful women in mathematics, those who have already made it by standard measures of success, often continue to feel (to varying degrees) like outsiders in the mathematical community? (pp. xvii–xviii)

Henrion came to the conclusion that there was a more basic question to be considered: "Are there ways in which the practices and ideology of this [mathematical] community create an atmosphere that prevents women from being completely accepted as full-fledged members?" (p. xvii)



Addressing this question meant that Henrion would have to identify the "ideology" of the mathematical community and investigate the impact of this ideology on women. The book in its final incarnation is thus a collection of interviews with prominent women mathematicians interspersed with musings about the ideology of the mathematical community and debunking of certain widespread myths about mathematicians and mathematical productivity. Underlying the whole narrative is the suggestion that while the women interviewed could successfully use mathematics as a way of breaking free of general societal prejudices about women's roles, it was less easy to break away from stereotypes *within* the mathematical community. "In this sense, while they could use mathematics as a refuge from the conflicting expectations of society, it was harder to escape the sometimes confining expectations of mathematics" (p. xix).

From 1988 to 1993 Henrion interviewed eleven women, and in 1996 she had follow-up conversations with all but one (Vivienne Malone-Mayes, who died in 1995). The women are Joan Birman,

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Lenore Blum, Fan Chung, Marcia Groszek, Fern Hunt, Linda Keen, Malone-Mayes, Marian Pour-El, Judy Roitman, Mary Ellen Rudin, and Karen Uhlenbeck. All except Groszek and Keen are given their own sections. (Keen, however, is barely referred to in the body of the work.)

In many respects, the interviews are the greatest strength of the book. Henrion's portraits make the subjects come alive; particularly vivid are her depictions of Roitman and Malone-Mayes, though all the women stand out as exciting, vibrant, impressive personalities.

Henrion is skillful at using the life stories of her interviewees to challenge some common misconceptions about the nature of the mathematical enterprise. Among the myths she debunks are: "mathematicians work in complete isolation" (this chapter is amusingly entitled "Rugged Individualism and the Mathematical Marlboro Man" and uses the stories of Karen Uhlenbeck and Marian Pour-El to illustrate her point); "women and mathematics don't mix" (here Mary Ellen Rudin and Fan Chung are highlighted); "mathematicians do their best work in their youth" (Joan Birman is the main example, but the book is dotted with refutations of this myth from the lives of both female *and* male mathematicians); "mathematics and politics don't mix" (the profiles are of Lenore Blum and Judy Roitman); and "only white males do mathematics" (Vivienne Malone-Mayes and Fern Hunt take center stage). The last chapter, which Henrion acknowledges will be the most controversial among mathematicians, takes on two more notions that she considers to be myths:"mathematics is a realm of complete objectivity" and "mathematics is nonhuman."

Henrion makes several concrete suggestions for changing the image of mathematics projected both inside and outside of the mathematical community. For example, she maintains that mathematicians should work to cultivate images of themselves as social beings rather than loner-misfits. (This could be problematic for some people, both men and women, who appear attracted to mathematics in part because their lack of social skills will not be held against them; see comments later in this review.) Collaboration should be encouraged in practice as well as in the image of mathematical work presented to the world at large.[1] And the community should recognize the implications of the fact that many mathematicians—especially, perhaps, women—do their best work later in life than the stereotypes assume. The restriction of the Fields Medal to mathematicians under forty thus becomes very questionable, even outright sexist.

Henrion also includes some insightful comments about women mathematicians' lack of confidence in themselves and their undervaluing of their own research. She notes that there is a tendency for women "to submit articles to less prestigious journals than they might be considered for." (p. 78) In fact, some editors of less prominent journals have remarked that their best papers are written by women (p. 274), presumably because the women set their sights too low when they decide where to submit their work. This undervaluing of their own achievements by women mathematicians can easily fuel the prejudices of their male colleagues and result in the work of the women being minimized by the mathematical community as a whole. It has, after all, been well documented that male academics (seemingly unconsciously) tend to assign higher status to males than to females on the basis of entirely equivalent credentials. For example, when asked to decide at what level they would recommend (fictitious) candidates for an appointment, chairs of science and mathematics departments have suggested the females for lower ranks than the males, although the résumés were completely comparable. (The most famous studies of this phenomenon were chronicled by Roberta Hall and Bernice Sandler; Henrion has references to their and many other studies of the same type on p. 274.) This unconscious tendency of some males to devalue women's credentials can only be exacerbated when the women themselves do not adequately recognize the worth of their own contributions to the field.

Despite everything that is interesting about this book, however (and there are parts of it that I like exceedingly well), it has some significant problems. One annoyance is the repetition of the same quotes in different sections; one keeps getting the feeling, to quote Yogi Berra, of "déjà vu all over again." Also, it's not always clear who says what; Henrion's voice and that of her interviewees are not consistently distinguished. And there is an unevenness of research methodology that can be disconcerting. For example, studies of the mathematical community that were originally published in 1951, 1971, or 1991 are treated as if they are all equally relevant for an analysis of the situation in 1997. It is unfair, however, to use a forty-year-old (or older) source to support a criticism of the mathematical community today.

It is also unfair to contort the story of an eminent woman mathematician of the past to conform to the author's viewpoint. The fact that Hermann Weyl alluded disparagingly to Sofia Kovalevskaia in his famous aphorism about women

[1] *Henrion appears unaware of the extent of collaboration in the mathematical community at the present time. According to Andrew Odlyzko ("Scholars in Cyberspace," November 3, 1997, talk at Wilfrid Laurier University, Waterloo, Canada), from 1940 to 1994 the percentage of single-authored papers abstracted in* Mathematical Reviews *has decreased from about 93% of the total to about 57%. I am grateful to him for sending me further information on this question.*

in mathematics—"There have been only two women in the history of mathematics, and one of them [Kovalevskaia] wasn't a mathematician, while the other [Emmy Noether] wasn't a woman"—in no way says anything about how Kovalevskaia was treated by mathematicians *during her lifetime.* Kovalevskaia was a well-respected member of the mathematical community of her time, widely considered by her peers as one of the best mathematical analysts of the age, and was fully integrated into professional life.[2] Yet Henrion uses Weyl's misogynist aphorism, which came into currency a good forty years after Kovalevskaia's death, as proof that Kovalevskaia, like all women mathematicians, however prominent, was considered an outsider.

In the same way, Henrion makes chronologically jumbled generalizations when she uses her interviewees as sources. Take, for example, her discussion of the way hiring is managed in the mathematical community. Several of the women mathematicians say that they basically had their first, second, even third positions handed to them; Mary Ellen Rudin, in fact, claims never to have actually applied for a job in her life (p. 14). Henrion suggests that this situation is common, even universal, in the mathematical community today and that connections with prominent persons or groups are more important than individual merit. In support of this she quotes Karen Uhlenbeck:

> That's how you get a job. It's really bad the last few years. There were no jobs for a while, so that wasn't good. It hasn't gotten any better in the abstract because every place like this [University of Texas at Austin] gets 750 job applications. We can't process that. So you hire people that you hear about—which means that your pals call you up. So it's gone back to the 'good old boy' system without any question because we can't handle the paperwork. Nobody really desires that.... [But because of the paperwork], you hire people that you know. For instructors it's pretty much who your friends are out there, because they haven't even had the opportunity to publish their work. (p. 13)

If, indeed, Uhlenbeck said this, and if she meant it the way it sounds, the University of Texas appears to be leaving itself wide open for lawsuits. What is more curious to me, however, is that Henrion not only accepts this interpretation of present-day hiring practices as accurate but does not particularly object to such practices. Yet most mathematicians I approached about this categorically rejected Uhlenbeck's and Henrion's version of the hiring process. One (born 1948) said he had applied for all of his own jobs and can vouch for the fact that his department (in a major state university) reviews all applications for every opening. Moreover, he said that he personally has never received a call from a "pal" of the type that Uhlenbeck describes.[3] This does not, of course, mean that such things do not happen. Certainly Henrion's cataloguing of them in the past (especially from the 1940s through the 1970s), and perhaps in Texas today, appears to be accurate. What seems doubtful is that they are still the norm in the profession.

Exaggerated rumors about hiring practices can be quite harmful for young people desiring to become mathematicians. Women graduate students could get discouraged because they might believe that their advisers are not powerful enough to wangle jobs for them, or even because their advisers expect them to apply for their own positions in the normal way. In either case, Henrion's skewed and cynical picture could contribute to lower morale among women graduate students.

I have been married to a mathematician for over twenty-five years. Partly because of that, and partly because my own research is in the history and current status of women in mathematics and the sciences, I tend to associate a lot with mathematicians of both sexes. Much of my disquiet over Henrion's account stems from the extent to which I find it discordant with my own research and with my friends' experiences and perceptions. Take, for example, Henrion's insistence that women mathematicians feel themselves to be outsiders even when they are extremely successful. While I do not question the perception, I wonder to what extent this is gender-specific. Virtually all the mathematicians I know *of both sexes* like to style themselves as outsiders on occasion. In fact, several of Henrion's interviewees explicitly or implicitly cited the lone-wolf image of the mathematician as being attractive to them, presumably because it appeals to some aspect of their own personalities.

Is it not part of the folklore of the mathematical community that the profession does not ostracize loners? Henrion puts a negative spin on this part of the mathematician stereotype by mocking the "rugged individualism" of the "mathematical Marlboro man." I can certainly see her point that the loner image belies the extent of cooperation,

[2] *For more information on this, see my "Sofia Kovalevskaia and the Mathematical Community",* The Mathematical Intelligencer *6, no. 1 (1984). It was only after Kovalevskaia's death that her reputation suffered at the hands of certain mathematicians; for details see Koblitz, "Changing Views of Sofia Kovalevskaia," in* The Legacy of Sonya Kovalevskaya *(Linda Keen, ed.),* Contemp. Math., *vol. 64, Providence, RI: Amer. Math. Soc., 1987).*

[3] *Obviously, the reputation and prominence of the thesis adviser and the writers of letters of recommendation have an influence. That is not surprising or improper. But what Uhlenbeck claims is going on is a very different matter.*

collaboration, and community among mathematicians. But there is a positive side to the stereotype also, which Henrion herself implicitly acknowledges through her accounts of the eleven women mathematicians. Namely, the mathematical community tends to be more welcoming of eccentricity, diversity, and personal quirkiness than many other scholarly professions, my own (history) emphatically included. If those who chose mathematics had wanted to join a profession that expects conformity, they might have done better to become historians or political scientists!

The final chapter of Henrion's book, "The Quest for Certain and Eternal Knowledge," will no doubt arouse contradictory reactions in many readers. Henrion says that a series of questions informs her last chapter: "But what is the basis for this belief that mathematics is certain and eternal knowledge? Is it an accurate description of mathematics? What impact does it have on women? Are there other ways to think about mathematical knowledge?" (p. 235). Henrion points out that "the idea of proof is evolving, controversial, and subject to social negotiation" (pp. 245–6). It is a mistake, she argues, to equate mathematics with formal deductive reasoning, because this "presents an artificially narrow view of what mathematics is all about, and in this way is misleading, if not inaccurate" (p. 246). Henrion reminds us that intuition and aesthetic sense play as important a part in mathematics as does formal proof.

All well and good. There is little if anything here with which the vast majority of mathematicians would disagree. Henrion goes further, however. She says:

> Ultimately, it is misleading to speak of 'pure mathematics' untainted by human values, bias, and customs, and it is impossible to separate the product from the process, or mathematics from the mathematician or the mathematical community. Like all intellectual activity, mathematics has subjectivity woven into the fabric of its existence. (p. 250)

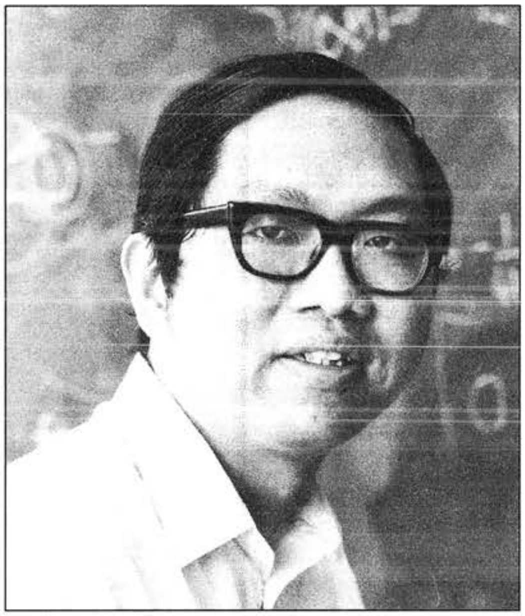
This stance would certainly please postmodern gender and science theorists such as Evelyn Fox Keller and Sandra Harding, to whom Henrion refers favorably. And statements such as these appear to place Henrion squarely on the side of the science critics in the current "Science Wars."[4] Henrion's stance, however, is less likely to appeal to most people who have direct experience of the nature of mathematical research and who have found it quite possible to separate the content of mathematics (the theorems) from the social aspects of the mathematical profession (questions of mathematical taste, allocation of resources, etc.). Such readers are apt to find Henrion's attempts to conflate mathematical content and community confusing, misguided, and ultimately unconvincing.

Despite these drawbacks, *Women in Mathematics* is worth reading. It is the kind of book that would make a provocative centerpiece for a math graduate student discussion group or for a meeting of an association of women mathematicians or scientists. Virtually no one in the mathematical community will agree with everything Henrion says. But the book will be useful for generating debate, and it makes an important contribution to scholarship on the interrelations of gender, mathematics, and culture in the U.S. in the second half of the twentieth century.[5]

[4] *Those unfamiliar with this debate (which has become exceedingly vitriolic in recent years) can consult Paul R. Gross and Norman Levitt,* Higher Superstition *(Baltimore, MD: Johns Hopkins Press, 1994) and Gerald Holton,* Science and Anti-Science *(Cambridge, MA: Harvard University Press, 1993) for the views of the "pro-science" camp. The collection* Science Wars, *edited by Andrew Ross (Durham, NC: Duke University Press, 1996), represents the "debunkers" of the scientific enterprise; among the more readable and reasonable pieces are those by Sandra Harding, Sharon Traweek, and Richard Levins. See also the articles by Michael Sullivan and Evans Harrell in the* Notices, *October 1996.*

[5] *My thanks to Judith Arms, Tom Duchamp, Neal Koblitz, Beth Ruskai, and Cora Sadosky for commenting on previous versions of this review.*

S.-T. Yau Receives National Medal of Science



Shing-Tung Yau

Shing-Tung Yau has received the National Medal of Science, the nation's highest scientific honor. On December 16, 1997, President Clinton presented medals to Yau and eight other laureates in a ceremony at the Old Executive Office Building in Washington, DC.

Established by Congress in 1959, the National Medal of Science is bestowed annually by the president on a select group of individuals "deserving of special recognition by reason of their outstanding contributions to knowledge in the physical, biological, mathematical, or engineering sciences." Congress expanded this definition in 1980 to recognize outstanding work in the social and behavioral sciences. In 1962 President John F. Kennedy awarded the first Medal of Science to the late Theodore Von Karman, president emeritus of aeronautical engineering at the California Institute of Technology. Including the 1997 winners, 353 individuals have been awarded the Medal of Science. In the past five years the National Medal of Science has been awarded to four who work in the mathematical sciences: Richard Karp and Steven Smale (1996), Martin Kruskal (1994), and Alberto Calderón (1992).

Yau was honored "for profound contributions to mathematics that have had a great impact on fields as diverse as topology, algebraic geometry, general relativity and string theory. His work insightfully combines two different mathematical approaches and has resulted in the solution of several long-standing and important problems in mathematics."

Shing-Tung Yau was born on April 4, 1949, in Kwuntung, China. He received his Ph.D. from the University of California, Berkeley, in 1971, where his advisor was S. S. Chern, who received the National Medal of Science in 1975. In 1971 Yau went to the Institute for Advanced Study (IAS) and the following year became an assistant professor at the State University of New York, Stony Brook. After that came appointments as professor at Stanford University (1974–79), professor at the IAS (1979–84), chair and professor at the University of California, San Diego (1984–87), and professor at Harvard University (1987–present). Currently he is also an adjunct professor at the Chinese University of Hong Kong. Yau held a Visiting Professorship and Sid Richardson Centennial Chair in Mathematics at the University of Texas at Austin in 1986 and was a Fairchild Distinguished Scholar at Caltech in 1990. During 1991–92, he was Wilson T. S. Wang Distinguished Visiting Professor at the Chinese University of Hong Kong and held a Special Chair at the National Tsing Hua University in Hsinchu, Taiwan.

Yau received a Fields Medal at the International Congress of Mathematicians in Warsaw in 1983. His other awards and honors include the AMS Veblen Prize (1981), the Carty Prize of the National Academy of Sciences (1981), a MacArthur Fellowship (1985), and the Crafoord Prize of the Royal Swedish Academy of Sciences (1994) (for an account of Yau's research, see the announcement of the Crafoord Prize, *Notices*, September 1994, page 794). He is a member of the National Academy of Sciences, the New York Academy of Sciences, and the American Academy of Arts and Sciences. He is a foreign member of the Chinese Academy of Sciences and a foreign academician of the Academia Sinica.

—Allyn Jackson

Andrew Wiles Receives Faisal Prize

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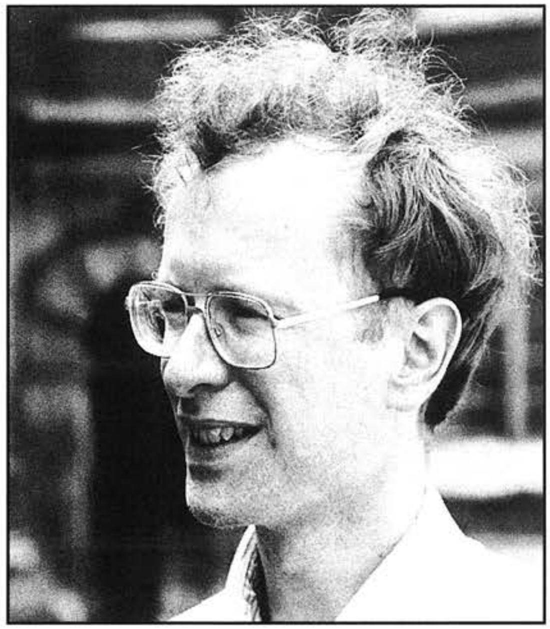

Andrew Wiles

For his proof of Fermat's Last Theorem, Andrew Wiles has received the 1998 King Faisal International Prize for Science. Wiles, the Eugene Higgins Professor of Mathematics at Princeton University, received the prize at a special ceremony in Riyadh, Saudi Arabia, on January 6, 1998. The prize consists of a $200,000 cash award and a commemorative gold medal. The prize citation noted that Wiles's contribution not only was a major addition to mathematical knowledge but also has had a positive influence on public perceptions of mathematics.

The King Faisal International Prize is presented by the King Faisal Foundation. The prize is divided into five general areas of expertise: service to Islam, Islamic studies, Arabic literature, science, and medicine. Science topics rotate among chemistry, biology, mathematics, and physics, with mathematics being the chosen topic for 1998. Previous recipients of the Faisal Prize in mathematics are Sir Michael Atiyah (1987) and Dennis Sullivan (1994).

In a set of lectures at the Isaac Newton Institute in Cambridge, England, in 1993, Andrew Wiles outlined the results of several years of solitary work that concluded in a proof of Fermat's Last Theorem. He also provided a proof of the Taniyama-Shimura Conjecture for semistable elliptic curves, which had been thought by many mathematicians to be totally inaccessible. This work was published in two papers, "Modular elliptic curves and Fermat's last theorem", by Wiles (Ann. of Math. (2) 141 (1995), no. 3, 443-551), and "Ring-theoretic properties of certain Hecke algebras", by Wiles and Richard Taylor (Ann. of Math. (2) 141 (1995), no. 3, 553-572).

Andrew John Wiles was born in Cambridge, England, on April 11, 1953. He attended Merton College, Oxford University, starting in 1971, and he received his B.A. there in 1974. That same year he went to Clare College, Cambridge University, earning his Ph.D. there in 1980.

From 1977 until 1980 Wiles was a Junior Research Fellow at Clare College and a Benjamin Peirce Assistant Professor at Harvard University. In 1981 he was a visiting professor at the Sonderforschungsbereich Theoretische Mathematik in Bonn, and later that year he was a member of the Institute for Advanced Study in Princeton. In 1982 he became a professor at Princeton University and in the spring of that year was a visiting professor at the Université de Paris, Orsay. On a Guggenheim Fellowship he was a visiting professor at the Institut des Hautes Études Scientifiques and at the École Normale Supérieure (1985-86). From 1988 to 1990 he was a Royal Society Research Professor at Oxford University. In 1994 he assumed his present position at Princeton.

Wiles was elected a Fellow of the Royal Society, London, in 1989. In 1995 he received the Schock Prize in Mathematics from the Royal Swedish Academy of Sciences. That same year he was awarded the Prix Fermat, presented by the Université Paul Sabatier and Matra Marconi Space. In 1996 Wiles received the Wolf Prize in mathematics and the Royal Medal of the Royal Society, London. Wiles was elected as a foreign member to the U.S. National Academy of Sciences in 1996 and also received the 1996 NAS Award in Mathematics (for an account of Wiles's research, see the announcement of the NAS Award, *Notices*, July 1996, page 760). In 1997 he received the historic Wolfskehl Prize, which was established in 1908 and which inspired thousands of people to attempt to prove Fermat's Last Theorem.

—Allyn Jackson

JPBM Communications Award Presented in Baltimore

Photograph by Sylvia Wiegand.

Constance Reid

The 1998 Communications Award of the Joint Policy Board for Mathematics (JPBM) was presented at the Joint Mathematics Meetings in Baltimore in January 1998. The award was established in 1988 to reward and encourage journalists and other communicators who, on a sustained basis, bring accurate mathematical information to nonmathematical audiences. The award recognizes a significant contribution or accumulated contributions to public understanding of mathematics. The JPBM consists of a small group of leaders from the AMS, the Mathematical Association of America, and the Society for Industrial and Applied Mathematics who work on projects of common interest to the three organizations.

The 1998 JPBM Communications Award was presented to Constance Reid. What follows is the award citation and her response upon receiving the award.

Citation

According to Martin Gardner, "No one today has written about mathematics with more grace, knowledge, skill and clarity than Constance Reid." *From Zero to Infinity*, her first book on mathematics, was published in 1955 and is now in its fourth edition. Turning to geometry, she wrote *A Long Way from Euclid*, the second edition due for publication by the MAA in 1998.

In the late sixties, her sister, Julia Robinson, suggested she do a book of short biographies of mathematicians. Instead of short biographies, she ended up doing several book-length biographies. *Hilbert*, the first of those, was published to great acclaim in 1970.

As a biographer she has always chosen to write about mathematicians whose contributions to mathematics have gone beyond their mathematical research. She followed Hilbert with the lives of Richard Courant, Jerzy Neyman, and E. T. Bell.

Of her Courant biography, Gerald L. Alexanderson, president of the Mathematical Association of America, says: "When *Courant* came out, I read it in one sitting, way into the night. It was as gripping for me as a mystery novel. A good mystery novel. Her ability to grab the attention of both professional and nonprofessional audiences and get them involved in mathematics and mathematical culture is extraordinary."

In collaboration with Donald J. Albers and G. L. Alexanderson, she also edited *More Mathematical People* and an illustrated history of the International Mathematical Congresses.

Her most recent work, *Julia, A Life in Mathematics*, gives us a personal, warm, and inspirational portrait of her sister, Julia Robinson, one of the great mathematicians of the twentieth century. Carol Wood, former president of the Association for Women in Mathematics, calls the book a "small treasure. I can think of no better advice to give a young mathematician than 'Be like Julia'."

She has won many other awards for her writing, including both the Pólya Prize and the Beckenbach Book Prize of the Mathematical Association of America.

John Ewing, executive director of the American Mathematical Society, reflecting on her work, says: "She has a special talent for understanding mathematicians and their culture. She understands us.

She is the Boswell for mathematics—a biographer who has made the mathematical life understandable both to the general public and to mathematicians themselves. Her work has enriched our entire profession."

Response

I am very honored to receive the Communications Award of the Joint Policy Board for Mathematics.

I am also pleased because it gives me an opportunity to acknowledge five individuals who by their interest in communicating mathematics have played a role in my career.

The first of these was Robert L. Crowell, who, reading a housewife's article on perfect numbers in *Scientific American*, invited her to do "a little book on numbers" for his family publishing firm, a kind of firm that unfortunately no longer exists.

The second and the third were my sister and brother-in-law, Julia and Raphael Robinson, who were like most mathematicians eager to communicate the joys of their subject. Their attitude was that if they could interest Julia's nonmathematical sister, Constance, in mathematics, why couldn't she interest others? To a certain extent they risked their professional reputations to back me, first in writing *From Zero to Infinity* and then in writing the life of the incomparable German mathematician David Hilbert—an audacious project.

The fourth is Klaus Peters, now the president of AK Peters Ltd., but at that time the mathematics editor of Springer-Verlag. It was Klaus who dared to take a life of Hilbert written by a woman who was not a mathematician, who was not a German, who had not personally known Hilbert and publish it under the distinguished imprint of Springer.

The fifth is Don Albers, the publications director of the Mathematical Association of America, who is simply indefatigable in his efforts to urge others to communicate the charm and excitement and reality of mathematics. But, in addition, in my own case he has permitted me to essentially design my last two books, *The Search for E. T. Bell* and *Julia, A Life in Mathematics*—for me, another part of the communication process in which I have not been able to participate in the past.

So I accept with great pleasure the Communications Award of the Joint Policy Board, both for myself and for these five who have played such important roles in my own career—and, may I also say, for everyone from research mathematicians to high school teachers—who make the effort to communicate to others the beauty of the subject that a great mathematician called "the Queen of the Sciences" and an unknown poet described as always "fresh as May."

Hail Community College
Hail, Saudi Arabia

under the auspices of King Fahd University of Petroleum & Minerals Dhahran, Saudi Arabia

Department of Mathematical Sciences
Lecturers for the Preparatory Year Math Program

Opening in September 1998, Hail Community College will provide a two-year English-medium program of technical higher education to male students of the north-central region of Saudi Arabia. Students will pursue either the two-year diploma or follow the university transfer program. The College will open with approximately 500 students enrolled in the pre-college Preparatory Year Program consisting of 20 hours weekly of intensive English for academic purposes, four hours of math, two hours of physical education, and two hours of shop/drafting/mechanical engineering. The Preparatory Year Program will replicate their counterparts at the KFUPM campus in Dhahran, using the same curriculum, materials and examinations. Support in all aspects of the new college will be provided by KFUPM administration.

The Hail Preparatory Program invites applications for qualified, experienced, flexible and enthusiastic lecturers for its Preparatory Year math program to start in September and February of each year. Lecturers teach pre-calculus and calculus courses in English. **Minimum qualifications:** MA in mathematics or MS degree equivalent to the degree awarded by European or North American universities. Preferences will be given to candidates with either college-level or IGCSE A-level teaching experience.

Compensation: Competitive salaries depending on qualifications and experience, monthly local transportation allowance, end-of-year service gratuity. **Benefits:** according to the policy of the College. Married and single status appointments (no international school facilities are available in Hail for school age children), rent-free, air-conditioned, furnished accommodation including basic utilities, free in-Kingdom health care, two-months' paid summer leave each year, recreational facilities, annual flights to and from Hail, faculty computer facilities including free e-mail access. More information about the nature of the program or Hail city is available. **Contract:** two years renewable.

Send your resume and a cover letter of application to:

Dean of Hail Community College
King Fahd University of Petroleum & Minerals
Dept. No. 1098
P.O. Box 5085
Dhahran 31261, Saudi Arabia

AWM Prizes Presented in Baltimore

At the Joint Mathematics Meetings in Baltimore in January 1998, the Association for Women in Mathematics (AWM) presented two prizes.

Hay Award for Contributions to Education

In 1990 the AWM established the Louise Hay Award for Contributions to Mathematics Education. The purpose of this award is to recognize outstanding achievements in any area of mathematics education, to be interpreted in the broadest possible sense. Named for Louise Hay, who was head of the Department of Mathematics, Statistics, and Computer Science at the University of Illinois at Chicago, the award is intended to highlight the importance of mathematics education and to evoke the memory of all that Hay exemplified as a teacher, scholar, administrator, and human being.

The 1998 Hay Award was presented to DEBORAH HUGHES HALLETT of Harvard University and the University of Arizona. The citation for the award calls Hughes Hallett a "first rate classroom teacher as well as a strong administrator." It goes on to say that "she has a unique ability to get into students' minds, to work out what they are missing, and to devise a new way to explain something that overcomes the obstacle." Hughes Hallett is part of the group that developed the so-called "Harvard calculus" book that has been much praised and much debated. "The controversy surrounding it shows how truly innovative it is," the citation notes. She has also been a major figure in national discussions of mathematics education at the K–12 and collegiate levels.

Schafer Prize for Undergraduate Women

In 1990 the AWM established the Alice T. Schafer Prize for Excellence in Mathematics by an Undergraduate Woman. The prize recognizes high achievement in mathematics by a female undergraduate student. The prize is named for Alice T. Schafer, professor emerita of Wellesley College and one of the founders of AWM.

The 1998 Schafer Prize was awarded jointly to SHARON ANN LOZANO of the University of Texas at Austin and JESSICA A. SHEPHERD of the University of Utah.

Sharon Ann Lozano is a senior mathematics major whose academic record places her in the top one percent of over 500 mathematics majors. Her honors thesis, written under the direction of Mary Wheeler, involves numerical modeling of surface water flow. The prize citation quotes one of Lozano's professors as saying: "Sharon is an extraordinary individual and brings to mathematics an excitement and vitality that enlivens the possibilities for the future of the profession."

Jessica A. Shepherd is a senior mathematics major with a minor in computer science. The citation notes that many of her professors say she is the strongest undergraduate mathematics student they have seen in decades at Utah and that she is on a par with their strongest graduate students. She is the co-author of two research papers. Quoted in the citation, one of her professors says: "Jessica has a superb intellect and tremendous drive and discipline. She has the potential to become an intellectual leader."

JIE LI of the University of Michigan was cited as runner-up for the Schafer Prize, and PATIENCE MORENO of Carnegie Mellon University and VERA PESHCHANSKY of the Polytechnic Institute of Brooklyn were named as honorable mentions.

—from AWM Announcements

MAA Prizes Presented in Baltimore

The Mathematical Association of America (MAA) presented a number of prizes during the Joint Mathematics Meetings in Baltimore in January 1998.

Distinguished Service Award

Alice T. Schafer of Wellesley College (retired) received the Yueh-Gin Gung and Dr. Charles Y. Hu Award for Distinguished Service to Mathematics. First presented in 1990, this is the MAA's most prestigious award, given in recognition of distinguished service to the mathematical community.

"The curriculum vitae of Alice T. Schafer lists two specializations: abstract algebra (group theory) and women in mathematics," the citation notes. "Her career as a mathematics educator evolved into her becoming a champion for the cause of full participation of women in mathematics." She was one of the prime movers in the founding of the Association for Women in Mathematics in 1971. The citation concludes, "Professor Schafer is known for her love of people, her boundless energy, and her fierce determination for a just cause."

Haimo Teaching Awards

The 1998 Deborah and Franklin Tepper Haimo Awards for Distinguished College or University Teaching of Mathematics were presented to three recipients: Colin C. Adams of Williams College, Rhonda L. Hatcher of Texas Christian University, and Rhonda J. Hughes of Bryn Mawr College.

According to the prize citation, Colin C. Adams has had "a tremendous positive effect on Williams students. He is unique in the quality of his exposition of mathematics, amazingly creative and energetic." He has played a crucial role in the doubling of mathematics enrollments at Williams and in the tripling of the number of mathematics majors.

Rhonda L. Hatcher was honored for being "one of the finest, most conscientious teachers" on the campus. "Her classes buzz with excitement," the citation says; "her students are having fun learning nontrivial mathematics. Not only is Professor Hatcher a first-rate teacher, she is also an excellent scholar."

"Professor Hughes is the consummate teacher," says the citation for Rhonda J. Hughes. Not only has she had a "profound influence on students at all levels," but she also has a vision of what constitutes a successful mathematics program and has built just that at Bryn Mawr. Since she arrived there in 1980, the number of mathematics majors has grown from 3 to 23 per year.

Beckenbach Book Prize

Sherman Stein of the University of California, Davis, and Sándor Szabó of the University of Bahrain have received the Beckenbach Book Prize for distinguished, innovative books published by the MAA.

Stein and Szabó received the prize for their book, *Algebra and Tiling*, Carus Mathematical Monograph Number 25, 1994. The citation calls the book "a simultaneously erudite and inviting exposition of this substantial and timeless area of mathematics."

Chauvenet Prize

Alan Edelman of the Massachusetts Institute of Technology and Eric Kostlan of Real Time Solutions, Berkeley, California, received the Chauvenet Prize. This prize is given for an outstanding expository article on a mathematical topic by a member of the MAA.

Edelman and Kostlan received the prize for their article, *How many zeroes of a random polynomial are real?*, Bulletin of the AMS (N.S.) **32** (1995). "The connections this subject has with ongoing research make it important that readers have a clear, interesting, and very accessible account of it," the citation says. "This Edelman and Kostlan have provided for us."

Certificates for Meritorious Service

Certificates of Meritorious Service are presented by the MAA in recognition of service to the MAA at the national level for service to a Section of the MAA. The following individuals received Certificates of Meritorious Service: Linda R. Sons, Northern Illinois University; Harold L. Thomas, Pittsburg State University; Christine Shannon, Centre College; Curtis N. Cooper, Central Missouri State University; Henry L. Alder, University of California, Davis; Howard E. Bell, Brock University; and Jenanathan Sriskandarajah, University of Wisconsin.

—from MAA News Releases

NSF Fiscal Year 1999 Budget Request

This article is the 26th in an annual series of reports outlining the president's request to Congress for the NSF budget. Last year's report appeared in the June/July 1997 issue of the Notices, *pages 690–693.*

On February 2, 1998, President Clinton presented his budget for fiscal year 1999 to Congress, marking the first time in thirty years that a president produced a balanced budget. There is much the scientific community can cheer about, for the budget contains a 2.6% increase for research and development overall and a 7.8% increase for basic civilian research. These increases are rather surprising, after the dire prognostications over the last several years of ever-leaner budgets for scientific research. But they also are the result of hard work by a coalition of leaders of about one hundred scientific societies, including the AMS, who have for the past year been making the case for support of science. Their efforts have paid off, not only in the strong showing of science in the Clinton budget, but also in the bipartisan support science enjoys in Congress.

Still, the road from request to appropriation can be a long and rocky one. As an example of the kinds of delays that can occur, consider that at the time President Clinton presented this budget request, the National Science Foundation (NSF) had still not received from Congress final approval for the current fiscal year (fiscal year 1998), which had started four months earlier. In addition, some Republicans claim that the Clinton budget's projections are overly optimistic.

There are other obstacles as well. In August 1997 President Clinton signed into law spending caps on discretionary funding. With the caps, nondefense R&D spending would be $4 billion less than the amount proposed in the budget request. To get around the caps, the president has proposed the formation of the "Research Fund for America" (also called the "21st Century Research Fund"), which encompasses the NSF and most programs supporting nondefense R&D. The fund would provide the additional $4 billion needed to bring spending on these programs up to the requested level. One difficulty is that $3.6 billion of that amount is to come from the settlement with tobacco companies. Congress has not approved a tobacco settlement, and any such legislation will likely prove highly contentious. In addition, it is unclear that Congress will agree to this attempt to exceed the spending caps set last year.

Assuming that the Clinton request becomes reality, the budget of the NSF would grow from $3.5 billion to $3.8 billion, an increase of around 9%. Within the NSF, mathematics has done quite well. One of the biggest initiatives at the NSF is Knowledge and Distributed Intelligence, which has a strong mathematics component and a requested budget of $78 million (see `www.nsf.gov/kdi/` for further information). The Mathematical and Physical Sciences (MPS) Directorate would receive an increase of $76.3 million or 10.7%, which is the largest dollar increase and the smallest percentage increase of all the NSF research directorates. The big winner among the divisions in the MPS is the Division of Mathematical Sciences (DMS), which is slated for a hefty 17.4% increase. The MPS budget document singles out "fundamental and applied mathematics" as one of its priority areas. This is the first time in the history of DMS that an increase was proposed that put it over the $100 million mark. Table 3 tracks the growth of the DMS budget over fifteen years, showing healthy constant-dollar increases after the 1984 appearance of the David Report and spotty growth since the late 1980s. Since 1994 the DMS has done fairly well, considering the weak pattern of growth for the NSF budget overall. In this period any growth in the DMS budget has stemmed from the Division's active participation in NSF initiatives.

Donald J. Lewis, director of the DMS, is happy but cautious about the requested increase for his division. Even if the increase emerges unscathed from the appropriations process, he points out that a certain amount will be taken out in the form of "taxes" that go to support NSF programs that stretch across several disciplines, such as the Office of Multidisciplinary Activities (OMA) or a program for research instrumentation. The money is not entirely lost to mathematics though, because the programs receiving the taxes are ones to which mathematicians may submit proposals. For example, Lewis notes that in recent years mathematicians have received $5-$7 million per year in grants from the OMA. How large the taxes might be for fiscal 1999 is not clear yet. As an example, Lewis notes that although the fiscal year 1997 budget for the DMS is officially $92.9 million, the DMS really had only about $90 million to spend after the taxes were taken out. Nevertheless, Lewis is optimistic about the 1999 budget request, which he says shows that "mathematics was getting a good reading" within the NSF. The director of MPS, Robert Eisenstein, is impressed with the work the DMS has supported and was the main force behind the division's large increase.

This increase is broken out into two components: Research Project Support, which would rise 12.7% (from $70.2 million to $79.1 million), and Infrastructure Support, which would rise 29.6% (from $27 million to $35 million). Research Project Support provides funding for principal investigator grants. Of the additional $8.9 million requested for this part of the DMS budget, about $6 million would be used to increase the size and duration of grants given to the most promising investigators. The increase in size can come in any grant component, including investigator salary. Right now a substantial proportion of DMS-supported investigators receive only one-month summer salary support. Many will bemoan the fact that the new funds would not be used to increase the number of grants DMS gives. The reason can be traced to the National Science Board, the policy-making body of the NSF, which has concluded that the NSF needs to increase the size and duration of its grants. In addition, the Office of Management and Budget specifically directed the NSF to increase grant size and duration in fiscal year 1999. Because grants in mathematics are already smaller than those in other areas, the pressure on the DMS to increase grant size is considerable. The remaining $2.9 million in the increase for Research Project Support would go toward grants in mathematics that con-

Table 1: National Science Foundation (Millions of Dollars)

	1995 Actual	Change	1996 Actual	Change	1997 Actual	Change	1998 Plan	Change	1999 Request
(1) Mathematical Sciences Research Support	$ 85.3	2.8%	$ 87.7	5.9%	$ 92.9	4.6%	$ 97.2	17.4%	$ 114.1
(2) Other Research Support (Note a)	2439.6	-2.4%	2381.0	2.8%	2447.2	5.7%	2586.0	9.3%	2826.7
(3) Education and Human Resources (Note b)	611.9	-1.7%	601.2	3.0%	619.1	2.2%	632.8	7.9%	683.0
(4) Salaries and Expenses (Note c)	133.5	2.2%	136.5	2.3%	139.6	1.6%	141.8	5.2%	149.2
(5) Totals	3270.3	-2.0%	3206.3	2.9%	3298.8	4.8%	3457.8	9.1%	3773.0
(6) (1) as a % of the sum of (1) and (2)	3.38%		3.55%		3.66%		3.62%		3.88%
(7) (1) as a % of (5)	2.61%		2.73%		2.82%		2.81%		3.02%

Note a: Support for research and related activities in areas other than the mathematical sciences. Includes scientific research facilities and instrumentation, and the Antarctic program. **Note b:** The programs in this category provide support in all fields, including the mathematical sciences. **Note c:** Administrative expenses of operating the Foundation, including the Office of Inspector General.

Table 2: Directorate for Mathematical and Physical Sciences (Millions of Dollars)

	1995		1996		1997		1998		1999	
	Actual	% of Total	Actual	% of Total	Actual	% of Total	Plan	% of Total	Request	% of Total
(1) Mathematical Sciences	$ 85.3	(13.2%)	$ 87.7	(13.3%)	$ 92.9	(13.4%)	$ 97.2	(13.6%)	$ 114.1	(14.4%)
(2) Astronomical Sciences	102.5	(16.0%)	108.7	(16.5%)	113.5	(16.4%)	117.8	(16.5%)	128.0	(16.2%)
(3) Physics	130.0	(20.1%)	131.9	(20.0%)	138.6	(20.0%)	148.5	(20.7%)	171.9	(21.7%)
(4) Chemistry	123.1	(19.1%)	127.7	(19.3%)	133.7	(19.3%)	135.6	(18.9%)	148.0	(18.7%)
(5) Materials Research	174.8	(27.1%)	175.1	(26.5%)	185.0	(26.7%)	186.6	(26.1%)	200.0	(25.2%)
(6) Office of Multidisciplinary Activities	29.5	(4.6%)	29.5	(4.5%)	29.8	(4.3%)	30.0	(4.2%)	30.0	(3.8%)
(7) Totals	645.2	(100.0%)	660.5	(100.0%)	693.5	(100.0%)	715.7	(100.0%)	792.0	(100.0%)

tribute to some of the areas of emphasis for the MPS in 1999, including research on the origins of the universe, on the "quantum realm," and on phenomena at the molecular level.

Infrastructure Support provides funding for a number of DMS activities, including institutes, conferences, and postdoctoral fellowships. The recompetition for the mathematics institutes is taking place this year; the deadline for proposals was in early February 1998. The DMS cannot release the exact number of proposals in the competition, but they say it is between ten and twenty. Lewis says the DMS will fund up to five grants, though some of these may be quite different from the current institutes in Berkeley and Minneapolis. About $0.5 million in the increase for Infrastructure Support would be set aside to allow flexibility in institute funding; $4.5 million of the increase would go into the VIGRE program (Vertically Integrated Grants for Research and Education in the Mathematical Sciences). VIGRE provides grants for mathematics departments for integrating efforts to improve research and education opportunities for undergraduate and graduate students and for postdocs. The remainder of the increase, $3 million, is slated for a program which would be run in collaboration with the Department of Education and would focus on improving the training and background of K-8 mathematics teachers. The DMS did not volunteer to become involved in this program; higher-ups at the NSF saw DMS involvement as a way of bringing in mathematics departments rather than focusing only on schools of education to improve the training of mathematics teachers.

—Allyn Jackson

Note on the tables: Last year the tables traditionally presented in the Notices *were amended to eliminate the Science and Technology Centers as a separate line item, since the funding for this budget component has reverted from a central office at the NSF to the disciplinary divisions. Because this change makes comparisons with past tables more difficult, this year Table 3 provides information going back fifteen years, prior to the establishment of the Science and Technology Centers program.*

Table 3: 15-Year Compilation of the NSF Budget, 1984–1999 (Millions of Dollars)

	1984 Actual	1985 Actual	1986 Actual	1987 Actual	1988 Actual	1989 Actual	1990 Actual	1991 Actual	1992 Actual
(1) Mathematical Sciences Research Support	$ 41.2	$ 47.7	$ 51.9	$ 59.9	$ 63.8	$ 66.0	69.3	73.1	78.4
Constant Dollars	*39.7*	*44.3*	*47.4*	*52.7*	*53.9*	*53.2*	*53.0*	*53.7*	*55.9*
(2) Other Research Support	1137.2	1302.6	1283.8	1390.3	1434.7	1557.5	1637.5	1913.9	1913.4
Constant Dollars	*1094.5*	*1210.6*	*1171.4*	*1223.9*	*1212.8*	*1256.0*	*1252.9*	*1405.2*	*1363.8*
***(3) Education and Human* Resources**	60.3	84.7	85.7	99.6	139.6	171.1	220.6	322.0	441.4
Constant Dollars	*58.0*	*78.7*	*78.2*	*87.7*	*118.0*	*138.0*	*168.8*	*236.4*	*314.6*
(4) Salaries and Expenses	66.3	72.0	71.8	77.8	84.5	91.3	98.7	104.1	113.9
Constant Dollars	*63.8*	*66.9*	*65.5*	*68.5*	*71.4*	*73.6*	*75.5*	*76.4*	*81.2*
(5) Totals	1305.0	1507.0	1493.2	1627.6	1722.6	1885.9	2026.1	2413.1	2547.1
Constant Dollars	*1256.0*	*1400.6*	*1362.4*	*1432.8*	*1456.1*	*1520.9*	*1550.2*	*1771.7*	*1815.5*

Table 3 continued

	1993 Actual	1994 Actual	1995 Actual	1996 Actual	1997 Actual	1998 Plan	1999 Request	1984–1997 Increase	1984–1999 Increase
(1) Mathematical Sciences Research Support	$ 77.6	$ 78.0	$ 85.3	$ 87.7	$ 92.9	97.2	114.1	125.5%	176.9%
Constant Dollars	*53.7*	*52.6*	*56.0*	*55.9*	*57.9*			*45.8%*	
(2) Other Research Support	2052.5	2212.8	2439.6	2381.0	2447.2	2586.0	2826.7	115.2%	148.6%
Constant Dollars	*1420.4*	*1493.1*	*1600.8*	*1517.5*	*1524.7*			*39.3%*	
(3) Education and Human Resources	505.1	569.0	611.9	601.2	619.1	632.8	683.0	926.7%	1032.7%
Constant Dollars	*349.6*	*383.9*	*401.5*	*383.2*	*385.7*			*565.0%*	
(4) Salaries and Expenses	114.5	127.4	133.5	136.5	139.6	141.8	149.2	110.6%	125.0%
Constant Dollars	*79.2*	*86.0*	*87.6*	*87.0*	*87.0*			*36.4%*	
(5) Totals	2749.7	2987.2	3270.3	3206.3	3298.8	3457.8	3773.0	152.8%	189.1%
Constant Dollars	*1902.9*	*2015.7*	*2145.9*	*2043.5*	*2055.3*			*63.6%*	

Current dollars are converted to constant dollars using the Consumer Price Index (based on prices during 1982–84).

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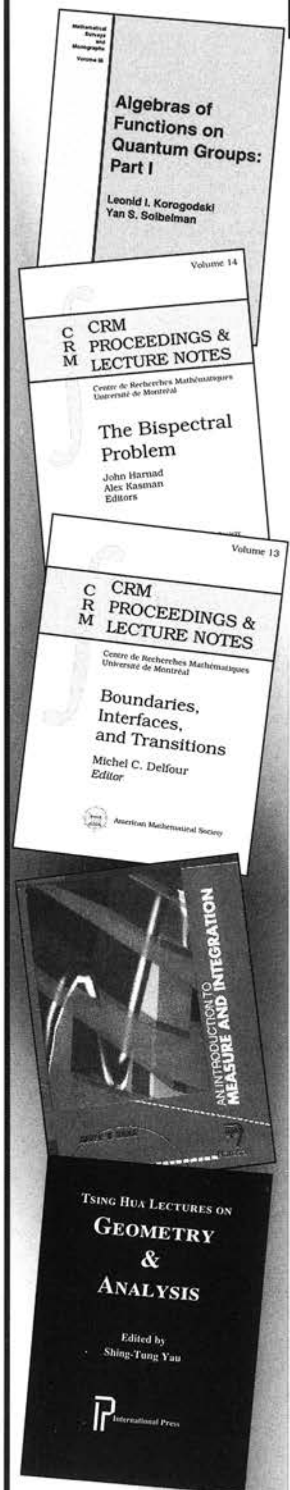

Independent Study

Algebras of Functions on Quantum Groups: Part I

Leonid I. Korogodski and **Yan S. Soibelman**, *Institute for Advanced Study, Princeton, NJ*

The book is devoted to the study of algebras of functions on quantum groups. The authors' approach to the subject is based on the parallels with symplectic geometry, allowing the reader to use geometric intuition in the theory of quantum groups. The book includes the theory of Poisson-Lie algebras (quasi-classical version of algebras of functions on quantum groups), a description of representations of algebras of functions and the theory of quantum Weyl groups. This book can serve as a text for an introduction to the theory of quantum groups.

Mathematical Surveys and Monographs; 1998; 150 pages; Hardcover; ISBN 0-8218-0336-0; List $49; All AMS members $39; Order code SURV/56RT85

The Bispectral Problem

John Harnad and **Alex Kasman**, *Centre de Recherches Mathématiques, Université de Montréal, PQ, Canada*, Editors

Although originally posed in the context of mathematical problems related to medical imaging, the bispectral problem is now closely related to other topics and has connections to many areas of pure and applied mathematics. The central theme of this book is the search for solutions to eigenvalue problems that satisfy additional equations in the spectral parameter, for example, pairs of eigenvalue equations. This problem, which looks very simple at first, has turned out to be both deep and difficult. Moreover, this concept of bispectrality has been shown to be useful in many active areas of current research in mathematics and physics.

Following several years of exciting new results on the subject, in March 1997 the Centre de Recherces Mathématiques held the first scientific meeting devoted exclusively to the bispectral problem. Collected in this volume are contributions from the speakers at this meeting. The participants at this workshop included a majority of those researchers who have made significant contributions to the subject and many others working on related problems.

CRM Proceedings & Lecture Notes, Volume 14; 1998; 235 pages; Softcover; ISBN 0-8218-0949-0; List $65; Individual member $39; Order code CRMP/14RT85

Boundaries, Interfaces, and Transitions

Michel C. Delfour, *Centre de Recherches Mathématiques, Montréal, PQ, Canada*, Editor

There is currently considerable mathematical interest and very real potential for applications in using geometry in the design, identification and control of technological processes. Geometry plays the role of a design variable in the shape optimization of mechanical parts. It also appears as a control variable in optimal swimming, shape control of aircraft wings or stabilization of membranes and plates by periodic variations of the boundary. As it is used as a design or control variable, it often undergoes "mutations" as in the microstructures of materials, crystal growth, image processing or the texture of objects which involve relaxations of classical geometry and geometrical entities. In other areas, such as free and moving boundary problems, the understanding of the underlying phenomena is very much related to the geometric properties of the fronts and the nature of the nonlinearities involved.

This book brings together tools that have been developed in a priori distant areas of mathematics, mechanics and physics. It provides coverage of selected contemporary problems in the areas of optimal design, mathematical models in material sciences, hysteresis, superconductivity, phase transition, crystal growth, moving boundary problems, thin shells and some of the associated numerical issues.

CRM Proceedings & Lecture Notes, Volume 13; 1998; approximately 352 pages; Softcover; ISBN 0-8218-0505-3; List $95; Individual member $57; Order code CRMP/13RT85

Deformations of Galois Representations and Hecke Algebras

J. Tilouine, *Université de Paris Nord, Villetaneuse, France*

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

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

1996; 108 pages; Softcover; ISBN 81-7319-106-9; List $24; All AMS members $19; Order code DGRRT85

Supplementary Reading

An Introduction to Measure and Integration

Inder K. Rana, *Indian Institute of Technology, Pawai*

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

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

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

1997; 380 pages; Hardcover; ISBN 81-7319-120-4; List $49; All AMS members $39; Order code IMIRT85

Tsing Hua Lectures on Geometry & Analysis

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

This book presents lectures given during a seminar organized by S.-T. Yau at Tsing Hua University (Taiwan). Included are lectures by experts in the field and students who studied under Yau. Contributions by guest lecturers and students made this a lively and successful seminar.

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

International Press; 1997; 322 pages; Hardcover; ISBN 1-57146-042-X; List $42; All AMS members $34; Order code INPR/25RT85

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Mathematics People

Kuijlaars Receives Popov Prize

A. B. J. KUIJLAARS has received the Popov Prize for outstanding research in approximation theory. The prize was presented on January 4, 1998, during the Approximation Theory IX Conference in Nashville, Tennessee. Created in memory of Vasil Popov and his many contributions to approximation theory, the prize is restricted to mathematicians who have held the doctorate for less than six years.

Kuijlaars was cited for his innovative work on Chebyshev quadrature problems for the sphere in arbitrary dimensions, his solutions of several difficult problems posed by V. Totik concerning approximation by polynomials with varying weights, and his contributions to asymptotic theory for minimum energy point arrangements on the sphere.

Kuijlaars did his undergraduate studies in mathematics at the Technical University in Eindhoven, the Netherlands, and his graduate work at the University of Utrecht under the direction of Emile Bertin. After completing his Ph.D. in 1991, Kuijlaars took a postdoctoral position at the University of Amsterdam, where he worked closely with Jaap Korevaar. Kuijlaars spent two semesters in the U.S., where he collaborated with Ed Saff at the University of South Florida and Walter Gautschi at Purdue University. Kuijlaars is now at the Katholieke Universiteit in Leuven, Belgium.

The Popov Prize was first awarded in 1995 to Albert Cohen. The selection committee for the 1998 prize consisted of Charles Chui, Ron DeVore, Paul Nevai, Pencho Petrushev, Allan Pinkus, and Ed Saff. The third Popov Prize will be awarded in 2001.

—from announcement of the Popov Prize Committee

NSF Program for Women

The National Science Foundation has made about 100 awards in its Professional Opportunities for Women in Research and Education (POWRE) program. POWRE supports activities designed to promote the development of scholarly and institutional leaders in research and education. The former Visiting Professorships for Women, Faculty Awards for Women, Research Planning Grants for Women, and Career Advancement Awards for Women programs have been integrated and incorporated into the POWRE program.

Among the POWRE awardees are a number who work in the mathematical sciences. They are listed below, together with their affiliations and the titles of their projects. MIN CHEN, Pennsylvania State University, Study of model equations for water waves; ZHILAN FENG, Purdue University, Mathematical models for host-parasite systems; RUTH E. GORNET, Texas Tech University, Spectral geometry of nilmanifolds and Kleinian groups; SUSAN LANDAU, University of Massachusetts, Amherst, Certification of security protocols; GAIL LETZTER, Virginia Polytechnic Institute, New constructions for quantized and classical enveloping algebras; DEBORAH NOLAN, University of California, Berkeley, Statistics: Research, education, and application; and SUELY OLIVEIRA, Texas A&M University, New numerical algorithms for particle transport and integral equations.

—from NSF announcement

Deaths

EUGENE J. GEHRIG, of Chicago, IL, died on October 18, 1997. Born on September 23, 1925, he was a member of the Society for 39 years.

DENNIS M. GIRARD, of the University of Wisconsin-Green Bay, died on December 10, 1997. Born in 1939, he was a member of the Society for 27 years.

THIRZA A. MOSSMAN, of Manhattan, KS, died on October 10, 1997. Born on March 8, 1895, she was a member of the Society for 74 years.

GYORGY TARGONSKI, professor emeritus, University of Marburg, Germany, died on January 10, 1998. Born on March 27, 1928, he was a member of the Society for 34 years.

About the Cover

The computer-generated image "Twisted Symmetries" is reproduced with the permission of Michael Field and Martin Golubitsky of the University of Houston. The quilt is a pattern of symmetry type **pg4** and was created using methods based on iterated function systems.

Invited Speakers for ICM-98

The International Congress of Mathematicians (ICM) 1998 will be held in Berlin, Germany, August 18–27, 1998. Presented below are the names and affiliations of individuals invited to present lectures at the Congress. For further information, consult the ICM Web site http://elib.zib.de/ICM98/. The ICM Second Announcement appeared in the February 1998 issue of the *Notices*, pages 317–341.

Plenary Speakers

Jean-Michel Bismut, U. Paris-Sud, Orsay, France; Christopher Deninger, U. Münster, Germany; Persi Diaconis, Cornell U., USA; Giovanni Gallavotti, U. La Sapienza, Roma, Italy; Wolfgang Hackbusch, U. Kiel, Germany; Helmut H. W. Hofer, Courant I., New York U., USA; Ehud Hrushovski, Hebrew U., Jerusalem, Israel; I. G. Macdonald, Queen Mary and Westfield College, U. London, UK; Stéphane Mallat, École Polytechnique, Palaiseau, France; Dusa McDuff, SUNY Stony Brook, USA; Tetsuji Miwa, RIMS, Kyoto U., Japan; Jürgen Moser, ETH, Zürich, Switzerland; George C. Papanicolaou, Stanford U., USA; Gilles Pisier, U. Paris 6, France, and Texas A&M U., USA; Peter Sarnak, Princeton U., USA; Peter W. Shor, AT&T Labs, USA; Karl Sigmund, U. Vienna, Austria; Michel Talagrand, C.N.R.S., U. Paris 6, France; Cumrun Vafa, Harvard U., USA, and Tehran, Iran; Marcelo Viana, IMPA, Rio de Janeiro, Brazil; Vladimir Voevodsky, Northwestern U., USA.

45-minute Speakers

Note: Each speaker will present only one talk. Some speakers are listed more than once because they fall under more than one section.

Section 1: Logic. Matthew Foreman, U. California-Irvine, USA; Gregory Hjorth, U. California-Los Angeles, USA; Ludomir Newelski, U. Wrocław, Poland; Stevo B. Todorcevic, U. Toronto, Canada, U. Paris 7, France, and Matematicki I., Beograd, Yugoslavia; Alex James Wilkie, U. Oxford, UK.

Section 2: Algebra. Eric Mark Friedlander, Northwestern U., USA; Sergei Ivanov, U. Illinois-Urbana, USA; William M. Kantor, U. Oregon, USA; Gunter Malle, I.W.R., Heidelberg, Germany; Aleksandr Pukhlikov, Moscow State U., Russia; Idun Reiten, Norwegian U. Science and Tech., Trondheim, Norway; Jeremy C. Rickard, U. Bristol, UK; Aner Shalev, Hebrew U., Jerusalem, Israel.

Section 3: Number Theory and Arithmetic Algebraic Geometry. Vladimir Berkovich, Weizmann I. of Science, Rehovot, Israel; Pierre Colmez, ENS, DMI, Paris, France; William Duke, Rutgers U.-New Brunswick, USA; François Gramain, U. Jean Monnet Saint-Etienne, France; Loic Merel, U. Paris 7, France; Shinichi Mochizuki, RIMS, Kyoto U., Japan; Hans Peter Schlickewei, U. Marburg, Germany; Takeshi Tsuji, RIMS, Kyoto U., Japan; Shou-Wu Zhang, Columbia U., USA.

Section 4: Algebraic Geometry. Paul S. Aspinwall, Duke U., USA; Victor V. Batyrev, U. Tübingen, Germany; Maurizio D. T. Cornalba, U. Pavia, Italy; Johan de Jong, Princeton U., USA; Robbert Dijkgraaf, U. Amsterdam, Netherlands; Mark Green, U. California-Los Angeles, USA; Mikhail M. Kapranov, Northwestern U., USA.

Section 5: Differential Geometry and Global Analysis. Dmitri Burago, Pennsylvania State U., USA; Tobias H. Colding, Courant I., New York U., USA; Simon K. Donaldson, Stanford U., USA; Boris Dubrovin, SISSA, Trieste, Italy; Yakov Eliashberg, Stanford U., USA; Sylvestre Gallot, ENS de Lyon, U.M.P.A., France; Gerhard Huisken, U. Tübingen, Germany; Dominic Joyce, Lincoln College, Oxford, UK; François Labourie, U. Paris-Sud, Orsay, France; Joachim Lohkamp, U. Augsburg, Germany; Ulrich Pinkall, TU Berlin, Germany; Leonid Polterovich, Tel Aviv U., Israel; Yongbin Ruan, U. Wisconsin-Madison, USA.

Section 6: Topology. Alexander N. Dranishnikov, U. Florida, USA; William G. Dwyer, U. Notre Dame, USA; Ronald A. Fintushel, Michigan State U., USA; Michael H. Freedman, U. California-San Diego, USA; Mark Mahowald, Northwestern U., USA; Tomotada Ohtsuki, Tokyo I. of Technology, Japan; Robert A. Oliver, U. Paris-Nord, Villetaneuse, France; Ronald J. Stern, U. California-Irvine, USA; Clifford H. Taubes, Harvard U., USA.

Section 7: Lie Groups and Lie Algebras. James G. Arthur, U. Toronto, Canada; Joseph Bernstein, Tel Aviv U., Israel; Ivan V. Cherednik, U. North Carolina-Chapel Hill, USA; Alexander Eskin, U. Chicago, USA; Robert E. Kottwitz, U. Chicago, USA; Laurent Lafforgue, U. Paris-Sud, Orsay, France; Shahar Mozes, Hebrew U., Jerusalem, Israel; Vera Serganova, U. California-Berkeley, USA; Kari Vilonen, Brandeis U., USA; Minoru Wakimoto, Kyushu U., Fukuoka, Japan.

Section 8: Analysis. Kari Astala, U. Jyväskylä, Finland; Michael Christ, U. California-Berkeley, USA; Nigel D. Higson, Pennsylvania State U., USA; Michael T. Lacey, Georgia I. of Technology, USA; Pertti Mattila, U. Jyväskylä, Finland; Vitali Milman, Tel Aviv U., Israel; Detlef H. Müller, U. Kiel, Germany; Stefan Müller, MPI f. Math. in den Naturwissenschaften, Leipzig, Germany; Sergey I. Pinchuk, Chelyabinsk State U. Technology, Russia; Kristian Seip, Norwegian U. Science and Technology, Trondheim, Norway; Hart F. Smith, U. Washington, USA; Nicole Tomczak-Jaegermann, U. Alberta, Edmonton, Canada; Stephen Wainger, U. Wisconsin-Madison, USA; Thomas Wolff, Caltech, USA.

Section 9: Ordinary Differential Equations and Dynamical Systems. Welington de Melo, IMPA, Rio de Janeiro, Brazil; Håkan Eliasson, Royal I. of Technology, Stockholm, Sweden; Shuhei Hayashi, School of Commerce, Waseda U., Tokyo, Japan; Michel Herman, U. Paris 7, France; Yuri Kifer, Hebrew U., Jerusalem, Israel; Sergei B. Kuksin, Steklov Math. I., Moscow, Russia, and Heriot-Watt U., Edinburgh, UK; Krystyna M. Kuperberg, Auburn U., USA; Curtis T. McMullen, Harvard U., USA; Grzegorz Swiatek, Pennsylvania State U., USA; Zhihong Xia, Northwestern U., USA.

Section 10: Partial Differential Equations. Fabrice Bethuel, U. Paris-Sud, Orsay, France; Frédéric Hélein, CMLA, ENS-Cachan, France; Robert R. Jensen, Loyola U., USA; Hans Lindblad, U. California-San Diego, USA; Matei Machedon, U. Maryland, USA; Frank E. Merle, U. Cergy-Pontoise, France; Gustavo A. Ponce, U. California-Santa Barbara, USA; Mikhail V. Safonov, U. Minnesota-Minneapolis, USA; Gunther A. Uhlmann, U. Washington, USA; Dmitri Yafaev, IRMAR, U. Rennes-1, France.

Section 11: Mathematical Physics. Paul S. Aspinwall, Duke U., USA; Eugene Bogomolny, I. de Physique Nucleaire, U. Paris Sud, Orsay, France; Detlev Buchholz, I. f. Theoret. Physik, U. Göttingen, Germany; Jennifer Chayes, Microsoft Research, USA; Pierre Collet, Centre de Physique Théorique, Palaiseau, France; Robbert Dijkgraaf, U. Amsterdam, Netherlands; Antonio Giorgilli, U. Milano, Italy; Gian M. Graf, ETH-Hönggerberg, Zürich, Switzerland; Barry McCoy, I. for Theoret. Physics, SUNY, Stony Brook, USA; Roberto Schonmann, U. California-Los Angeles, USA; Fedor Smirnov, LPTHE, U. Pierre et Marie Curie, Paris, France; Horng-Tzer Yau, Courant I., New York U., USA.

Section 12: Probability and Statistics. David John Aldous, U. California-Berkeley, USA; Marco Avellaneda, Courant I., New York U., USA; Maury D. Bramson, U. Minnesota-Minneapolis, USA; Mark Freidlin, U. Maryland, USA; Jayanta K. Ghosh, Indian Statistical I., Calcutta, India; Friedrich Götze, U. Bielefeld, Germany; Peter G. Hall, Australian National U., Canberra, Australia; Iain M. Johnstone, Stanford U., USA; Jean-François Le Gall, ENS, DMI, Paris, France; David O. Siegmund, Stanford U., USA; Alain-Sol Sznitman, ETH, Zürich, Switzerland; Boris Tsirelson, Tel Aviv U., Israel; Ruth J. Williams, U. California-San Diego, USA.

Section 13: Combinatorics. Béla Bollobás, Trinity College, Cambridge, UK, and U. Memphis, USA; András Frank, Eötvös U., Budapest, Hungary; Alain Lascoux, U. Marne-la-Vallée, Noisy-le-Grand, France; Jiri Matoušek, Charles U., Praha, Czech Republic; Harald Niederreiter, Austrian Acad. Sci., Vienna, Austria; Neil J. A. Sloane, AT&T Research Labs, USA; Joseph A. F. Thas, U. Ghent, Belgium; Andrei V. Zelevinsky, Northeastern U., USA.

Section 14: Mathematical Aspects of Computer Science. Miklos Ajtai, IBM Almaden Research Center, USA; Joan Feigenbaum, AT&T Research Labs, USA; Johan Håstad, Royal I. of Technology, Stockholm, Sweden; Toniann Pitassi, U. Arizona, USA; Madhu Sudan, MIT, USA; Emo Welzl, ETH, Zürich, Switzerland.

Section 15: Numerical Analysis & Scientific Computing. Gregory Beylkin, U. Colorado-Boulder, USA; Percy A. Deift, Courant I., New York U., USA ; Bjorn E. Engquist, KTH-NADA, Stockholm, Sweden, and U. California-Los Angeles, USA; Hisashi Okamoto, Kyoto U., Japan; Jan-Olov Strömberg, U. Tromsø, Norway; Lloyd N. Trefethen, U. Oxford, UK.

Section 16: Applications. a) Marco Avellaneda, Courant I., New York U., USA; Ulf Grenander, Brown U., USA; Gerard M. Iooss, I. Universitaire de France, INLN, Valbonne, France.

b) Bonnie Berger, MIT, USA; William J. Cook, Rice U., USA; Andreas W. M. Dress, U. Bielefeld, Germany; Frank Hoppensteadt, Arizona State U., USA; Charles S. Peskin, Courant I., New York U., USA.

c) Leslie Frederick Greengard, Courant I., New York U., USA; Thomas Yizhao Hou, Caltech, USA; Graeme W. Milton, U. Utah, USA; Rolf Rannacher, U. Heidelberg, Germany.

Section 17: Control Theory and Optimization. William J. Cook, Rice U., USA; Michel X. Goemans, CORE, Louvain-L.-N., Belgium; Jorge Nocedal, Northwestern U., USA; William R. Pulleyblank, IBM T.J. Watson Research Center, USA; Alexander Schrijver, CWI, Amsterdam, Netherlands; Jan C. Willems, U. Groningen, Netherlands; Jochem Zowe, U. Erlangen, Germany.

Section 18: Teaching and Popularization of Mathematics. James Stigler, U. California-Los Angeles, USA; Jan de Lange, Freudenthal I., U. Utrecht, Netherlands; Mogens Niss, Roskilde U., Denmark.

a) *Speak and answer:* Michele Artigue, U. Paris 7, France; Hans-Georg Steiner, IDM, U. Bielefeld, Germany.

b) *Roundtable:* George E. Andrews, Pennsylvania State U., USA; Donald J. Lewis, National Science Foundation, USA; David Alexander Smith, Duke U., USA.

c) *Roundtable:* Miguel de Guzman, U. Complutense de Madrid, Spain; Bernard R. Hodgson, Université Laval, Québec, Canada; Aline Robert, U. Paris 7, France; Vinicia Villani, U. degli Studi di Pisa, Italy.

Section 19: History of Mathematics. Karine Chemla, Paris, France; Joseph Dauben, City U. New York, USA; Jeremy J. Gray, Open U., Milton Keynes, UK.

—from ICM Announcement

Mathematics Opportunities

Program on Algorithms and Application Libraries

The Division of Mathematical Sciences (DMS) of the National Science Foundation (NSF) has announced a new program solicitation called OPAAL (Optimized Portable Algorithms and Application Libraries). The competition will focus on algorithms and libraries for virtual prototyping and simulation in advanced materials. Fresh ideas, approaches, techniques, the formation of new teams, and the participation of researchers new to such problem areas will be encouraged. Areas of mathematics which are not currently considered "applied" are a likely source of such fresh ideas, approaches, and techniques.

This activity is in collaboration with the Defense Advanced Research Projects Agency (DARPA) and with other units and directorates within NSF. They plan jointly to support research and development of new approaches to the design and creation of efficient algorithms and optimized libraries for large-scale numerical modeling and simulation of physical phenomena arising in industrial applications.

The deadlines are **May 22, 1998**, for an e-mail letter of intent and **July 1, 1998**, for proposal receipt.

The solicitation is available electronically on the Web at `http://www.nsf.gov/cgi-bin/getpub?nsf9864/`; there will not be a printed version of the solicitation. Questions about the program may be addressed to representatives from the participating agencies. Within the DMS the representatives are A. I. Thaler, telephone 703-306-1880, e-mail: `thaler@nsf.gov`; and J. Strikwerda, telephone 703-306-1870, e-mail: `jstrikwe@nsf.gov`. The DARPA representative is Anna Tsao, telephone 703-696-2287, e-mail: `atsao@darpa.mil`.

—DMS Announcement

Grants for Collaborations on Complex Biological Systems

The National Institute of General Medical Sciences (NIGMS), a component of the National Institutes of Health (NIH), has announced a new, ongoing program to support quantitative approaches to the study of complex biological processes by encouraging nontraditional collaborations across disciplinary lines. The collaborations will be funded through supplements to existing NIGMS grants to support the salary and expenses of investigators who have expertise in physics, engineering, mathematics, and other fields involving quantitative skills relevant to the analysis of complex systems. It is expected that the collaborations will result in new directions for the existing projects or in new research projects that will compete for independent funding.

Examples of research that could be supported by this program include modeling and simulation approaches for the analysis of genetic regulatory circuitry, the development of techniques to obtain complex kinetic data from living cells, methods to study the dynamics of cellular substructure assembly, and approaches to analyzing complex physiological interactions of clinical significance.

An application must include a specific research project that is based on the aims of the parent grant but that expands the scope of the grant to incorporate new quantitative approaches. The applicant must be the principal investigator of an active, investigator-initiated NIGMS research grant (R01, R37, or P01) that will have at least one year of support remaining at the time of the supplemental award. To find the names of NIGMS principal investigators for possible collaborations, use the NIGMS-specific grants database on the World Wide Web at `http://cos.gdb.org/best/fedfund/nih-select/gm.html`. The collaborator need not have prior experience with biological problems, but should have expertise that does not substantially overlap that of the principal investigator. A grant may have only one supplemental award at a time under this program.

Application receipt dates are **March 1**, **July 1**, and **November 1**. Details on this program are published in the NIH *Guide for Grants and Contracts* as Program Announcement PA-98-024. The program announcement and additional information for applicants can be found on the NIGMS Web site at `http://www.nih.gov/nigms/funding/pa/comsupp.html`.

Questions may also be directed to any of the following individuals at the NIH: James C. Cassatt, Division of Cell Biology and Biophysics, telephone 301-594-0828, e-mail: `czj@nih.gov`; Judith H. Greenberg, Division of Genetics and Developmental Biology, telephone 301-594-0943, e-mail: `greenbej@nigms.nih.gov`; Michael E. Rogers, Division of Pharmacology, Physiology, and Biological Chemistry, telephone 301-594-3827, e-mail: `rogersm@nigms.nih.gov`.

—NIH Announcement

For Your Information

Call for Nominations for AWM Schafer Prize

The Executive Committee of the Association for Women in Mathematics (AWM) calls for nominations for the Alice T. Schafer Mathematics Prize, to be awarded to an undergraduate woman for excellence in mathematics. All members of the mathematical community are invited to submit nominations for the prize. The nominee may be at any level in her undergraduate career, but must either be a U.S. citizen or have a school address in the U.S. The prize will be awarded at the Joint Prize Session at the Joint Mathematics Meetings in San Antonio in January 1999.

The Schafer Prize was established in 1990 by the Executive Committee of the AWM and is named for former AWM president and one of its founding members, Alice T. Schafer, who has contributed a great deal to women in mathematics throughout her career.

A letter of nomination should include, but not be limited to, an evaluation of the nominee based on the following criteria: 1) quality of performance in advanced mathematics courses and special programs, 2) demonstration of real interest in mathematics, 3) ability for independent work in mathematics, and 4) performance in mathematical competitions at the local or national level, if any. Supporting materials (e.g., reports from summer work using mathematics, copies of talks given in student chapters, transcripts, etc.) should be enclosed with the nomination.

Send *five* complete copies of nominations for this award to: The Alice T. Schafer Award Selection Committee, Association for Women in Mathematics, 4114 Computer & Space Sciences Building, University of Maryland, College Park, Maryland 20742-2461. Nominations via e-mail or fax are not acceptable.

For further information contact the AWM by telephone at 301-405-7892 or by e-mail at `awm@math.umd.edu`. The nomination deadline is **September 15, 1998.**

—from AWM Announcement

Job Seekers List on e-MATH

Beginning April 1, the AMS Job Seekers List will be reactivated on e-MATH at `http://www.ams.org/jobseekers/`. This list of names and contact information is intended to assist employers who need, late in the hiring season, to go back to applications that may have been received months ago and who therefore need a central source of information about which applicants are still on the job market. Job seekers currently on the market for academic positions in mathematics who have not accepted a position yet should enter their contact information into the list directly from the Web site. The list will remain active until late summer.

—Professional Programs and Services, AMS

Correction

The March 1998 issue of the *Notices* carried an article entitled "The Demise of the Young Scholars Program". The article mentioned a program at Michigan State University that had received funding from the Young Scholars and Summer Science Training programs of the National Science Foundation. The article incorrectly stated that Gail Richmond of Michigan State has run this program since 1959. The program has been in existence since 1959, and Professor Richmond has been its director since 1987

The announcement about the 1998 Steele Prizes, which appeared in the April 1998 *Notices*, presented an incomplete list of the members of the prize selection committee. Bertram Kostant and Marc Rieffel were inadvertently omitted from the list.

The *Notices* regrets these errors.

From the AMS

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2. As you mail each application, fill in the remaining questions neatly on one cover sheet and include it *on top of* your application materials.

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

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

JCEO Recommendations for Professional Standards in Hiring Practices

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

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

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

Academic Employment in Mathematics

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

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Indicate *the mathematical subject area(s) in which you have done research using, if applicable, the 1991 Mathematics Subject Classification printed on the back of this form. If listing more than one number, list first the one number which best describes your current primary interest.*

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Give a brief synopsis *of your current research interests (e.g. finite group actions on four-manifolds). Avoid special mathematical symbols and please do not write outside of the boxed area.*

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☐

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14 Algebraic geometry
15 Linear and multilinear algebra, matrix theory
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17 Nonassociative rings and algebras
18 Category theory, homological algebra
19 K-theory
20 Group theory and generalizations
22 Topological groups, Lie groups
26 Real functions
28 Measure and integration
30 Functions of a complex variable
31 Potential theory
32 Several complex variables and analytic spaces
33 Special functions
34 Ordinary differential equations
35 Partial differential equations
39 Finite differences and functional equations
40 Sequences, series, summability
41 Approximations and expansions
42 Fourier analysis
43 Abstract harmonic analysis
44 Integral transforms, operational calculus
45 Integral equations
46 Functional analysis
47 Operator theory
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53 Differential geometry
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55 Algebraic topology
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68 Computer science
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73 Mechanics of solids
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Leopold Infeld; **Quest: An Autobiography;** 1980; 361 pp.; Hardcover; ISBN 0-8284-0309-0; List $20; All AMS members $18; Order code CHEL/309NC58

Charles Jordan; **Calculus of Finite Differences;** 1965; 654 pp.; Hardcover; ISBN 0-8284-0033-4; List $34; All AMS members $31; Order code CHEL/33NC58

Gerhard Kowalewski; **Einführung in die Determinantentheorie: einschliesslich der Fredholmschen Determinanten;** 1948; 320 pp.; Hardcover; ISBN 0-8284-0039-3; List $20; All AMS members $18; Order code CHEL/39NC58

Dénes König; **Theorie der endlichen und unendlichen Graphen;** 1950; 258 pp.; Hardcover; ISBN 0-8284-0072-5; List $16; All AMS members $14; Order code CHEL/72NC58

A. G. Kurosh; **Theory of Groups, Volume 1;** 1960; 272 pp.; Hardcover; ISBN 0-8284-0107-1; List $19; All AMS members $17; Order code CHEL/107NC58

A. G. Kurosh; **Theory of Groups, Volume 2;** 1960; 308 pp.; Hardcover; ISBN 0-8284-0109-8; List $19; All AMS members $17; Order code CHEL/109NC58

Edmund Landau; **Grundlagen der Analysis;** 1965; 173 pp.; Softcover; ISBN 0-8284-0141-1; List $14; All AMS members $13; Order code CHEL/141NC58

Edmund Landau; **Handbuch der Lehre von der Verteilung der Primzahlen;** 1974; 1001 pp.; Hardcover; ISBN 0-8284-0096-2; List $59; All AMS members $53; Order code CHEL/96NC58

Edmund Landau; **Vorlesungen über Zahlentheorie. Aus der elementaren Zahlentheorie;** 1950; 180 pp.; Hardcover; ISBN 0-8284-0026-1; List $18; All AMS members $16; Order code CHEL/26NC58

Pierre Simon Laplace; **Celestial Mechanics;** 1966; 3664 pp.; Hardcover; ISBN 0-8284-0194-2; List $250; All AMS members $225; Order code CHEL/194NC58

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J. A. Lappo-Danilevsky; **Mémoires sur la théorie des Systèmes des équations différentieles linéaires;** 1953; 457 pp.; Hardcover; ISBN 0-8284-0094-6; List $35; All AMS members $32; Order code CHEL/94NC58

Howard Levi; **Elements of Algebra;** 1961; 189 pp.; Hardcover; ISBN 0-8284-0103-9; List $14; All AMS members $13; Order code CHEL/103NC58

G. G. Lorentz; **Approximation of Functions;** 1997; 188 pp.; Hardcover; ISBN 0-8284-0322-8; List $17; All AMS members $15; Order code CHEL/322NC58

G. G. Lorentz; **Bernstein Polynomials;** 1997; 134 pp.; Hardcover; ISBN 0-8284-0323-6; List $15; All AMS members $14; Order code CHEL/323NC58

Percy A. MacMahon; **Combinatory Analysis, Volumes I and II;** 1984; 642 pp.; Hardcover; ISBN 0-8284-1137-9; List $50; All AMS members $45; Order code CHEL/137NC58

Karl Menger; **Kurventheorie;** 1967; 374 pp.; Hardcover; ISBN 0-8284-0172-1; List $19; All AMS members $17; Order code CHEL/172NC58

L. M. Milne-Thomson; **The Calculus of Finite Differences;** 1981; 558 pp.; Hardcover; ISBN 0-8284-0308-2; List $30; All AMS members $27; Order code CHEL/308NC58

Pierre Remond de Montmort; **Essay d'analyse sur les jeux de Hazard;** 1980; 414 pp.; Hardcover; ISBN 0-8284-0307-4; List $40; All AMS members $36; Order code CHEL/307NC58

Trygve Nagell; **Introduction to Number Theory;** 1964; 309 pp.; Hardcover; ISBN 0-8284-0163-2; List $20; All AMS members $18; Order code CHEL/163NC58

Neils Nielsen; **Die Gammafunktion;** 1965; 430 pp.; Hardcover; ISBN 0-8284-0188-8; List $29; All AMS members $26; Order code CHEL/188NC58

B. Noble; **Methods Based on the Wiener-Hopf Technique for the Solution of Partial Differential Equations;** 1988; 246 pp.; Hardcover; ISBN 0-8284-0332-5; List $20; All AMS members $18; Order code CHEL/332NC58

W. F. Osgood; **Lehrbuch der Funktionentheorie, Volume 2;** 1965; 686 pp.; Hardcover; ISBN 0-8284-0182-9; List $25; All AMS members $23; Order code CHEL/182NC58

Kurt Reidemeister; **Einführung in die kombinatorische Topologie;** 1950; 209 pp.; Hardcover; ISBN 0-8284-0076-8; List $15; All AMS members $14; Order code CHEL/76NC58

George Salmon; **A Treatise on Conic Sections;** 1954; 399 pp.; Softcover; ISBN 0-8284-0098-7; List $29; All AMS members $26; Order code CHEL/98NC58

George Salmon; **A Treatise on Conic Sections;** 1954; 399 pp.; Hardcover; ISBN 0-8284-0099-7; List $29; All AMS members $26; Order code CHEL/99NC58

E. Schrödinger; **Collected Papers on Wave Mechanics;** 1982; 207 pp.; Hardcover; ISBN 0-8284-1302-9; List $20; All AMS members $18; Order code CHEL/302NC58

J. F. Scott; **The Mathematical Work of John Wallis;** 1981; 240 pp.; Hardcover; ISBN 0-8284-0314-7; List $17; All AMS members $15; Order code CHEL/314NC58

H. Seifert and W. Threlfall; **Lehrbuch der Topologie;** 1980; 353 pp.; Hardcover; ISBN 0-8284-0031-8; List $29; All AMS members $26; Order code CHEL/31NC58

H. Seifert and W. Threlfall; **Variationsrechnung im Grossen;** 1971; 116 pp.; Hardcover; ISBN 0-8284-0049-0; List $14; All AMS members $13; Order code CHEL/49NC58

Daniel Shanks; **Solved and Unsolved Problems in Number Theory;** 1993; 305 pp.; Hardcover; ISBN 0-8284-1 297-9; List $28; All AMS members $25; Order code CHEL/297NC58

David Eugene Smith; **Rara Arithmetica;** 1970; 703 pp.; Hardcover; ISBN 0-8284-0192-6; List $49; All AMS members $44; Order code CHEL/192NC58

Virgil Snyder, Amos H. Black, Arthur B. Coble, Leaman A. Dye, Arnold Emch, Solomon Lefschetz, F. R. Sharpe, and Charles H. Sisam; **Selected Topics in Algebraic Geometry;** 1970; 484 pp.; Hardcover; ISBN 0-8284-0189-6; List $29; All AMS members $26; Order code CHEL/189NC58

D. M. Y. Sommerville; **Bibliography of Non-Euclidean Geometry;** 1970; 410 pp.; Hardcover; ISBN 0-8284-0175-6; List $30; All AMS members $27; Order code CHEL/175NC58

Tracy Yerkes Thomas; **The Differential Invariants of Generalized Spaces;** 1991; 240 pp.; Hardcover; ISBN 0-8284-0336-8; List $28; All AMS members $25; Order code CHEL/336NC58

J. F. Traub; **Iterative Methods for the Solution of Equations;** 1982; 310 pp.; Hardcover; ISBN 0-8284-0312-0; List $30; All AMS members $27; Order code CHEL/312NC58

Balth Van Der Pol and H. Bremmer; **Operational Calculus Based on the Two-Sided LaPlace Integral;** 1987; 415 pp.; Hardcover; ISBN 0-8284-0327-9; List $20; All AMS members $18; Order code CHEL/327NC58

H. Weyl, E. Landau, and B. Riemann; **Das Kontinuum und andere Monographien;** 1973; 368 pp.; Hardcover; ISBN 0-8284-0134-9; List $19; All AMS members $17; Order code CHEL/134NC58

Robert Woodhouse; **A History of the Calculus of Variations in the Eighteenth Century;** 1988; 154 pp.; Hardcover; ISBN 0-8284-0177-2; List $14; All AMS members $13; Order code CHEL/177NC58

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Reference

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

Upcoming Deadlines

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

December 1, 1998: Deadline for applications for fellowship opportunities in Asia offered by the NSF. World Wide Web: `http://www.twics.com/~nsftokyo/home.html` or by e-mail: `JKPinfo@nsf.gov`.

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Where to Find It

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  - Strasbourg, France at http://irmasrv1.u-strasbg.fr/mathscinet/
  - Bonn, Germany at http://klymene.mpim-bonn.mpg.de/mathscinet/
  - Bielefeld, Germany at http://ams.mathematik.uni-bielefeld.de/mathscinet/
  - Providence, RI, USA at http://www.ams.org/mathscinet/
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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/`.

May 1998

* 1-3 **Pure, Applied, and Industrial Mathematics: Strength through Connections**, University of Minnesota, Minneapolis, Minnesota.

Organizers: R. Gulliver, N. Jain, W. Miller.

Information: Institute for Mathematics and its Applications, University of Minnesota, 206 Church St., SE, Minneapolis, MN 55455; tel: 612-624-6066; e-mail: `staff@ima.umn.edu`; `http://www.ima.umn.edu/dynsys/`.

* 2-4 **Quadratic Forms and Orthogonal Groups: Conference in Honor of the 70th Birthday of O. Timothy O'Meara**, University of Notre Dame, Notre Dame, Indiana. (Feb. 1998, p. 292)

Principal Speakers: M. Aschbacher, J. Conway, M. Knebusch, T. Y. Lam, G. Margulis, G. Prasad, C. Riehm.

Contributed Papers: A limited number of short talks on topics close to Professor O'Meara's work on quadratic forms and classical groups will be scheduled.

Organizers: M. Dyer, A. Hahn, B. Pollak, and W. Wong.

Information: Write to any one of the organizers at the University of Notre Dame, Notre Dame, IN 46556-5683, e-mail: `wong.1@nd.edu`, or see the Web: `http://www.science.nd.edu/math/OMeara/index.html`.

* 7-9 **Dynamical Systems in Oceanography: Chaotic Advection in Ocean Mesoscale Structures**, University of Minnesota, Minneapolis, Minnesota.

Organizer: C. Jones.

Information: Institute for Mathematics and its Applications, University of Minnesota, 206 Church St., SE, Minneapolis, MN 55455; tel 612-624-6066; e-mail: `staff@ima.umn.edu`; `http://www.ima.umn.edu/dynsys/`.

* 11-15 **IMA Workshop: Pattern Formation in Continuous and Coupled Systems**, University of Minnesota, Minneapolis, Minnesota.

Organizers: M. Golubitsky, D. Luss, S. Strogatz.

Information: Institute for Mathematics and its Applications, University of Minnesota, 206 Church St. SE, Minneapolis, MN 55455; tel: 612-624-6066; e-mail: `staff@ima.umn.edu`; `http://www.ima.umn.edu/dynsys/`.

* 11-16 **Workshop on Homotopy Theory for Algebraic Varieties with Applications to *K*-Theory and Quadratic Forms**, Mathematical Sciences Research Institute, Berkeley, California.

Program: Very recent work of V. Voevodsky and his collaborators has much advanced our knowledge of Galois cohomology and algebraic *K*-theory. This work involves a global approach to the algebraic geometry of algebraic varieties which entails the development of a suitable homotopy theory. This meeting will offer an exposition of these new techniques and discuss some of the applications to algebraic *K*-theory and the theory of quadratic forms.

Primary Speaker: V. Voevodsky (Northwestern).

Organizers: S. Bloch and E. M. Friedlander.

Financial Support: A limited amount of funding is available for partial support of people wishing to attend. Students, recent Ph.D.s, women, and minorities are particularly encouraged to apply. To apply for funding, send a letter explaining your interest in the workshop together with a vita or bibliography and a budget for travel/living expenses. If you are a student, also solicit a letter from a faculty advisor. All information should be received by March 15, 1998.

Information: Communications about this workshop should be sent either by e-mail to `ktheory@msri.org` or by regular mail to Homotopy Theory for Algebraic Varieties with Applications to *K*-theory and Quadratic Forms, Mathematical Sciences Research Institute, 1000 Centennial Drive, Berkeley, CA 94720-5070; `http://www.msri.org/activities/events/9798/ktheory/`.

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.)

* 21-22 **Twentieth Symposium on Mathematical Programming with Data Perturbations**, George Washington University, Washington, D.C.
Objective: The objective is to bring together practioners who use mathematical programming optimization models and deal with questions of sensitivity analysis, with researchers who are developing techniques applicable to these problems.
Contributed Papers: Contributed papers in mathematical programming are solicited in the following areas: sensitivity and stability analysis and their applications; solution methods for problems involving implicitly defined functions; solution methods for problems involving deterministic or stochastic parameter changes; solution approximation techniques and error analysis. "Clinical" presentations that describe problems in sensitivity analysis encountered in applications are also invited.
Registration: Registration and abstracts can be sent by mail or e-mail to any member of the Organizing Committee, or submitted by using the electronic form included in the symposium home page: `http://rutcor.rutgers.edu:80/~bisrael/MPDP-20.html` where further information on the symposium and on Washington, DC is available. Abstracts should provide a good technical summary of key results, avoid mathematical symbols and references, not exceed 500 words, and include a title and the name and full address of each author. Registration fee: $50, payable at the meeting.
Deadlines: Registration and submission of tentative title and abstract: March 15, 1998; submission of final abstract: May 1, 1998.
General Chairman: A. V. Fiacco, `avfnlp@seas.gwu.edu`, The George Washington Univ., tel: 202-994-7511, fax: 202-994-0245.
Organizing Committee: H. Abeledo, `abeledo@seas.gwu.edu`, The George Washington Univ., tel: 202-994-7521, fax: 202-994-0245 or W. Alt, `alt@minet.uni-jena.de`, Friedrich-Schiller Univ. Jena, Germany; tel: +49-3641-946213; fax: +49-3641-946202.

* 22-25 **The 1997-98 ASL Annual Meeting**, University of Toronto, Canada.
Program: The program will include the annual Gödel Lecture and the awarding of the Karp Prize.
Invited Speakers: W. Goldfarb, A. Myasnikov, T. Slaman, R. Sommer, P. Speissegger, S. Todorčevic, S. Wainer, and H. Woodin. A tutorial on complexity theory and logic will be given by S. Cook. There will be special sessions in model theory and set theory. Speakers for the model theory session include D. Haskell, J. Iovino, S. Kuhlmann, C. Miller, R. Willard, and C. Wood. Speakers for the set theory session include H. Becker, D. Burke, R. Dougherty, M. Foreman, S. Jackson, and E. Schimmerling.
Program Committee: T. Carlson, K. Compton, S. Friedman, B. Hart (chair), A. Nies, and A. Urquhart.
Abstracts: Abstracts of contributed papers from ASL members (300 words, one-page limit in 12 pt font) should be sent by the deadline of March 9, 1998, to the Program Chair: B. Hart, Dept. of Math., McMaster Univ., Hamilton, Ontario, Canada L8S 4K1; e-mail: `hartb@mcmaster.ca`.
Local Organizing Committee: A. Urquhart, chair.

* 24-30 **The 36th International Symposium on Functional Equations**, Hotel Santon, Brno-Bystrc, Czech Republic.
Scientific Committee: J. Aczél (Waterloo, Canada), W. Benz (Hamburg), R. Ger (Katowice), J. Raetz (Bern), L. Reich (Graz), A. Sklar (Chicago).
Local Organizers: J. Chvalina (Masaryk Univ., Brno), F. Neuman and J. Šimša (Math. Inst. Acad. Sci., Brno).
Information: Participation is by invitation only. Those who wish to be invited should write to: 36th ISFE, Math. Inst. Acad. Sci., Zizkova 22, 616 62 Brno, Czech Republic; fax: ++420-5-41218657; e-mail: `math@ipm.cz`.

* 25-29 **NSF/CBMS Regional Research Conference: Blocks of Finite Reductive Groups, Deligne-Lusztig Varieties, and Complex Reflection Groups**, University of North Texas, Denton, Texas.
Principal Speaker: M. Broue.
Organizer: M. Douglass.
Information: `http://hilbert.math.unt.edu/cbms.html`.

June 1998

* 1-5 **IMA Workshop: Animal Locomotion and Robotics**, University of Minnesota, Minneapolis, Minnesota.
Organizers: J. Collins, D. Koditschek.
Information: Institute for Mathematics and its Applications, University of Minnesota, 206 Church St. SE, Minneapolis, MN 55455; tel: 612-624-6066; e-mail: `staff@ima.umn.edu`; `http://www.ima.umn.edu/dynsys/`.

* 1-6 **Shape Optimization**, Troia, Portugal.
Scientific Direction: A. Cellina (Univ. di Milano), A. Ornelas (Univ. of Evora).
Courses: Four lectures in English for each course: Some nonconvex optimal shape problems, B. Kawohl (Univ. Koeln, Germany); Shape control and optimal shape design, O. Pironneau (Analyse Numerique, Paris VI); Homogenization methods in optimal design, L. Tartar (Carnegie Mellon Univ.); Explicit solutions in elastic optimization, P. Villaggio (Univ. di Pisa); Optimal shape design: Theory, modelling and numerical algorithms, J. P. Zolesio (CNRS, Sophia Antipolis).
Applications: There is a registration fee of 9,000 Portuguese escudos (approximately US $50). Those who want to attend the session should fill in an application that can be obtained by e-mail from `shape98@hermite.cii.fc.ul.pt`, **no later than April 15, 1998**.
Information: `http://www.cim.pt/`.

* 1-6 **Table Ronde de Géométrie Pseudo-Riemannienne Globale**, Institut Élie Cartan (IECN), Université Henri Poincaré, Nancy I, France.
Speakers: S. Adams (Minneapolis), L. Anderson (Stockholm), R. Bartnik (Canberra), R. Beig (Wien), M. Berger (Bures/Yvette), T. Branson (Iowa City), T. Drumm (Swarthmore), J. Eschenburg (Augsburg), H. Friedrich (Potsdam), G. Galloway (Coral Gables), W. Goldmann (College Park), M. Herzlich (Montpellier), G. Huisken (Tuebingen) T. Ilmanen (Potsdam), H. Karcher (Bonn), B. Klingler (Paris), R. Kulkarni (New York), G. Mess (Los Angeles), S. Montiel (Granada), A. Rendall (Potsdam), J. Ritter (Paris), L. Rozoy (Grenoble), J.-M. Schlenker (Paris), B. Schmidt (Potsdam), W. Simon (Wien), G. Stuck (College Park), G. Tomanov (Lyon).
Information: Contact A. L. Besse, Institut Élie Cartan, Université Henri Poincare, B.P. 239, 54506 Vandœuvre-lès-Nancy Cedex, France; e-mail: `psriem@iecn.u-nancy.fr`; tel: 33-3-83-91-26-76; fax: 33-3-83-28-09-89; `http://www.iecn.u-nancy.fr/~troh/besse.html`.

* 4-6 **Basle Geometry Days**, University of Basle, Basel, Switzerland.
First Announcement: This is the first announcement of a short meeting on some current topics in geometry and topology.
Invited Speakers: M. Boileau (Toulouse), M. Furuta (RIMS Kyoto and MPI Bonn), P. Gauduchon (École Polytech., Palaiseau), E. Ghys* (ENS Lyon), R. E. Gompf (Austin, Texas), M. Gromov* (IHES and Courant Institute), N. J. Hitchin* (Oxford), M. Min-Oo (McMaster), T. S. Mrowka* (MIT), L. Polterovich (Tel Aviv and ETH Zürich). (* to be confirmed.)
Business Meeting: There will be a business meeting of the Swiss Mathematical Society on June 6, 1998.
Information: For further information or to apply for support, write to Basler Geometrie Tage, z. H. Frau M. Karatay, Mathematisches Institut, Rheinsprung 21, 4051 Basel, Switzerland; `gtb@math-lab.unibas.ch`.

* 8-12 **IMA Workshop: Continuum Mechanics and Nonlinear Partial Differential Equations**, University of Minnesota, Minneapolis, Minnesota.
Organizers: R. James (Univ. of Minnesota), S. Mueller (Max-Planck Inst., Leipzig), and V. Sverak (Univ. of Minnesota).
Information: Institute for Mathematics and its Applications, University of Minnesota, 206 Church St., SE, Minneapolis, MN 55455; tel: 612-624-6066; e-mail: `staff@ima.umn.edu`; `http://www.ima.umn.edu/dynsys/`.

* 11-13 **Lehigh University Geometry/Topology Conference**, Lehigh University, Bethlehem, Pennsylvania.
Invited Speakers: M. Goresky (IAS), L. Jeffrey (McHill), J. P. May (Chicago), K. Orr (Indiana), P. Petersen (UCLA), F. Quinn (VPI&SU).
Program: Participants may give 40-minute contributed talks. Send abstract to D. John-

son.
Information: D. L. Johnson, Dept. of Math., Lehigh Univ., Bethlehem, PA 18015; e-mail: dlj0@lehigh.edu; http://www.lehigh.edu/dlj0/public/www-data/geotop.html.

* 11-16 **Venice-2/Symposium on Applied and Industrial Mathematics**, Venice, Italy.
Invited Speakers: M. Avellaneda, F. Brezzi, R. Caflisch, G. Dal Maso, G. Dell'Antonio, E. Di Benedetto, B. Engquist, A. Fasano, A. Friedman, M. M. Lavrentiev (Sr.), A. Linan, H. McKean, L. Pastur, D. Schaeffer, and *R. Varadhan (*unconfirmed).
Information: Send e-mail to: venice2@dmsa.unipd.it and an automatic reply will be sent; http://www.dmsa.unipd.it/~venice2/.

* 13-20 **Dynamical Systems and Small Divisors**, Grand Hotel San Michele, Cetraro (Cosenza), Italy.
Scientific Direction: S. Marmi (Univ. di Firenze) and J.-C. Yoccoz (Univ. de Paris-Sud, Orsay).
Courses: KAM-theory for linear quasi-periodic systems (8 lectures in English), L. H. Eliasson (KTH, Stockholm); Invariant tori (8 lectures in English), M. Herman (Univ. de Paris 7, École Polytech.); Geometrical methods in small divisor problems (8 lectures in English), J.-C. Yoccoz (Univ. de Paris-Sud, Orsay).
Applications: Those who want to attend the session should send an application to the director of C.I.M.E at the address below **no later than April 15, 1998.**
Information: Fondazione C.I.M.E. c/o Dipartimento di Matematica "U. Dini", Viale Morgagni, 67/A - 50134 Firenze, Italy; tel: +39-55-434975, +39-55-4237123; fax: +39-55-434975, +39-55-4222695; e-mail: CIME@UDINI.MATH.UNIFI.IT. Information on C.I.M.E. can be obtained on the World Wide Web at http://WWW.MATH.UNIFI.IT/CIME/WELCOME.TO.CIME/.

* 21-27 **Groups of Finite Morley Rank**, Anogia, Crete, Greece.
Organizers: A. Borovik (Manchester, United Kingdom), G. Cherlin (Rutgers Univ.), A. Nesin (Istanbul, Turkey).
Main Speakers: T. Altinel (Université Lion 1, France), A. Borovik (Manchester, United Kingdom), E. Bouscaren (Université Paris VII, France), Z. Chatzidakis (Université Paris VII, France), G. Cherlin (Rutgers Univ.), R. Lyons (Rutgers Univ.), H. van Maldeghem (Gent, Belgium), A. Nesin (Istanbul, Turkey), K. Peterzil (Haifa, Israel).
Information: For additional information please contact the local co-ordinator: S. Papadopoulou, Dept. of Mathematics, Univ. of Crete, Heraklion, Crete, Greece; fax: 81-393373; e-mail: souzana@math.uch.gr.

* 22-26 **Low Dimensional Topology—The KirbyFest**, Mathematical Sciences Research Institute, Berkeley, California.
Program: As a followup to its 1996-97 program on low-dimensional topology and to celebrate the 60th birthday of Robion Kirby, MSRI will host a week-long workshop on low-dimensional topology during the week June 22-26, 1998.
Aim: Recent years have seen spectacular new developments in the study of three- and four-dimensional manifolds and in knot theory. Connections have been established to mathematical physics (gauge theory, statistical mechanics, quantum field theory), differential geometry (symplectic/contact geometry, hyperbolic geometry, minimal surfaces), complex algebraic geometry, and representation theory. This conference aims to bring together researchers in these areas to see what common threads emerge. We hope to encourage cross-fertilization of ideas and techniques, host a large number of graduate students, and encourage new collaborations.
Topics: Current research areas on which the conference will focus include gauge theory and smooth structures on 4-manifolds, symplectic and contact topology, topology of 4-manifolds, quantum topology and perturbative invariants of knots and 3-manifolds, hyperbolic geometry in dimension 3, and combinatorial methods in knot theory and 3-dimensional topology. These are all areas in which Rob Kirby and his students have made important contributions, and special events honoring Kirby on the occasion of his 60th birthday will be a part of this event.
Invited Speakers: J. Birman, A. Casson, S. Donaldson, R. Edwards, M. Freedman, C. Gordon, V. F. R. Jones, R. Kirby, M. Kontsevich, R. Lickorish, J. Morgan, L. Siebenmann, D. Sullivan, C. Taubes, W. Thurston.
Organizers: A. Casson, T. Cochran, J. Hass, P. Melvin, and M. Scharlemann.
Financial Support: A limited amount of funding is available for partial support of people wishing to attend. Students, recent Ph.D.s, women, and minorities are particularly encouraged to apply. To apply for funding, send a letter explaining your interest in the workshop together with a vita or bibliography and a budget for travel/living expenses. If you are a student, also solicit a letter from a faculty advisor. All information should be received by March 16, 1998.
Information: Communications about this workshop should be sent either by e-mail to kirbyfest@msri.org or by regular mail to Low Dimensional Topology—The KirbyFest, Mathematical Sciences Research Institute, 1000 Centennial Drive, Berkeley, CA 94720-5070; http://www.msri.org/activities/events/9798/kirbyfest/.

* 23-27 **Twenty-second Summer Symposium in Real Analysis**, University of California, Santa Barbara, California.
Program: The Twenty-second Summer Symposium in Real Analysis will be a celebration of the work of Professor Andrew Bruckner.
Organizers: C. Akemann (Univ. of California, Santa Barbara), akemann@math.ucsb.edu; P. Humke (St. Olaf College, Minnesota), humke@stolaf.edu; T. H. Steele (Weber State Univ., Utah), thsteele@weber.edu.
Information: Please visit our Web site for complete information on conference activities and registration: http://www.stolaf.edu/people/analysis/UCSB98.

* 29-July 4 **School-Conference on Dynamical Systems: From Crystal to Chaos**, Marseille-Luminy, France.
Focus: Dynamical systems is a field in constant evolution in many directions. This school will focus on **interactions** between discrete and geometric dynamical systems, and between dynamical systems, theoretical physics and computer sciences. This summer school will be followed by an international conference on the same topic.
Topics: **Symbolic dynamics and quasi-crystals**: Auto-similarity; fractals sets; substitutions; K-theory. **Dynamical systems: geometry and chaos**: Statistical and ergodic behaviour; non-linear physics; turbulence; multifractal analysis of complex systems. **Interaction between geometric and symbolic systems**: Coding problems; geometric representation of symbolic systems; adic systems. Time will be reserved for tutorial lectures for specialized seminars and for informal discussions organized by the junior participants.
Invited Lecturers: V. Afraimovich (Taiwan Univ.), P. Arnoux (Univ. de la Méditerranée), J. Bellissard (Univ. Toulouse III), P. Coullet (INLN, Nice), J. Peyriere (Univ. Paris XI).
Registration: Participants are encouraged to propose seminars talk on their current work. Titles and abstracts should be submitted before April 30. There is no registration fee. Minimal lodging costs are around 1100 FF in student dormitories. For exceptional situations, financial support can be required. Further practical information will be supplied upon request.
Organizing Committee: S. Ferenczi, J.-M. Gambaudo, P. Hubert, R. Lima, S. Vaienti.
Information: R. Lima, Centre de Physique Théorique, C.N.R.S. Luminy case 907, 13288-Marseille Cedex 09, France; telephone: 33-0-491269524; fax: 33-0-491269553; e-mail: lsd98@cpt.univ-mrs.fr.

July 1998

* 2-3 **European Women in Mathematics Workshop on Moduli Spaces in Mathematics and Physics**, Oxford, England.
Goal: The purpose of this interdisciplinary workshop is to explain to nonspecialists different uses of moduli spaces in various areas of mathematics and physics such as differential and algebraic geometry, dynamical systems, Yang-Mills theory and conformal field theory, and to facilitate the exchange of ideas between workers in these fields. The workshop will be a small scale two-day meeting with about six talks and ample time for discussion.
Speakers: L. Jeffrey (McGill), F. Kirwan (Oxford), R. M. Miro-Roig (Barcelona), R. Piene

(Oslo), M. Rees (Liverpool), T. S. Tsun (Oxford), and C. Voisin (Paris XI).
Organizing Committee: F. Kirwan (Oxford), S. Paycha (Clermont-Ferrand) and T. S. Tsun (Oxford). Please let the organizers know by June 1, 1998, if you would like to take part in the workshop, and which nights you would like accommodation. Financial support will be available for a few participants; please let the organizers know by **May 1, 1998**, if you would like to be considered for financial support to attend the workshop.
Accommodation: Accommodation will be organized nearby in Balliol College at a cost of around £20 per night. A registration fee of £15 will be charged to cover tea, coffee, and two sandwich lunches.
Information: Contact F. Kirwan, kirwan@maths.ox.ac.uk or T. S. Tsun, tsou@maths.ox.ac.uk, Mathematical Institute, 24-29 St. Giles, Oxford OX1 3LB, England.

*5-18 **NATO Advanced Study Institute on Signal Processing for Multimedia**, Il Ciocco Resort Hotel, Tuscany, Italy.
Director: J. Byrnes (Prometheus Inc. and Univ. of Mass., Boston), e-mail: asi@cs.umb.
Speakers: L. Atlas (Univ. of Washington), Representing variations in acoustic signals for military and speech applications; J. Benedetto (Univ. of Maryland), Mathematics for multimedia signal processing, I; J. Biemond (Delft Univ. of Technology), Video processing; E. Biglieri (Politecnico di Torino), Digital communication over the wireless channel, today and tomorrow; J. Byrnes (Prometheus Inc. and Univ. of Mass., Boston), Energy spreading transforms for robust data compression and transmission; P. Duhamel (ENST, France), Joint source-channel coding; P. Ferreira (Univ. de Aveiro), Mathematics for multimedia signal processing, II, and Interpolation methods applied to telecommunication problems; S. Jaffard (Univ. of Paris XII), Analysis of multifractal signals; V. Mertzios (Democritus Univ. of Thrace), Pattern recognition, and Applications of pattern recognition to telemedicine and human-machine interaction; S. Mjolsnes (Norwegian Univ. of Science and Technology), Secure digital payments and other Internet commercial transactions; P. Noll (Technische Univ. Berlin), Wideband audio; T. Ramstad (Norwegian Univ. of Science and Technology), Robust image and video communication for mobile multimedia, and Mobile multimedia; M. Schroeder (Univ. Göttingen), Speech processing; T. Sikora (Heinrich Hertz Institut), Standards for multimedia; A. Tescher (Lockheed Martin), An overview of signal processing for multimedia, from the past to the future; B. Torresani (Centre de Physique Theorique, Marseille), Time-frequency and time-scale transforms.
Information: Please see the Web site http://www.cs.umb.edu/~asi/, or send e-mail (plain text only, please) to the director at asi@cs.umb.edu.

*6-10 **Systèmes Dynamiques: Du Cristal Au Chaos (to honour the sixtieth birthday of Gérard Rauzy)**, Marseille-CIRM, France.
Focus: This conference will focus on the **interactions** between discrete and geometric dynamical systems, and between dynamical systems, theoretical physics and computer sciences.
Main Topics: Symbolic systems and quasicrystals: Modelization of some physical phenomena with regularity and auto-similarity properties; e.g tiling problems and fractal sets. The mathematical tools: symbolic dynamical systems, formal languages, and more precisely substitutions and their multidimensionnal generalizations. The physical properties of quasicrystals are described in terms of quantization involving the C*-algebra of observable. Their spectral properties may be classified in terms of K-theory, Cantor spectrum, scaling laws and spectral exponents. **Dynamical systems: geometry and chaos**: Statistical and ergodic properties of dynamical systems. Applications to non-linear physics, with a particular interest in stability, chaos, turbulence and multifractal analysis of complex systems. **Interaction between geometric and symbolic systems**: Symbolic systems associated with a geometric system (coding problems), and (the more difficult) converse problem of geometric representation of symbolic systems. The case of two commuting transformations, one having a chaotic behavior and the other an almost periodic structure (geodesic and horocycle flow, substitution and adic system).
Organizers: S. Ferenczi (IML, ferenczi@iml.univ-mrs.fr), J.-M. Gambaudo (ENS Lyon, jmgambau@umpa.ens-lyon.fr), P. Hubert (IML and Univ. de la Méditerranée, hubert@iml.univ-mrs.fr), R. Lima (CPT, lima@cpt.univ-mrs.fr), S. Vaienti (CPT and Univ. de Toulon, vaienti@cpt.univ-mrs.fr).
Scientific Committee: F. Ledrappier (president), S. Aubry, J. Bellissard, M. Keane, A. Vershik, J.-C. Yoccoz.

*6-18 **IMA Summer Program: Coding and Cryptography**, University of Minnesota, Minneapolis, Minnesota.
Organizers: I. Blake, R. Calderbank, A. Odlyzko, V. Pless.
Information: Institute for Mathematics and its Applications, University of Minnesota, 206 Church St., SE, Minneapolis, MN 55455; tel: 612-624-6066; e-mail: staff@ima.umn.edu; http://www.ima.umn.edu/cc/.

*7-17 **Emerging Applications of Dynamical Systems**, University of Minnesota, Minneapolis, Minnesota. (Sept. 1997, p. 1029)
Program: IMA Summer Program: Coding and Cryptography.
Organizers: R. Calderbank, A. Odlyzko, V. Pless.
Information: Institute for Mathematics and its Applications, University of Minnesota, 206 Church St. SE, Minneapolis, MN 55455; tel: 612-624-6066; e-mail: staff@ima.umn.edu; http://www.ima.umn.edu/dynsys/.

*15-18 **MAA Mathfest 98**, Ryerson Polytechnic College, Toronto, Canada.
Program: Invited lectures, contributed-paper sessions, student contributed-paper sessions, minicourses, short course, exhibits, and book sale.
Information: Visit "MAA Online" at http://www.maa.org/.

*15-22 **Mathematical Problems in Semiconductor Physics**, Grand Hotel San Michele, Cetraro (Cosenza), Italy.
Scientific Direction: M. Anile (Univ. di Catania), P. Degond (Univ. Paul Sabatier, Toulouse), and P. A. Markowich (TU, Berlin).
Courses: Unless otherwise noted, courses have 6 lectures in English: Drift diffusion equations and applications, W. Allegretto (Univ. of Alberta, Canada); An introduction to kinetic theory, D. Levermore (Univ. of Arizona, Tucson); Transport modelling in semiconductors, F. Poupaud (Univ. de Nice); Foundations of mathematical models for semiconductors (5 lectures in English), C. Ringhofer (Arizona State Univ., Tempe).
Applications: Those who want to attend the session should send an application to the director of C.I.M.E at the address below **no later than April 30, 1998.**
Information: Fondazione C.I.M.E. c/o Dipartimento di Matematica "U. Dini", Viale Morgagni, 67/A - 50134 Firenze, Italy; tel: +39-55-434975, +39-55-4237123; fax: +39-55-434975, +39-55-4222695; e-mail: CIME@UDINI.MATH.UNIFI.IT; WWW: http://WWW.MATH.UNIFI.IT/CIME/WELCOME.TO.CIME/.

*19-25 **Galois Representations in Arithmetic Geometry**, Anogia, Crete, Greece.
Organizers: I. Antoniadis (Crete, Greece), G. Pappas (Princeton), M. Taylor (Manchester, United Kingdom).
Main Speakers: D. Burns (London, United Kingdom), T. Chinburg (Univ. of Pennsylvania), K. Kato (Tokyo, Japan), T. Saito (Tokyo, Japan).
Information: For additional information please contact the local co-ordinator: S. Papadopoulou, Dept. of Mathematics, Univ. of Crete, Heraklion, Crete, Greece; fax: 81-393373; e-mail: souzana@math.uch.gr.

*20-August 7 **DIMACS Research and Education Institute 1998 Graph Theory and Combinatorial Optimization**, DIMACS Center, Rutgers University, Piscataway, New Jersey.
Participation: Researchers in graph theory and mathematics or computer science teachers or supervisors of grades 9-12 are invited to attend.
Aim: Working toward integration of education and research in the mathematical and computational sciences.
Activities: Week-long workshops: July 20-24 Paths and Cycles; July 27-31 Graph Embedding; August 3-7 Graph Coloring. There will also be seminars for researchers and all-institute activities, focused on issues of interest to both teachers & researchers. Deadline for applications is March 2, 1998.

Information: URL: `http://dimacs.rutgers.edu/drei/1998/`.

* 22–31 **Mathematical Modeling in Industry, A Workshop for Graduate Students**, University of Minnesota, Minneapolis, Minnesota.
Organizers: F. Reitich, F. Santosa.
Information: Contact: Institute for Mathematics and its Applications, Univ. of Minnesota, 206 Church St. SE, Minneapolis, MN 55455; tel: 612-624-6066; e-mail: `staff@ima.umn.edu`; `http://www.ima.umn.edu/modeling/`.

* 26–August 1 **Front Propagation: Theory and Applications**, Anogia, Crete, Greece.
Organizers: P.-L. Lions (Paris-Dauphine, France), A. Majda (Courant Inst.), P. Souganidis (Univ. of Wisconsin).
Main Speakers: G. Barles (Tours, France), V. Caselles (Illes Balears Univ., Spain), M. Crandall (Univ. of California at Santa Barbara), P.-L. Lions (Université Paris-Dauphine, France), S. Luckhaus (Bonn, Germany), A. Majda (Courant Inst.), C. Verdi (Milano, Italy).
Information: For additional information please contact the local co-ordinator: S Papadopoulou, Dept. of Mathematics, Univ. of Crete, Heraklion, Crete, Greece; fax: 81-393373; e-mail: `souzana@math.uch.gr`.

August 1998

* 6–10 **Stokes Summer School**, County Sligo, Skreen, Ireland.
Goal: A celebration at his birthplace of the many areas of physics and mathematics to which Sir George Gabriel Stokes made major contributions. Among the speakers are some of the world's leading authorities.
Organizers: M. Berry (Bristol Univ.), A. Wood (Dublin City Univ.).
Deadline: May 30, 1998. The number of participants is limited to 50.
Information: C. Morley, School of Mathematical Sciences, Dublin City University, Dublin 9, Ireland; e-mail: `carmel.morley@dcu.ie`; tel: +353-1-704-5293; fax: +353-1-704-5786.

* 9–11 **Fifth International Symposium on Solving Irregularly Structured Problems in Parallel (IRREGULAR'98)**, NERSC, Lawrence Berkeley National Laboratory, Berkeley, California.
Scope: The symposium focuses on algorithmic, applicational, and system aspects arising in the development of efficient parallel solutions to irregularly structured problems. It aims, in particular, at fostering cooperation among practitioners and theoreticians in the field. IRREGULAR'98 is the fifth in the series, after Geneva, Lyon, Santa Barbara, and Paderborn.
Topics: Papers are solicited in all research areas related to the parallelism of irregular problems, including but not limited to: abstract parallel models, applications, approximation, automatic program synthesis, combinatorial optimization, compiler optimization, computational geometry, data structures, graph algorithms, load balancing, mapping and scheduling, memory management, mesh computations, numerical algorithms, parallel I/O, parallel languages, randomization, sparse matrix computations, symbolic computation, particles simulations.
Speakers: J. R. Gilbert, B. Hendrickson, G. L. Miller, K. Pingali, M. Valero.
Local Organizer: R. Boucher, Lawrence Berkeley National Laboratory; e-mail: `RLBoucher@lbl.gov`.
Important Dates: Submissions: January 30, 1998; notification: April 12, 1998; camera-ready: May 24, 1998.
Information: `http://www.nersc.gov/Irregular98/`.

* 9–16 **The 1998 ASL European Summer Meeting (Logic Colloquium '98)**, Prague, Czech Republic.
Topics: The main topics of the meeting are proof theory, model theory, set theory, recursion theory, logic in computer science, and history and philosophy of logic.
Invited Speakers: J. van Benthem, S. B. Cooper, T. Coquand, A. Ekert, L. Fortnow, B. Hart, G. Hjorth, T. Jech, C. G. Jockusch, P. Komjáth, L. M. Lipshitz, Y. Palyutin, A. A. Razborov, A. G. Setzer, T. Strahm, G. Takeuti, and P. Welch.
Program: Tutorials will be given on several topics including fuzzy logic (P. Hájek), complexity and bounded arithmetic (J. Krajíček), and the elementary theory of free groups (Z. Sela). There will be special sessions in computability theory (A. Kučera and R. Shore), model theory (L. van den Dries and A. Macintyre), set theory (L. Bukovsky and B. Velickovic), philosophical logic (R. Parikh), and proof theory (W. Buchholz). Contributed talks are invited from all fields of logic.
Program Committee: K. Ambos-Spies, L. Bukovský, S. Buss (chair), P. Clote, S. Cook, L. van den Dries, P. Hájek, A. Macintyre, Y. Moschovakis, D. Mundici, R. Parikh, P. Pudlák, J.-P. Ressayre, S. Wainer, and B. Zilber.
Local Arrangements: Local arrangements including registration will be handled by Agentura Action M, Vršovická 68, 101 00 Praha 10, Czech Republic; tel: +420-2-6731 2333; fax: +420-2-6731 0503.
Information: Logic Colloquium 1998, Mathematical Institute AVČR, Žitná 25, CZ-11567 Praha 1, Czech Republic; tel: +420-2-222 11 631 (operator, ask for J. Sgall or P. Pudlák); WWW: `http://www.math.cas.cz/~lc98/`; e-mail: `lc98@math.cas.cz`.

* 10–12 **Conference on Combinatorics and Physics**, Los Alamos National Laboratory, Los Alamos, New Mexico.
Organizing Committee: B. Chen (Los Alamos National Laboratory), D. Jackson (Univ. of Waterloo), J. Louck (Los Alamos National Laboratory), G.-C. Rota (Massachusetts Institute of Technology), and P. Shiue (Univ. of Nevada, Las Vegas).
Program: Interdisciplinary research at the Los Alamos National Laboratory offers many opportunities for applications of combinatorics to physical problems. The aims of this conference are to highlight applications of combinatorics to physics and to identify further areas of interaction. The conference will feature several principal lectures. There will also be sessions for contributed papers.
Topics: Any topic that involves combinatorics and its connections or potential applications to any of the following areas of mathematical physics is welcome: symmetry methods, discrete dynamical systems, Kac-Moody algebra, Yang-Baxter equations, statistical mechanics, quasi-crystals, supersymmetries, string theory, quantum field theory, combinatorics of the symmetric group, computer simulation of physical systems, cellular automata and simulation, and related subjects.
Abstracts: Selected papers presented at the conference will be published in a special issue of *Annals of Combinatorics*. Abstracts should be submitted by May 31, 1998. Notification of acceptance will be made by June 15, 1998.
Information: More detailed information, including the list of principal speakers, may be found on the Web at `http://cnls.lanl.gov/~chen/CAP98/` or can be requested from B. Chen, Los Alamos National Laboratory, e-mail: `chen@t7.lanl.gov`; or P. Shiue, Dept. of Math. Sci., Univ. of Nevada, Las Vegas, NV 89154-4020; tel: 702-895-3748; fax: 702-895-4343; e-mail: `shiue@nevada.edu`.

* 10–14 **7th International Conference "Differential Geometry and Applications", Satellite Conference of ICM in Berlin**, Masaryk University, Brno, Czech Republic.
Topics: The conference is devoted to a wide range of topics in differential geometry, global analysis, and applications to mathematical physics. The meeting of the editorial board of the journal *Differential Geometry and Its Applications* will take place during the conference.
Organizers: The co-chairmen of the Program Committee are O. Kowalski (Charles Univ., Prague) and P. Michor (Univ. of Vienna). The chairman of the Organizing Committee is J. Slovak (Masaryk Univ. in Brno).
Information: `http://www.math.muni.cz/~slovak/DGA98.html`; e-mail: `dga@math.muni.cz`; postal mail: DGA98, Dept. of Algebra and Geometry, Masaryk University, Janackovo n. 2a, 662 95 Brno, Czech Republic.

* 12–16 **Georgia Topology Conference**, University of Georgia, Athens, Georgia.
Theme: Geometry and topology of 3-manifolds.
Speakers: J. Anderson (Southampton), A. Basmajian (Connecticut College), D. Canary (Michigan), T. Comar (Valparaiso), C. Fan (Oklahoma State), B. Goldman (Mary-

land), H. Howards (Wake Forest), A. Jones (Vassar), B. Magnum (Columbia), M. Morrill (Maryland), R. Roberts (Washington Univ.), K. Scannell (Rice), E. Sedgwick (Oklahoma State).

Organizers: E. Hamilton (Emory Univ.), emh@mathcs.emory.edu; C. McCrory (Univ. of Georgia), clint@math.uga.edu.

Information: http://www.math.uga.edu/~clint/gtc.html.

* 17-26 **Introductory Workshop in Foundations of Computational Mathematics and Symbolic Computation in Geometry and Analysis**, Mathematical Sciences Research Institute, Berkeley, California.

Program: It is usual to launch a special semester at MSRI with an introductory workshop. This time the two programs sharing the MSRI facilities in autumn 1998 are organizing a joint introductory workshop combining themes in foundations of computational mathematics and in symbolic computation in geometry and analysis. This workshop is not intended for the specialist, although many experts will be there to participate and interact with others interested in learning about this material, but rather for the mathematician in any field who would like to know more about these exciting areas and their applications to other parts of mathematics. The organizers have great interest in attracting to the workshop participants from all types of institutions and all backgrounds, including researchers from areas outside the main subjects of the workshop. They are in particular strongly encouraging mathematicians from traditionally underrepresented groups to apply. The format: Mornings will consist of brief minicourses, while afternoons will be devoted to study in small groups, seminars, and informal interaction.

Minicourses: Minicourses in foundations of computational mathematics: Solving polynomial equations (T. Krick), Complexity theory in numerical analysis (S. Smale), Homotopy methods (T. Y. Li), Optimization and interior point methods (J. Renegar), Computational dynamics (A. Stuart), Geometric integration (A. Iserles); and in symbolic computation in geometry and analysis: Gröbner bases (M. Stillman), Symbolic solution of differential equations (M. van der Put), Algebraic analysis (N. Takayama), Differential ideal theory (W. Sit), Real algebraic geometry (M. Coste), Combinatorial methods (J. De Loera). No prior knowledge of the subjects in question is assumed. Each participant will have an opportunity to tailor his/her menu according to personal tastes and preferences.

Organizers: A. Iserles, T. Krick, M.-F. Roy, M. Singer, A. Stuart, B. Sturmfels.

Financial Support: A limited amount of funding is available for partial support of people wishing to attend. Students, recent Ph.D.s, women, and minorities are particularly encouraged to apply. To apply for funding, send a letter explaining your interest in the workshop together with a vita or bibliography and a budget for travel/living expenses. If you are a student, also solicit a letter from a faculty adviser. All information should be received at MSRI by May 22, 1998.

Information: http://www-sccm.stanford.edu/FoCM/MSRI.html.

* 24-September 1 **Filtration in Porous Media and Industrial Applications**, Grand Hotel San Michele, Cetraro, Italy.

Scientific Direction: A. Fasano (Univ. di Firenze) and H. van Duijn (Univ. of Amsterdam).

Courses: Mathematical models for oil reservoirs engineering (6 lectures in English), M. S. Espedal (Univ. of Bergen); Filtration processes in various industrial problems (4 lectures in English), A. Fasano (Univ. di Firenze); Reactive transport processes in porous media (3 lectures in English), P. Knaber (Univ. Erlangen-Nürenberg); Homogenization theory and applications to filtration processes (6 lectures in English), A. Mikelic (Univ. Lyon I); Some nonlinear models arising in subsurface transport (3 lectures in English), H. van Duijn (Delft Univ. of Technology).

Applications: Those who want to attend the session should send an application to the director of C.I.M.E at the address below **no later than May 15, 1998.**

Information: Fondazione C.I.M.E. c/o Dipartimento di Matematica "U. Dini", Viale Morgagni, 67/A - 50134 Firenze, Italy; tel: +39-55-434975, +39-55-4237123; fax: +39-55-434975, +39-55-4222695; e-mail: CIME@UDINI.MATH.UNIFI.IT; WWW: http://WWW.MATH.UNIFI.IT/CIME/WELCOME.TO.CIME/.

* 24-September 1 **Stochastic PDEs and Kolmogorov Equations in Infinite Dimensions**, Grand Hotel San Michele, Cetraro, Italy.

Scientific Direction: G. Da Prato (S. N. S., Pisa).

Courses: Kolmogorov equations (8 lectures in English), N. V. Krylov (Univ. of Minnesota, Minneapolis); L^p-analysis of finite and infinite dimensional diffusion operators (8 lectures in English), M. Röckner (Univ. Bielefeld); Kolmogorov equations with infinite numbers of variables (8 lectures in English), J. Zabczyk (Polskiej Akademii Nauk, Warsaw).

Applications: Those who want to attend the session should send an application to the director of C.I.M.E at the address below **no later than May 15, 1998.**

Information: Fondazione C.I.M.E. c/o Dipartimento di Matematica "U. Dini", Viale Morgagni, 67/A - 50134 Firenze, Italy; tel: +39-55-434975, +39-55-4237123; fax: +39-55-434975, +39-55-4222695; e-mail: CIME@UDINI.MATH.UNIFI.IT; WWW: http://WWW.MATH.UNIFI.IT/CIME/WELCOME.TO.CIME/.

* 26-28 **Randomized Algorithms, a Satellite Workshop to MFCS'98**, Brno, Czech Republic.

Focus: The workshop focuses on algorithmic and complexity aspects arising in the development of efficient randomized solutions to computationally difficult problems. It aims, in particular, to foster cooperation among practitioners and theoreticians and among algorithmic and complexity researchers in the field. The workshop is organized in conjunction with Mathematical Foundations of Computer Science, the leading conference on theoretical computer science in E. Europe. MFCS'98 celebrates 25 years of MFCS.

Papers: Papers are solicited in all research areas related to randomization and approximation, including, but not limited to: design and analysis of randomized algorithms, randomized complexity, derandomization techniques, design and analysis of approximation algorithms, complexity of approximation problems, parallel and network algorithms, randomized learning, quantum computation versus randomized computation, various applications.

Program Committee: S. Arikawa (Fukuoka), S. Arora (Princeton), H. Buhrman (Amsterdam), C. Calude (Auckland), L. Fortnow (Chicago), R. Freivalds (chair, Riga), M. Golin (Hong Kong), J. Hromkovic (Aachen), R. Impagliazzo (San Diego), L. Kucera (Prague), M. Li (Waterloo), A. Lingas (Lund), S. Rajasekaran (Gainesville), J. Rolim (Geneva), O. Watanabe (Tokyo), R. Wiehagen (Kaiserslautern), T. Zeugmann (Fukuoka).

Invited Speakers: A. Ambainis (Berkeley) and M. Karpinski (Bonn).

Submissions: Contributions may be submitted electronically only by e-mailing a PostScript file to rand@cclu.lv. Submissions should consist of: a cover page, with the author's full name, address, fax number, e-mail address, a 100-word abstract, and keywords (this page should be in the form of a separate ASCII-only e-mail); an extended abstract describing original research in no more than 12 pages; an optional appendix, with more details to be read/consulted at the discretion of the Program Committee. It is expected that accepted papers will be presented at the workshop. Simultaneous submission to other conferences with published proceedings is not allowed except to MFCS'98, with the understanding that if the paper is accepted to MFCS'98, then the paper will not be published by RANDOMIZED ALGORITHMS.

Dates: Submissions: March 20, 1998; notifications: May 20,1998; camera-ready: June 10, 1998.

Information: http://www.latnet.lv/LU/MII/MII_staff/rusins/rand.html.

September 1998

* 7-10 **Undergraduate Mathematics Teaching Conference (UMTC98)**, Sheffield Hallam University, Sheffield, England.

Program: This is a working conference based this year on four group themes: Modern Approaches to Teaching Calculus, The Impact of Technology on Assessment, What is a Mathematics Degree for? and Students Talking Mathematics. Reports from each group are refereed by other groups and published in the conference proceedings. There are two plenary sessions with presentations this year given by Professor Sir Robert May, Chief Scientific Advisor to the UK Government and Head of the Office of Science and Technology and Dr. Michael Emery, Associate Director of the Quality Assessment Agency for HE in the UK. While most of the conference is spent in the workgroups, there is an opportunity for delegates to give short presentations, abstracts from which will appear in the conference proceedings.

Information: See UMTC98 Web page: `http://www.hull.ac.uk/mathskills/umtc/umtc98/`.

*14-18 **Solving Systems of Equations**, Mathematical Sciences Research Institute, Berkeley, California.

Focus: This workshop is a joint effort of both special semesters that will be held concurrently at MSRI: Foundations of Computational Mathematics and Symbolic Computation in Geometry and Analysis.

Organizers: J.-P. Dedieu, M.-F. Roy, M. Shub, and B. Sturmfels.

Information: `http://wocket.msri.org/activities/programs/9899/focm/`.

*14-19 **6th International Conference on Evolution Equations and Their Applications in Physical and Life Sciences**, Bad Herrenalb, Germany.

Topics: Topics range from functional analytic methods for partial differential equations to the modelling of physical and biological processes by evolution equations, with particular emphasis on: nonlinear evolution equations, (e.g., reaction-diffusion equations, Hamilton-Jacobi equations), semigroups and PDEs, stochastic evolution equations, mathematical physics (e.g., fluid mechanics, quantum physics, statistical mechanics), and mathematical biology (e.g., population dynamics, spreading of epidemics). Besides survey talks and individual lectures there will also be workshop discussions dedicated to these subjects.

Scientific Committee: S. Albeverio (Bonn), H. Amann (Zürich), W. Arendt (Ulm), G. Da Prato (Pisa), G. Lumer (Mons), J. Prüß (Halle), L. Weis (Karlsruhe).

Lecturers: S. Albeverio, H. Amann, I. Antoniou, W. Arendt, P. Auscher, C. J. Batty, Ph. Bénilan, J. v. Below, I. Cioranescu, Ph. Clément, T. Coulhon, M. G. Crandall, G. Da Prato, E. B. Davies, M. Demuth, O. Diekmann, K.-J. Engel, J. Escher, A. Favini, G. Goldstein, J. Goldstein, M. Gyllenberg, K. P. Hadeler, M. Hieber, M. Iannelli, N. Jacob, W. Jäger, A. Lasota, Y. Latushkin, R. de Laubenfels, P.-L. Lions, S.-O. Londen, G. Lumer, A. Lunardi, V. P. Maslov, S. Monniaux, R. Nagel, J. van Neerven, S. Nicaise, S. Oharu, I. Prigogine, J. Prüß, F. Räbiger, M. Röckner, S. Romanelli, W. Rueß, B.-W. Schulze, G. Simonett, J. Sprekels, Th. Sturm, K. Taira, A. Venni, Q.-Ph. Vu, W. v. Wahl, V. Wrobel, J. Zabczyk.

Sponsors: Deutsche Forschungsgemeinschaft (DFG), Landesregierung Baden-Württemberg, Universität Karlsruhe. Furthermore, the organizers are hopeful that the European Union will grant additional funds specifically to support the participation of a number of highly promising young researchers.

Information: Contact L. Weis, Conf. on Evolution Eq., Mathematisches Institut I, Universität Karlsruhe, 76128 Karlsruhe, Germany; fax: +49-0-721-608-6177; e-mail: `Conf-Evolve 98@math.uni-Karlsruhe.de`. Updates of this information will be given on the WWW: `http://ma1serv.mathematik.uni-Karlsruhe.de/c.html`.

*14-December 18 **Mathematical Questions in Signal and Image Processing**, Institut Henri Poincaré, Paris, France.

Purpose: Image and signal processing interact today with various mathematical domains. Statistics, but also geometric measure theory, nonlinear partial differential equations and wavelet theory are deeply and fruitfully involved. The purpose of the lectures is to describe these interactions. Tutorials and computer assisted demonstrations will illustrate and validate the progresses achieved by the use of those new conceptual tools.

Courses and Speakers: L Ambrosio: Geometric measure theory and applications to computer vision; R. Azencott: Théorie de l'information et reconnaissance des formes; D. Donoho: Statistical theory of optimal denoising; O. Faugeras: Géométrie et vision; J. Kovačevič: Traitement de la parole; S. Mallat: Traitement du signal et ondelettes; Y. Meyer: Ondelettes; J.-M. Morel: Filtrage interactif des images et équations aux dérivées partielles; D. Mumford: Pattern theory and vision; L. Yaroslavsky: The theory and practice of image processing. A regular seminar will be organized by L. Ambrosio, G. David, Y. Meyer, J. Petitot, and B. Teissier.

Workshops: French-American encounter on mathematics of image processing (Organized by R. Carmona and R. Lau with the support of the Office of Naval Research); Methodology in cognitive sciences (organized by J. Petitot, B. Teissier, and Fondation des Treilles).

Organizers: R. Azencott (École normale supérieure de Cachan), `azencott@cmla.ens-cachan.fr`; Y. Meyer (École normale supérieure de Cachan), `ymeyer@cmla.ens-cachan.fr`; J.-M. Morel (École normale supérieure de Cachan), `morel@ceremade.dauphine.fr`; D. Mumford (Brown Univ., Providence), `David_Mumford@Brown.edu`.

Information: The participation of graduate or postgraduate students is encouraged. Office space is spared for them. Some financial support can be provided: to apply, a CV (with a letter of recommendation for students) should be sent to the secretary of the Centre, É. Borel, tel: 01-44-27-67-75; fax: 01-44-07-09-37; e-mail: `image@ihp.jussieu.fr`.

October 1998

*7-11 **International Conference on Operator Theory and Its Applications to Scientific and Industrial Problems**, Winnipeg, Canada.

Principal Organizers: A. G. Ramm (KSU, USA), P. N. Shivakumar (Manitoba, Canada), and A. Strauss (Ulyanovsk, Russia).

Scope: This conference is a sequel to the one held by IIMS in 1994. Its scope is considerably broader and includes theory and applications.

Topics: The topics include: Functional models and characteristic functions of linear operators, operators in spaces with indefinite inner product, Schroedinger operators, spectral and scattering theory, infinite matrices and projection methods, interpolation of rational matrix functions, Hankel operators, operator theory and control theory, wave propagation and scattering, mathematical physics and fluid mechanics, signal and image processing, inverse problems, biomathematics and financial mathematics.

Information: IIMS Web page: `http://www.iims.umanitoba.ca`, or contact P. N. Shivakumar, e-mail: `insmath@umanitoba.ca`, tel: 204-474-6724, fax: 204-474-7602.

*8-9 **Third International Conference on Mathematical Modelling and Analysis (MMA-98)**, Institute of Mathematics, Riga, Latvia.

Focus: The conference focuses on various aspects of mathematical modelling and usage of difference methods for numerical solution of modern problems of science and engineering. It aims, in particular, to foster cooperation among practitioners and theoreticians in this field.

Topics: Analysis of numerical methods for solving problems of mathematical physics, parallel algorithms and parallel computing, applications of difference methods to engineering problems, analysis of ODE and PDE problems and applications. The scientific program includes invited plenary talks (40 min.) and contributed talks (20 min.). A volume of proceedings will be published after the conference. All papers will be refereed.

Call for Papers: Abstracts for contributed papers should be received by June 1, 1998.

Program and Organizing Committee: A. Buikis (vice-chair), J. Cepitis, R. Ciegis (vice-chair), O. Judrups, H. Kalis, A. Kilbas, M. Meilunas, H. Neunzert (vice-chair), A. Pedas, A. Reinfelds (chair), M. Sapagovas, V. Skakauskas, A. Zemitis.

Information: Institute of Mathematics, Akademijas laukums 1, LV-1524, Riga, Latvia; e-mail: `aijal@lanet.lv`; tel: +371-7615753, 7225674; fax: +371-7227520.

*16-17 **18th Annual South-Eastern Atlantic Regional Conference on Differen-**

tial Equations, Auburn University, Auburn, Alabama.

Organizing Committee: A. J. Meir (e-mail: ajm@math.auburn.edu), G. Harris, J. Henderson, G. Hetzer, P. G. Schmidt, and W. Shen.

* 18-23 **IEEE Visualization 1998 (Vis98)**, Sheraton Imperial Hotel, Research Triangle Park, North Carolina.

Aim: Visualization is a vital research and applications frontier shared by a variety of science, medical, engineering, business, and entertainment fields. The ninth IEEE Visualization conference focuses on interdisciplinary methods. It supports collaboration among developers and users of visualization techniques across all of science, engineering, medicine, and commerce. The conference week will include tutorials, symposia, and mini-workshops Sunday through Tuesday, and papers, panels, case studies, and late-breaking hot topics presentations Wednesday through Friday.

Topics: Visualization algorithms: volume rendering, flow visualization, isosurfaces, compression, vector and tensor visualization, sonification, etc.; Visualization techniques/emerging technologies: information visualization, databases, human perception, human factors, multi-variate visualization, virtual reality, etc.; Visualization applications: archaeology, astrophysics, aerospace, automotive, biomedicine, chemistry, education, electronics, environment, finance, mathematics, mechanics, molecular biology, physics, virtual reality, WWW, Java, VRML, HTML, AVS, data explorer, iris explorer, khoros, etc.

Paper Submissions: Papers are solicited that present research results related to all areas of visualization. Original papers should be limited to 5,000 words. The submission of NTSC VHS video (up to 5 minutes in length) to accompany the paper is strongly recommended. Please submit 7 copies of all materials. An electronic abstract must be sent through the conference Web site for each submission. For submissions and questions contact H. Rushmeier, IBM T. J. Watson Research Center, 30 Saw Mill River Rd., Hawthorne, NY 10532; tel: 914-784-7252, fax: 914-784-7667, e-mail: holly@watson.ibm.com.

Information: See the conference Web page for complete up-to-date information and submission details: http://www.erc.msstate.edu/vis98.

* 23-24 **The 20th Midwest Probabilty Colloquium**, Northwestern University, Evanston, Illinois.

Speakers: I. Karatzas (Columbia Univ.), Probabilistic Aspects of Finance (I, II); D. Khoshnevisan (Univ of Utah) and H.-T. Yau (Courant Institute).

Information: More information may be obtained from the organizer M. Pinsky, pinsky@math.nwu.edu.

November 1998

* 2-6 **Complexity Theory in Numerical Analysis**, Mathematical Sciences Research Institute, Berkeley, California.

Focus: Complexity theory is a central common denominator underlying foundations of computational mathematics. Hence this workshop will be of interest to theoretical numerical analysts as well as to computer scientists and algebraic geometers.This workshop is part of the fall 1998 semester program in Foundations of Computational Mathematics at MSRI.

Organizers: F. Cucker and J. Renegar.

Information: http://www-sccm.stanford.edu/FoCM/MSRI.html.

December 1998

* 19-21 **(ORSI Convention) International Conference on Operations Research and Industry**, Institute of Basic Science, Agra, India.

Focus: The conference focuses on Operations Research and its applications in Industry/Management with emphasis on real life problems.

Topics: Mathematical programming, stochastic processes, inventory control, queueing theory, network and information technology, system analysis and design, game theory, operational management, analysis and allied topics.

Call for Papers: Please send extended abstracts not exceeding 1,000 words, by August 31, 1998, to G. C. Sharma, Institute of Basic Science, Khandari, Agra - 282002, India.

Registration Fee: Indian delegates: Rs. 1600.00; Foreign delegates: US$ 150.00; Life member: Rs. 800.00; Students: Rs. 400.00. Fee should be paid by demand draft or cheque (with Rs. 20.00 extra) payable to ORSI, AGRA CHAPTER. Registration fee along with draft/cheque be mailed to: G. C. Sharma at the address above.

Important Dates: Last date for receipt of abstracts: August 31, 1998; last date for receipt of full paper: October 31, 1998; last date for receipt of registration fee: November 31, 1998; Conference in Agra, India: December 19 - 21, 1998.

Information: http://www.pen.eiu.edu/~cgdb/orsi.html; or e-mail to: D. Bhardwaj at dheerajb@cdac.ernet.in or cgdb@pen.eiu.edu.

January 1999

* 8-12 **Twenty-third Holiday Symposium: Algebraic Structures For Logic**, New Mexico State University, Las Cruces, New Mexico.

Program: The centerpiece of the program will consist of five one-hour lectures given by W. Blok (Univ. of Illinois at Chicago) and B. Jonsson (Vanderbilt Univ.) each. The lecture series will give a comprehensive view of the current state of algebraic logic and its universal algebraic counterparts in a manner accessible to graduate students and researchers from logic, universal algebra, and the information sciences. The purpose is to strengthen the cross-fertilization between research in logic and universal algebra, and to make accessible powerful recent techniques to potential users. Research papers on related topics will be presented as well.

Call for Papers: Abstracts should be sent to the organizers by November 7, 1998.

Organizers: M. Gehrke and J. Harding (New Mexico State Univ.), e-mail: holiday@nmsu.edu.

Information: http://www.math.nmsu.edu/~holsymp.

* 15-16 **ASL Winter Meeting (in conjunction with AMS meeting)**, San Antonio, Texas.

March 1999

* 20-23 **ASL Annual Meeting**, San Diego, California.

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.

July 1999

* 12-17 **Journees Arithmetiques 1999**, Rome, Italy.

Information: e-mail: ja99@mat.uniroma3.it.

August 2000

* 7-12 **Nevanlinna Colloquium**, University of Helsinki, Helsinki, Finland.

Program: The 18th Nevanlinna Colloquium will be held in Helsinki in August 2000. It continues the long series of Nevanlinna Colloquiums, of which the 17th was in Lausanne in 1997. The program will consist of about 40 invited talks. The talks are intended to cover a wide range of topics, and as in earlier Nevanlinna Colloquiums emphasis will be on subjects in some way connected to analysis and especially to geometric aspects of analysis.

Organizer: The meeting is organized by the Department of Mathematics at the Univ. of Helsinki.

Information: P. Tukia, pekka.tukia@helsinki.fi.

New Publications Offered by the AMS

Algebra and Algebraic Geometry

Systèmes de Racines Infinis

Nicole Bardy, *University of Nancy I, France*

This work creates sets of axioms of root systems that are general enough to include Kac-Moody algebras and the systems that appear in Borcherds' generalization of these algebras or in their almost-K-split forms and compatible with Moody and Pianzola's axiomatization of "real root systems".

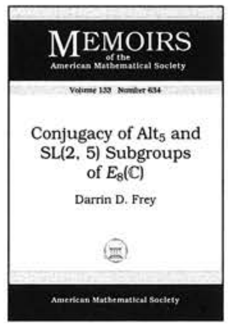
The author provides the basic theorems (essential to make the theory useful) that deal with the problems of subroot systems, conjugacy of bases, field extensions and quotient root systems (which appear in the study of almost-K-split forms). Text is in French.

Titles in this series are published by the Société Mathématique de France and distributed by the AMS in the United States, Canada, and Mexico. Orders from other countries should be sent to the SMF, Maison de la SMF, 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; Système de racines d'une algèbre de Kac-Moody-Borcherds; Systèmes de racines à base libre—axiomes et construction; Coracines des racines imaginaires dans le cas libre; Systèmes générateurs de racines et systèmes de racines engendrés; Sous-systèmes et Théorème de conjugaison des bases; Quotients d'un système générateur de racines; Bibliographie; Index des notations et des définitions; Index des définitions et axiomes; Index des propriétés.

Memoires de la Société Mathématique de France, Number 65

February 1998, 188 pages, Softcover, ISBN 2-85629-056-6, 1991 *Mathematics Subject Classification*: 17B67, 17B65, 20F55, **Individual member $47**, List $52, Order code SMFMEM/65N



Conjugacy of Alt_5 and SL(2, 5) Subgroups of $E_8(\mathbb{C})$

Darrin D. Frey, *Winona State University, MN*

Exceptional complex Lie groups have become increasingly important in various fields of mathematics and physics. As a result, there has been interest in expanding the representation theory of finite groups to include embeddings into the exceptional Lie groups. Cohen, Griess, Lisser, Ryba, Serre and Wales have pioneered this area, classifying the finite simple and quasisimple subgroups that embed in the exceptional complex Lie groups.

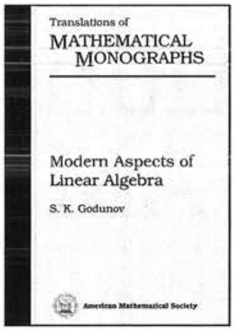
This work contains the first major results concerning conjugacy classes of embeddings of finite subgroups of an exceptional complex Lie group in which there are large numbers of classes. The approach developed in this work is character theoretic, taking advantage of the classical subgroups of $E_8(\mathbb{C})$. The machinery used is relatively elementary and has been used by the author and others to solve other conjugacy problems. The results presented here are very explicit. Each known conjugacy class is listed by its fusion pattern with an explicit character afforded by an embedding in that class.

Contents: Introduction and preliminaries; The dihedral group of order 6; The dihedral group of order 10; The Alt_5 and $SL(2,5)$ fusion patterns in $G, \mathcal{A}, \Delta$ and Ω; Fusion patterns of Alt_5 and $SL(2,5)$ subgroups of H; Fusion patterns of Alt_5 subgroups of $\mathcal{E}$; Conjugacy classes of Alt_5 subgroups of G; Conjugacy classes of $SL(2,5)$ subgroups of G; Appendix; Table of notation; References.

Memoirs of the American Mathematical Society, Volume 133, Number 634

May 1998, 175 pages, Softcover, ISBN 0-8218-0778-1, LC 98-2682, 1991 *Mathematics Subject Classification*: 22E40, 20C33, 20B35, 20D06, **Individual member $28**, List $47, Institutional member $38, Order code MEMO/133/634N

Supplementary Reading



Modern Aspects of Linear Algebra

S. K. Godunov, *Russian Academy of Sciences, Novosibirsk*

This book discusses fundamental ideas of linear algebra. The author presents the spectral theory of nonselfadjoint matrix operators and matrix pencils in a finite dimensional Euclidean space. Statements of computational problems and brief descriptions of numerical algorithms, some of them nontraditional, are given.

Proved in detail are classical problems that are not usually found in standard university courses. In particular, the material shows the role of delicate estimates for the resolvent of an operator and underscores the need for the study and use of such estimates in numerical analysis.

Contents: *Introduction:* Euclidean linear spaces; Orthogonal and unitary linear transformations; Orthogonal and unitary transformations. Singular values; *Matrices of operators in the Euclidean space:* Unitary similar transformations. The Schur theorem; Alternation theorems; The Weyl inequalities; Variational principles; Resolvent and dichotomy of spectrum; Quadratic forms in the spectrum dichotomy problem; Matrix equations and projections; The Hausdorff set of a matrix; *Application of spectral analysis. The most important algorithms:* Matrix operators as models of differential operators; Application of the theory of functions of complex variable; Computational algorithms of spectral analysis; Bibliography; Index.

Translations of Mathematical Monographs

June 1998, approximately 309 pages, Hardcover, ISBN 0-8218-0888-5, LC 98-13024, 1991 *Mathematics Subject Classification*: 15-01, 65-01; 47Axx, 34A40, 35A40, **Individual member $71**, List $119, Institutional member $95, Order code MMONO-GODUNOV1N

On the Search of Genuine p-adic Modular L-Functions for $GL(n)$

Haruzo Hida, *University of California, Los Angeles*

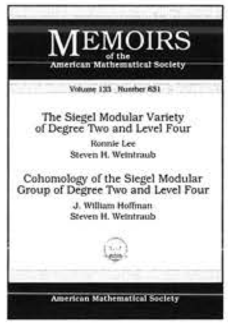
This volume states several conjectures concerning the existence and the meromorphy of many variable p-adic L-functions attached to many variable Galois representations (for example having values in $GL_n(Z_p[[X_1,\dots,X_r]])$) and presents supporting examples for the conjectures. The discussion begins speculatively but gradually becomes more concrete.

Titles in this series are published by the Société Mathématique de France and distributed by the AMS in the United States, Canada, and Mexico. Orders from other countries should be sent to the SMF, Maison de la SMF, B.P. 67, 13274 Marseille cedex 09, France, or to Institut Henri Poincaré, 11 rue Pierre et Marie Curie, 75231 Paris cedex 05, France. Members of the SMF receive a 30% discount from list.

Contents: Introduction; p-Acid Hecke algebras; Periods of motives; Periods of arithmetic Galois representations; Periods of tensor products of motives; p-Adic Rankin products; pAdic Rankin products in partially CM case; p-Ordinary Katz p-adic L-functions; Bibliography; Correction to [41]; List of symbols.

Memoires de la Société Mathématique de France, Number 67

February 1998, 110 pages, Softcover, ISBN 2-85629-054-X, 1991 *Mathematics Subject Classification*: 11F13, 11F41, 11F67, 11F70, 11F85, **Individual member $28**, List $31, Order code SMFMEM/67N



The Siegel Modular Variety of Degree Two and Level Four/Cohomology of the Siegel Modular Group of Degree Two and Level Four

Ronnie Lee, *Yale University, New Haven, CT*, and
Steven H. Weintraub and **J. William Hoffman**, *Louisiana State University, Baton Rouge*

The Siegel Modular Variety of Degree Two and Level Four, by Ronnie Lee and Steven H. Weintraub

Let $\mathbf{M}_n$ denote the quotient of the degree two Siegel space by the principal congruence subgroup of level n of $Sp_4(\mathbb{Z})$. $\mathbf{M}_n$ is the moduli space of principally polarized abelian surfaces with a level n structure and has a compactification $\mathbf{M}_n^*$ first constructed by Igusa. $\mathbf{M}_n^*$ is an almost non-singular (non-singular for $n > 1$) complex three-dimensional projective variety (of general type, for $n > 3$).

The authors analyze the Hodge structure of $\mathbf{M}_4^*$, completely determining the Hodge numbers $h^{p,q} = \dim H^{p,q}(\mathbf{M}_4^*)$. Doing so relies on the understanding of $\mathbf{M}_2^*$ and exploitation of the regular branched covering $\mathbf{M}_4^* \to \mathbf{M}_2^*$.

Cohomology of the Siegel Modular Group of Degree Two and Level Four, by J. William Hoffman and Steven H. Weintraub

The authors compute the cohomology of the principal congruence subgroup $\Gamma_2(4) \subset S_p4(\mathbb{Z})$ consisting of matrices $\gamma \equiv \mathbf{1}$ mod 4. This is done by computing the cohomology of the moduli space $\mathbf{M}_4$. The mixed Hodge structure on this cohomolgy is determined, as well as the intersection cohomology of the Satake compactification of $\mathbf{M}_4$.

Contents: *The Siegel Modular Variety of Degree Two and Level Four:* Introduction; Algebraic background; Geometric background; Taking stock; Type III A; Type II A; Type II B; Type IV C; Summing up; Appendix. An exact sequence in homology; References; *Cohomology of the Siegel Modular Group of Degree Two and Level Four:* Introduction; The building; Cycles; The main theorems; References.

Memoirs of the American Mathematical Society, Volume 133, Number 631

May 1998, 75 pages, Softcover, ISBN 0-8218-0620-3, LC 98-2692, 1991 *Mathematics Subject Classification*: 14J30; 11F46, 14C30, 32M15, 57T99, **Individual member $23**, List $38, Institutional member $30, Order code MEMO/133/631N

Faisceaux Pervers, Transformation de Mellin et Déterminants

François Loeser, *École Polytechnique, Palaiseau, France*

The Mellin transformation of l-adic perverse sheaves on a torus associates a coherent module on the scheme of l-adic characters of the torus to a perverse sheaf. In this volume, the author studies the arithmetical aspects of the Mellin transformation, such as the semi-linear Galois action on the Mellin transform. Specifically expressed are several determinants associated to perverse sheaves in terms of hypergeometric perverse sheaves. Text is in French.

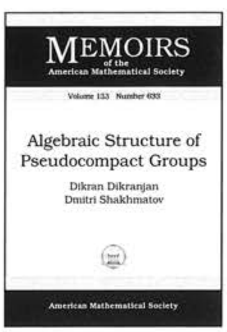
Titles in this series are published by the Société Mathématique de France and distributed by the AMS in the United States, Canada, and Mexico. Orders from other countries should be sent to the SMF, Maison de la SMF, B.P. 67, 13274 Marseille cedex 09, France, or to Institut Henri Poincaré, 11 rue Pierre et Marie Curie, 75231 Paris cedex 05, France. Members of the SMF receive a 30% discount from list.

Contents: Introduction; Notations et conventions; Rappels et compléments; Faisceaux pervers hypergéométriques et calcul de $\det_{\text{int}}$; Transformation de Mellin sur un corps fini; Démonstrations; Action du groupe de Galois sur le transformé de Mellin; Caractéristique 0; Appendice A; Appendice B; Bibliographie.

Memoires de la Société Mathématique de France, Number 66

February 1998, 105 pages, Softcover, ISBN 2-85629-053-1, 1991 *Mathematics Subject Classification*: 11K30, 14G10, **Individual member $25**, List $28, Order code SMFMEM/66N

Analysis



Algebraic Structure of Pseudocompact Groups

Dikran Dikranjan, *University of Udine, Italy*, and
Dmitri Shakhmatov, *Ehime University, Matsuyama, Japan*

The fundamental property of compact spaces—that continuous functions defined on compact spaces are bounded—served as a motivation for E. Hewitt to introduce the notion of a pseudocompact space. The class of pseudocompact spaces proved to be of fundamental importance in set-theoretic topology and its applications.

This clear and self-contained exposition offers a comprehensive treatment of the question, *When does a group admit an introduction of a pseudocompact Hausdorff topology that makes group operations continuous?* Equivalently, what is the algebraic structure of a pseudocompact Hausdorff group?

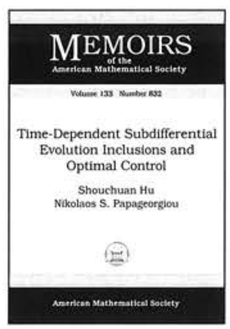
The authors have adopted a unifying approach that covers all known results and leads to new ones. Results in the book are free of any additional set-theoretic assumptions.

Contents: Introduction; Principal results; Preliminaries; Some algebraic and set-theoretic properties of pseudocompact groups; Three technical lemmas; Pseudocompact group topologies on $\mathcal{V}$-free groups; Pseudocompact topologies on torsion Abelian groups; Pseudocompact connected group topologies on Abelian groups; Pseudocompact topologizations versus compact ones; Some diagrams and open questions; Diagram 2; Diagram 3; Bibliography.

Memoirs of the American Mathematical Society, Volume 133, Number 633

May 1998, 83 pages, Softcover, ISBN 0-8218-0629-7, LC 98-2683, 1991 *Mathematics Subject Classification*: 22A05, 54D30; 03E10, 03E35, 04A10, 20E05, 20E10, 20E26, 20E34, 20F50, 20K10, 20K20, 20K45, 22C05, 54A25, 54A35, 54C25, 54D05, 54D20, 54H11, **Individual member $23**, List $39, Institutional member $31, Order code MEMO/133/633N

Differential Equations



Time-Dependent Subdifferential Evolution Inclusions and Optimal Control

Shouchuan Hu, *Southwest Missouri State University, Springfield*, and
Nikolaos S. Papageorgiou, *National Technical University, Athens, Greece*

This volume studies multivalued evolution equations driven by time-dependent subdifferential operators and optimal control problems for such systems. The formulation is general enough to incorporate problems with time varying constraints. For evolution inclusions, existence relaxation and structural results for the solution set are proved. For optimal control problems, a general existence theory is developed, different forms of the relaxed problem are introduced and studied, well-posedness properties are investigated and the precise relation between the properties of relaxability and well-posedness is established. Various examples of systems which fit in the abstract framework are analyzed.

Contents: Introduction; Preliminaries: Mathematical background and terminology; Evolution inclusions; Optimal control; Applications; References.

Memoirs of the American Mathematical Society, Volume 133, Number 632

Continued

May 1998, 81 pages, Softcover, ISBN 0-8218-0779-X, LC 98-2684, 1991 *Mathematics Subject Classification*: 34A60, 34G20, 35K22, 35R70, 49J27, 49J40, 49J45, **Individual member $23**, List $38, Institutional member $30, Order code MEMO/133/632N

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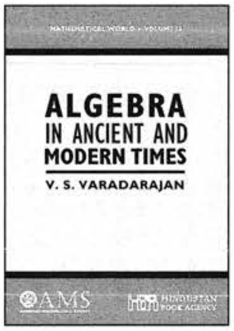


Algebra in Ancient and Modern Times

V. S. Varadarajan, *University of California, Los Angeles*

This text offers a special account of Indian work in diophantine equations during the 6th through 12th centuries and Italian work on solutions of cubic and biquadratic equations from the 11th through 16th centuries. The volume traces the historical development of algebra and the theory of equations from ancient times to the beginning of modern algebra, outlining some modern themes, such as the fundamental theorem of algebra, Clifford algebras and quarternions. It is geared toward undergraduates who have no background in calculus.

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

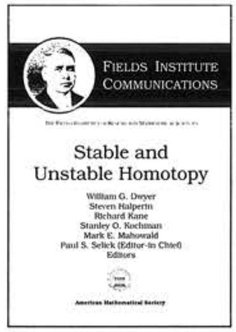
This book is co-published with the Hindustan Book Agency (New Delhi) and is distributed worldwide, except in India, Sri Lanka, Bangladesh, Pakistan, and Nepal by the American Mathematical Society.

Contents: *Some history of early mathematics:* Eucild–Diophantus–Archimedes; Pythagoras and the Pythagorean triplets; Āryabhaṭa–Brahmagupta–Bhāskara; Irrational numbers: construction and approximation; Arabic mathematics; Beginnings of algebra in Europe; The cubic and biquadratic equations; *Solutions for the cubic and biquadratic equations:* Solution of the cubic equation; Solution of the biquadratic equation; *Some themes from modern algebra:* Numbers, algebra, and the physical world; Complex numbers; Fundamental theorem of algebra; Equations of degree greater than four; General number systems and the axiomatic treatment of algebra; References; Chronology; Index.

Mathematical World, Volume 12

April 1998, approximately 174 pages, Softcover, ISBN 0-8218-0989-X, LC 98-15355, 1991 *Mathematics Subject Classification*: 01-01, 12-01, 12-03; 01A20, 01A29, 01A30, 01A40, **All AMS members $20**, List $25, Order code MAWRLD/12N

Geometry and Topology



Stable and Unstable Homotopy

William G. Dwyer, *University of Notre Dame, IN, USA* **Steven Halperin**, *University of Toronto, ON, Canada*, **Richard Kane**, *University of Western Ontario, London, Canada*, **Stanley O. Kochman**, *York University, Toronto, ON, Canada*, **Mark E. Mahowald**, *Northwestern University, Evanston, IL, USA*, and **Paul S. Selick**, *University of Toronto, Scarborough, ON, Canada*, Editors

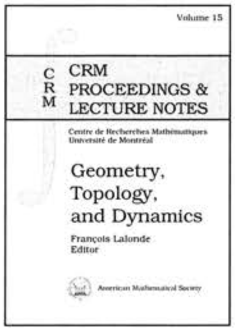
This volume presents the proceedings of workshops on stable homotopy theory and on unstable homotopy theory held at The Fields Institute as part of the homotopy program during the year 1996. The papers in the volume describe current research in the subject, and all included works were refereed. Rather than being a summary of work to be published elsewhere, each paper is the unique source for the new material it contains.

The book contains current research from international experts in the subject area, and presents open problems with directions for future research.

Contents: **G. Arone** and **M. Kankaanrinta**, A functorial model for iterated Snaith splitting with applications to calculus of functors; **R. R. Bruner**, Some remarks on the root invariant; **F. R. Cohen**, On the Lusternik-Schnirelmann category of an iterated loop space; **F. R. Cohen** and **V. V. Vershinin**, Thom spectra which are wedges of Eilenberg-MacLane spectra; **O. Cornea**, Some properties of the relative Lusternik-Schnirelmann category; **E. S. Devinatz**, The generating hypothesis revisited; **B. Gray**, The periodic lambda algebra; **J. P. Greenlees**, Rational $O(2)$-equivariant cohomology theories; **J. Grodal**, The transcendence degree of the mod p cohomology of finite Postnikov systems; **J. Harper**, Cogroups which are not suspensions. II; **M. J. Hopkins**, **D. C. Ravenel**, and **W. S. Wilson**, Morava Hopf algebras and spaces $K(n)$ equivalent to finite Postnikov systems; **N. E. Kechagias**, The transfer between rings of modular invariants of subgroups of $GL(n,p)$; **K. Y. Lam** and **D. Randall**, Projectivity of Im J, cospherical classes, and geometric dimension; **J.-M. Lemaire**, Inert and lazy n-cones; **J. P. Lin**, Mod 3 truncated polynomial algebras over the Steenrod algebra; **W.-H. Lin**, A differential in the Adams spectral sequence for spheres; **C. A. McGibbon**, Some problems about phantom maps; **N. Minami**, On some BP_*BP-primitive elements related to the Kervaire invariant problem; **J. M. Møller**, Deterministic p-compact groups; **P. Selick**, Space exponents for loop spaces of spheres; **J.-Y. Tai**, On f-localization functors and connectivity; **T. Yamaguchi**, On characterizations of rational homotopy types with some rational cyclic cohomologies; List of participants.

Fields Institute Communications, Volume 19

May 1998, 316 pages, Hardcover, ISBN 0-8218-0824-9, LC 98-11194, 1991 *Mathematics Subject Classification*: 55-06; 55Pxx, **Individual member $47**, List $79, Institutional member $63, Order code FIC/19N



Geometry, Topology, and Dynamics

François Lalonde, *University of Quebec at Montreal, PQ, Canada*, Editor

This volume contains the proceedings from the workshop on "Geometry, Topology and Dynamics" held at CRM at the University of Montreal. The event took place at a crucial time with respect to symplectic developments. During the previous year, Seiberg and Witten had just introduced the famous gauge equations. Taubes then extracted new invariants that were shown to be equivalent in some sense to a particular form of Gromov invariants for symplectic manifolds in dimension 4. With Gromov's deformation theory, this constitutes an important advance in symplectic geometry by furnishing existence criteria.

Meanwhile, contact geometry was rapidly developing. Using both holomorphic arguments in symplectizations of contact manifolds and ad hoc topological arguments—or even gauge theoretic methods—several results were obtained on 3-dimensional contact manifolds and new surprising facts were derived about the Bennequin-Thurston invariant.

Furthermore, a fascinating relation exists between Hofer's geometry, pseudoholomorphic curves and the K-area recently introduced by Gromov. Finally, longstanding conjectures on the flux were resolved in a substantial number of specific cases by comparing various aspects of Floer-Novikov homology with Morse homology.

The papers in this volume are written by leading experts and are all clear, comprehensive, and original. The work covers a complete range of exciting new developments in symplectic and contact geometries.

Contents: A. Banyaga, Isomorphisms between classical diffeomorphism groups; **Y. Eliashberg** and **M. Fraser**, Classification of topologically trivial Legendrian knots; **H. Geiges** and **C. B. Thomas**, Contact structures on 7-manifolds; **F. Lalonde**, **D. McDuff**, and **L. Polterovich**, On the flux conjectures; **V. Lizan**, About the bubbling off phenomenon in the limit of a sequence of J-curves; **J. D. McCarthy** and **J. G. Wolfson**, Symplectic resolution of isolated algebraic singularities; **D. Milinkovic** and **Y.-G. Oh**, Generating functions versus action functional stable Morse theory versus Floer theory; **M. Min-Oo**, Scalar curvature rigidity of certain symmetric spaces; **K. F. Siburg**, Bi-invariant metrics for symplectic twist mappings on $T^*\mathbb{T}^n$ and an application in Aubry-Mather theory.

CRM Proceedings & Lecture Notes, Volume 15

May 1998, 148 pages, Softcover, ISBN 0-8218-0877-X, LC 98-13428, 1991 *Mathematics Subject Classification*: 03C15, 58Dxx, 58Fxx, **Individual member $21**, List $35, Institutional member $28, Order code CRMP/15N

The b-Pseudodifferential Calculus on Galois Coverings and a Higher Atiyah-Patodi-Singer Index Theorem

Eric Leichtnam, *École Nationale Superieure, Paris, France*, and **Paolo Piazza**, *Massachusetts Institute of Technology, Cambridge*

Let $\Gamma \to \tilde{M} \to M$ be a Galois covering with boundary. In this book, the authors develop a b-pseudodifferential calculus on the noncompact manifold $\tilde{M}$. The main application is the proof of a higher Atiyah-Patodi-Singer index formula for a generalized Dirac operator $\tilde{D}$ on $\tilde{M}$, under the assumption that the group Γ is of polynomial growth with respect to a word metric and that the L^2-spectrum of the boundary operator $\tilde{D}_0$ has a gap at zero. Results extend the work of Atiyah-Patodi-Singer, Connes-Moscovici, and Lott.

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

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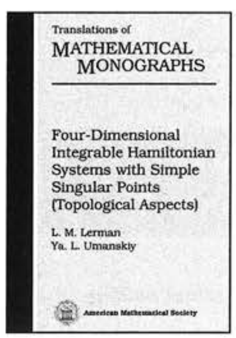
Contents: Introduction; Higher index theory on closed manifolds; Galois coverings and the b-calculus; Higher Atiyah-Patodi-Singer index theory; Appendices.

Memoires de la Société Mathématique de France, Number 68

January 1998, 121 pages, Softcover, ISBN 2-85629-060-4, 1991 *Mathematics Subject Classification*: 58G12, 58G20, 46L87, 58G15, **Individual member $24**, List $27, Order code SMFMEM/68N



Four-Dimensional Integrable Hamiltonian Systems with Simple Singular Points (Topological Aspects)

L. M. Lerman, *Research Institute for Applied Mathematics and Cybernetics, Nizhni Novgorod, Russia*, and **Ya. L. Umanskiy**, *Total System Services, Inc., Atlanta, GA*

The main topic of this book is the isoenergetic structure of the Liouville foliation generated by an integrable system with two degrees of freedom and the topological structure of the corresponding Poisson action of the group $\mathbb{R}^2$. This is a first step towards understanding the global dynamics of Hamiltonian systems and applying perturbation methods. Emphasis is placed on the topology of this foliation rather than on analytic

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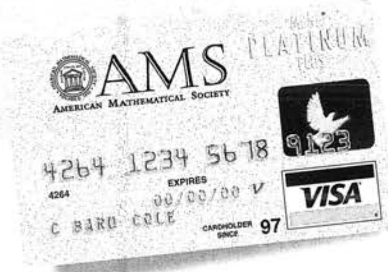

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representation. In contrast to previously published works in this area, here the authors consistently use the dynamical properties of the action to achieve their results.

Contents: General results of the theory of Hamiltonian systems; Linear theory and classification of singular orbits; IHVF and Poisson actions of Morse type; Center-center type singular points of PA and elliptic singular points of IHVF; Saddle-center type singular points; Saddle type singular points; Saddle-focus type singular points; Realization; Normal forms of quadratic Hamilton functions and their centralizers in $sp(4,\mathbb{R})$; The gradient system on M compatible with the Hamiltonian; Bibliography.

Translations of Mathematical Monographs

May 1998, approximately 192 pages, Hardcover, ISBN 0-8218-0375-1, 1991 *Mathematics Subject Classification*: 58F05, 70Hxx, **Individual member $47**, List $79, Institutional member $63, Order code MMONO-LERMANN

Mathematical Physics

The Γ-Equivariant Form of the Berezin Quantization of the Upper Half Plane

Florin Rădulescu, *University of Iowa, Iowa City*

The author defines the Γ equivariant form of Berezin quantization, where Γ is a discrete lattice in $PSL(2,\mathbb{R})$. The Γ equivariant form of the quantization corresponds to a deformation of the space $\mathbb{H}/\Gamma$ ($\mathbb{H}$ being the upper halfplane). The von Neumann algebras in the deformation (obtained via the Gelfand-Naimark-Segal construction from the trace) are type II_1 factors. When Γ is $PSL(2,\mathbb{Z})$, these factors correspond (in the setting considered by K. Dykema and independently by the author, based on the random matrix model of D. Voiculescu) to free group von Neumann algebras with a "fractional number of generators". The number of generators turns out to be a function of Planck's deformation constant. The Connes cyclic 2-cohomology associated with the deformation is analyzed and turns out to be (by using an automorphic forms construction) the coboundary of an (unbounded) cycle.

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

Contents: Introduction; Definitions and outline of the proofs; Berezin quantization of the upper half plane; Smooth algebras associated to the Berezin quantization; The Berezin quantization for quotient space $\mathbb{H}/\Gamma$; The covariant symbol in invariant Berezin quantization; A cyclic 2-cocycle associated to a deformation quantization; Bounded cohomology and the cyclic 2-cocycle of the Berezin's deformation quantization; Bibliography.

Memoirs of the American Mathematical Society, Volume 133, Number 630

May 1998, 70 pages, Softcover, ISBN 0-8218-0752-8, LC 98-2681, 1991 *Mathematics Subject Classification*: 46L35; 46L37, 46L57, 81S99, 11F99, **Individual member $23**, List $38, Institutional member $30, Order code MEMO/133/630N

American Mathematical Society

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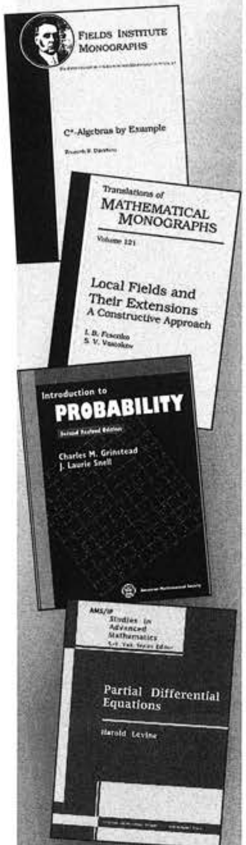

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Shreeram S. Abhyankar, *Purdue University, West Lafayette, IN*

Mathematical Surveys and Monographs, Volume 35; 1990; ISBN 0-8218-1535-0; 295 pages; Softcover; **All AMS members $29**, List $34, Order Code SURV/35CI85

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Kenneth R. Davidson, *University of Waterloo, ON, Canada*

The writing is clear and easy to follow ... an outstanding book that should be on every operator algebraists bookshelf.
—***Mathematical Reviews***

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Fields Institute Monographs, Volume 6; 1996; ISBN 0-8218-0599-1; 309 pages; Hardcover; **All AMS members $47**, List $59, Order Code FIM/6CI85

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I. B. Fesenko, *University of Nottingham, England*, and **S. V. Vostokov**, *Russian Academy of Sciences, St. Petersburg*

It is remarkable to see just how far the subject has developed since 1968 ... contains an absolute wealth of material ... this approach is a real success ... results are obtained with a minimum of fuss, so that the story unfolds rather quickly and holds the reader's interest ... a copious supply of well-structured exercises ... most certainly a valuable addition to the literature ... carefully written and well-presented state of the art account of local fields, which contains much ... of interest to the expert and non-expert alike ... its appeal should go well beyond the usual public number of theorists.
—***Bulletin of the London Mathematical Society***

Well written ... A big amount of exercises contribute to the attraction of this highly original book.
—***Zentralblatt für Mathematik***

Translations of Mathematical Monographs, Volume 121; 1993; ISBN 0-8218-4613-2; 283 pages; Softcover; **All AMS members $39**, List $49, Order Code MMONO/121CI85

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Phillip A. Griffiths, *Institute for Advanced Study, Princeton, NJ*

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—***Mathematical Reviews***

Translations of Mathematical Monographs, Volume 76; 1989; ISBN 0-8218-4537-3; 221 pages; Softcover; **All AMS members $32**, List $39, Order Code MMONO/76CI85

Introduction to Probability
Second Revised Edition

Charles M. Grinstead, *Swarthmore College, PA*, and **J. Laurie Snell**, *Dartmouth College, Hanover, NH*

1997; ISBN 0-8218-0749-8; 510 pages; Hardcover; **All AMS members $39**, List $49, Order Code IPROBCI85

Lectures on the Mathematics of Finance

Ioannis Karatzas, *Columbia University, New York, NY*

CRM Monograph Series, Volume 8; 1996; ISBN 0-8218-0909-1; 148 pages; Softcover; **All AMS members $31**, List $39, Order Code CRMM/8.SCI85

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Harold Levine, *Stanford University, CA*

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AMS/IP Studies in Advanced Mathematics, Volume 6; 1997; ISBN 0-8218-0775-7; 706 pages; Hardcover; **All AMS members $55**, List $69, Order Code AMSIP/6CI85

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Andy R. Magid, *University of Oklahoma, Norman*

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—***Bulletin of the AMS***

University Lecture Series, Volume 7; 1994; ISBN 0-8218-7004-1; 105 pages; Softcover; **All AMS members $16**, List $19, Order Code ULECT/7CI85

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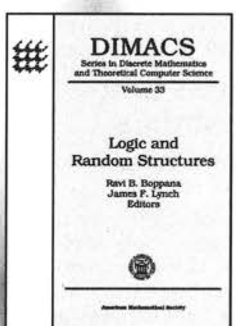
American Mathematical Society

Logic and Random Structures



Ravi B. Boppana, *New York University, Courant Institute, NY,* and **James F. Lynch**, *Clarkson University, Potsdam, NY,* Editors

This volume contains selected papers from the DIMACS Workshop on Logic and Random Structures held in November 1995. The workshop was a major event of the DIMACS Special Year on Logic and Algorithms. The central theme was the relationship between logic and probabilistic techniques in the study of finite structures.

In the last several years, this subject has developed into a very active area of mathematical logic with important connections to computer science. The DIMACS workshop was the first of its kind devoted to logic and random structures. Recent work of leaders in the field is contained in the volume, as well as new theoretical developments and applications to computer science.

DIMACS: Series in Discrete Mathematics and Theoretical Computer Science, Volume 33; 1997; 130 pages; Hardcover; ISBN 0-8218-0578-9; List $29; Individual member $17; Order code DIMACS/33NA

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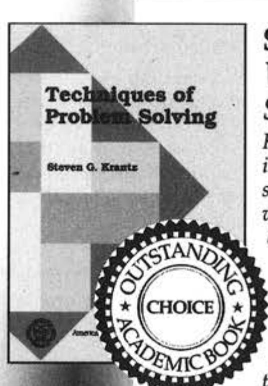

Steven G. Krantz, *Washington University, St. Louis, MO*

Krantz has collected a thoroughly engaging arsenal of problems and problem-solving techniques. Most scientists will want to have a copy for personal reference and for the mental stimulation that it provides. It is well written in a style that encourages the reader to become actively involved ... a myriad of fascinating related problems are provided. After a delightful introductory chapter, the chapters are primarily organized around specific techniques and their applicability in areas such as geometry, logic, recreational math, and counting. The book is written in a linear fashion that makes it advisable to tackle problems in sequential order ... would be an excellent tool for teaching novices to read some mathematics

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1997; 465 pages; Softcover; ISBN 0-8218-0619-X; List $29; All AMS members $23; Order code TPSNA

Solutions Manual for Techniques of Problem Solving

Luis Fernández and **Haedeh Gooransarab,** *Washington University, St. Louis, MO,* with assistance from Steven G. Krantz

1997; 188 pages; Softcover; ISBN 0-8218-0628-9; List $12; All AMS members $10; Order code SMTPSNA

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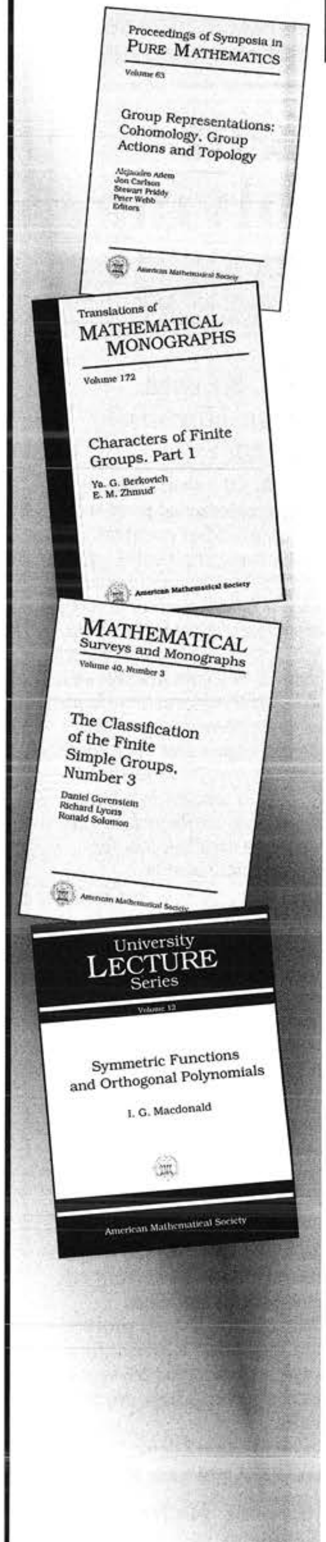

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Alejandro Adem, *University of Wisconsin, Madison*, **Jon Carlson**, *University of Georgia, Athens*, **Stewart Priddy**, *Northwestern University, Evanston, IL*, and **Peter Webb**, *University of Minnesota, Minneapolis*, Editors

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Proceedings of Symposia in Pure Mathematics, Volume 63; 1998; 532 pages; Hardcover; ISBN 0-8218-0658-0; List $99; Individual member $59; Order code PSPUM/63NA

Characters of Finite Groups. Part 1

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

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

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

Translations of Mathematical Monographs, Volume 172; 1998; 382 pages; Hardcover; ISBN 0-8218-4606-X; List $129; Individual member $77; Order code MMONO/172NA

The Classification of the Finite Simple Groups, Number 3

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

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

This volume offers a wealth of basic facts and computations. Much of the material is not readily available from any other source. In particular, the book contains the statements and proofs of the fundmental Borel-Tits Theorem and Curtis-Tits Theorem. It also contains complete information about the centralizers of semisimple involutions in groups of Lie type, as well as many other local subgroups.

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

Independent Study

Algebras of Functions on Quantum Groups: Part I

Leonid I. Korogodski and **Yan S. Soibelman**, *Institute for Advanced Study, Princeton, NJ*

The book is devoted to the study of algebras of functions on quantum groups. The authors' approach to the subject is based on the parallels with symplectic geometry, allowing the reader to use geometric intuition in the theory of quantum groups. The book includes the theory of Poisson-Lie algebras (quasi-classical version of algebras of functions on quantum groups), a description of representations of algebras of functions and the theory of quantum Weyl groups. This book can serve as a text for an introduction to the theory of quantum groups.

Mathematical Surveys and Monographs, Volume 56; 1998; 150 pages; Hardcover; ISBN 0-8218-0336-0; List $49; All AMS members $39; Order code SURV/56NA

Symmetric Functions and Orthogonal Polynomials

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

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

University Lecture Series, Volume 12; 1998; 53 pages; Softcover; ISBN 0-8218-0770-6; List $19; All AMS members $15; Order code ULECT/12NA

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Meetings & Conferences of the AMS

PROGRAM ALERT: In order that AMS meeting programs include the most timely information for each speaker, abstract deadlines have been moved to dates much closer to the meeting. What this means is that most meeting programs will appear in the *Notices* *after* the meeting takes place. However, complete meeting programs will be available on e-MATH about two to three weeks after the abstract deadline. ***Remember***, e-MATH is your most comprehensive source for up-to-date meeting information. See `http://www.ams.org/meetings/`.

Louisville, Kentucky

University of Louisville

March 20–21, 1998

Meeting #931

Southeastern Section
Associate secretary: Robert J. Daverman
Announcement issue of *Notices*: January 1998
Program issue of *Notices*: May 1998
Issue of *Abstracts*: Volume 19, Issue 2

Manhattan, Kansas

Kansas State University

March 27–28, 1998

Meeting #932

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: January 1998
Program issue of *Notices*: June 1998
Issue of *Abstracts*: Volume 19, Issue 2

Philadelphia, Pennsylvania

Temple University

April 4–6, 1998

Meeting #933

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: January 1998
Program issue of *Notices*: June 1998
Issue of *Abstracts*: Volume 19, Issue 2

Davis, California

University of California

April 25–26, 1998

Meeting #934

Western Section
Associate secretary: Robert J. Daverman
Announcement issue of *Notices*: February 1998
Program issue of *Notices*: June 1998
Issue of *Abstracts*: Volume 19, Issue 2

Deadlines

For organizers: Expired

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

Invited Addresses

Edward Frenkel, UC Berkeley, *Recent progress in geometric Langlands correspondence.*

Ian Putnam, University of Victoria, *Interactions between C*-algebras and dynamics.*

Boris Rozovsky, University of Southern California, *Wiener chaos and stochastic PDEs.*

William Thurston, University of California, Davis, *Three-manifolds, foliations and circles.*

Special Sessions

C-algebras and Dynamics*, **Jerry Kaminker**, Indiana Univ-Purdue University at Indianapolis, **Ian Fraser Putnam**, University of Victoria, and **Jack Spielberg**, Arizona State University.

Differential Equations with Applications, **Sally Sailai Shao**, Cleveland State University, and **Tatsuhiko J. Tabara**, Golden Gate University.

Dualities in Mathematics and Physics, **Edward Frenkel** and **Nicolai Reshetikhin**, University of California, Berkeley.

Dynamical Systems and Mathematical Physics, **Motohico Mulase** and **Bruno L Nachtergaele**, University of California, Davis.

Finite Groups and Representations, **Kenechukwu Kenneth Nwabueze**, University of Brunei Darussalam.

Geometric Analysis, **Chikako Mese**, University of Southern California, and **Richard M. Schoen**, Stanford University.

Graph Theory, **David Barnette**, University of California, Davis.

Mathematical Biology, **Alexander Isaak Mogilner**, University of California, Davis.

Nonlinear Analysis, **John K. Hunter** and **Blake Temple**, University of California, Davis.

Random Fields and Stochastic Partial Differential Equations, **Arthur J. Krener**, University of California, Davis, and **Boris Rozovsky**, University of Southern California.

The Geometry and Topology of 3-manifolds, **Dmitry Fuchs**, **Joel Hass**, **Ramin Naimi**, and **William Thurston**, University of California, Davis.

Chicago, Illinois

DePaul University-Chicago

September 12–13, 1998

Meeting #935

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: June 1998
Program issue of *Notices*: November 1998
Issue of *Abstracts*: Volume 19, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: May 26, 1998
For abstracts: July 21, 1998

Invited Addresses

Vitaly Bergelson, Ohio State University, *Title to be announced.*

Sheldon Katz, Oklahoma State University, *Title to be announced.*

Ralf Spatzier, University of Michigan, *Title to be announced.*

Vladimir Voevodsky, Northwestern University, *Title to be announced.*

Special Sessions

Algebraic Coding (Code: AMS SS C1), **William C. Huffman**, Loyola University of Chicago, and **Vera S. Pless**, University of Illinois at Chicago.

Algebraic Combinatorics: Association Schemes and Related Topics (Code: AMS SS L1), **Sung Yell Song**, Iowa State University.

Algebraic Geometry and Mirror Symmetry (Code: AMS SS N1), **Ezra Getzler** and **Mikhail Kapranov**, Northwestern University, and **Sheldon Katz**, Oklahoma State University.

Commutative Algebra (Code: AMS SS J1), **Irena V. Peeva**, Massachusetts Institute of Technology, and **Michael Stillman**, Cornell University.

Complex Dynamics (Code: AMS SS H1), **Shmuel Friedland**, University of Illinois at Chicago.

Complexity of Geometric Structures on Manifolds (Code: AMS SS F1), **Melvin G. Rothenberg** and **Shmuel A. Weinberger**, University of Chicago.

Ergodic Theory and Topological Dynamics (Code: AMS SS G1), **Roger L. Jones**, DePaul University, and **Randall McCutcheon**, Wesleyan College.

Fourier Analysis (Code: AMS SS E1), **Marshall Ash**, DePaul University, and **Mark A. Pinsky**, Northwestern University.

K-Theory and Motivic Cohomology (Code: AMS SS D1), **Kevin Knudson**, Northwestern University, and **Mark Walker**, University of Nebraska-Lincoln.

Nonlinear Partial Differential Equations (Code: AMS SS O1), **Gui-Qiang Chen** and **Konstantina Trivisa**, Northwestern University.

Number Theory (Code: AMS SS I1), **Jeremy T. Teitelbaum** and **Yuri Tschinkel**, University of Illinois at Chicago.

Orthogonal Polynomial Series, Summability and Conjugates (Code: AMS SS M1), **Calixto P. Calderon**, University of Illinois at Chicago, and **Luis A. Caffarelli**, University of Texas at Austin.

Rigidity in Geometry and Dynamics (Code: AMS SS K1), **Steven E Hurder**, University of Illinois at Chicago, and **Ralf J. Spatzier**, University of Michigan.

Stochastic Analysis (Code: AMS SS A1), **Richard B. Sowers**, University of Illinois-Urbana, and **Elton P. Hsu**, Northwestern University.

Topics in Mathematics and Curriculum Reform (Code: AMS SS B1), **Richard J. Maher**, Loyola University Chicago.

Winston-Salem, North Carolina

Wake Forest University

October 9–10, 1998

Meeting #936

Southeastern Section
Associate secretary: Robert J. Daverman
Announcement issue of *Notices*: August 1998
Program issue of *Notices*: December 1998
Issue of *Abstracts*: Volume 19, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: June 23, 1998
For abstracts: August 18, 1998

Invited Addresses

David F. Anderson, University of Tennessee, *Title to be announced.*

Idris Assani, University of Carolina, Chapel Hill, *Title to be announced.*

Marcy Barge, Montana State University-Bozeman, *Title to be announced.*

Roger Temam, University of Paris XI and Indiana University, *Title to be announced.*

Special Sessions

Abelian Groups and Modules (Code: AMS SS B1), **Ulrich Albrecht**, Auburn University.

Boundary Value Problems (Code: AMS SS K1), **John V. Baxley** and **Stephen B. Robinson**, Wake Forest University.

Combinatorics and Graph Theory (Code: AMS SS A1), **Bruce Landman**, University of North Carolina.

Commutative Ring Theory (Code: AMS SS E1), **David F. Anderson**, University of Tennessee, Knoxville, and **Evan Houston**, University of North Carolina, Charlotte.

Ergodic Theory (Code: AMS SS F1), **Idris Assani**, University of North Carolina, Chapel Hill.

Modern Methods in Set Theory and General Topology (Code: AMS SS H1), **Winfried Just** and **Paul Szeptycki**, Ohio University.

Noncommutatuve Algebra (Code: AMS SS C1), **Ellen Kirkman** and **James Kuzmanovich**, Wake Forest University.

Operator Theory and Holomorphic Spaces (Code: AMS SS L1), **Tavan T. Trent** and **Zhijian Wu**, University of Alabama.

Recent Results on the Topology of Three-Manifolds (Code: AMS SS D1), **Hugh Nelson Howards**, Wake Forest University.

Spectral Theory of Differential Equations and Applications (Code: AMS SS G1), **Dominic Clemence** and **Alexandra Kurepa**, North Carolina A&T University.

Topology in Dynamics (Code: AMS SS J1), **Marcy Barge**, Montana State University-Bozeman, and **Krystyna M. Kuperberg**, Auburn University.

State College, Pennsylvania

Pennsylvania State University

October 24–25, 1998

Meeting #937

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: August 1998
Program issue of *Notices*: January 1999
Issue of *Abstracts*: Volume 19, Issue 4

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: July 7, 1998
For abstracts: September 1, 1998

Invited Addresses

Jeffrey Adams, University of Maryland, College Park, *Title to be announced.*

Nigel D. Higson, Pennsylvania State University, *Title to be announced.*

Tasso J. Kaper, Boston University, *Title to be announced.*

Kate Okikiolu, University of California, San Diego, and MIT, *Title to be announced.*

Special Sessions

C-Algebraic Methods in Geometry and Topology* (Code: AMS SS B1), **Nigel D. Higson**, Pennsylvania State University, and **Erik Guentner** and **John D. Trout Jr.**, Dartmouth College.

Least Squares and Total Least Squares (Code: AMS SS G1), **Jesse L. Barlow**, Pennsylvania State University.

Mathematical Modeling of Inhomogeneous Materials: Homogenizaton and Related Topics (Code: AMS SS D1), **Leonid Berlyand**, Pennsylvania State University, and **Karl Voss**, Yale University.

Metric Topology (Code: AMS SS F1), **Steve Armentrout, Joseph Borzelino, Hossein Movahedi-Lankarani**, and **Robert Wells**, Pennsylvania State University.

Modeling of Phase Transitions of Partially Ordered Physical Systems (Code: AMS SS C1), **Maria-Carme T. Calderer.**

Partitions and q-Series (Code: AMS SS A1), **George E. Andrews** and **Ken Ono**, Pennsylvania State University.

Symplectic Geometry and Quantization (Code: AMS SS E1), **Jean-Luc Brylinski, Ranee Brylinski, Boris Tsygan**, and **Ping Xu**, Pennsylvania State University.

Tucson, Arizona

University of Arizona-Tucson

November 14-15, 1998

Meeting #938

Western Section
Associate secretary: Robert M. Fossum
Announcement issue of *Notices*: September 1998
Program issue of *Notices*: To be announced
Issue of *Abstracts*: Volume 19, Issue 4

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: July 29, 1998
For abstracts: September 23, 1998

San Antonio, Texas

Henry B. Gonzales Convention Center

January 13-16, 1999

Meeting #939

Joint Mathematics Meetings, including the 105th Annual Meeting of the AMS, 82nd Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL).

Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: October 1998
Program issue of *Notices*: January 1998
Issue of *Abstracts*: Volume 20, Issue 1

Deadlines

For organizers: April 14, 1998
For consideration of contributed papers in Special Sessions: August 6, 1998
For abstracts: October 1, 1998
For summaries of papers to MAA organizers: To be announced

Gainesville, Florida

University of Florida

March 12-13, 1999

Meeting #940

Southeastern Section
Associate secretary: Robert J. Daverman
Announcement issue of *Notices*: To be announced
Program issue of *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: June 11, 1998
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Special Sessions

Continuum Theory and Dynamical Systems (Code: AMS SS A1), **Philip Boyland** and **Beverly Brechner**, University of Florida, and **John Mayer**, University of Alabama at Birmingham.

Finite Groups and Their Representations (Code: AMS SS D1), **Alexandre Turull**, University of Florida.

Galois Theory (Code: AMS SS E1), **J. G. Thompson** and **H. Voelklein**, University of Florida.

Groups and Geometries (Code: AMS SS F1), **Chat Ho** and **Peter Sin**, University of Florida.

Markov Processes and Potential Theory (Code: AMS SS C1), **Joe Glover** and **Murali Rao**, University of Florida.

The Erdős Legacy and Connections to Florida (Code: AMS SS B1), **Krishnaswami Alladi** and **Jean Larson**, University of Florida.

Urbana, Illinois

University of Illinois, Urbana-Champaign

March 18-21, 1999

Meeting #941

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: To be announced
Program issue of *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: June 18, 1998
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Special Sessions

Galois Representations (Code: AMS SS C1), **Nigel Boston**, University of Illinois-Urbana, and **Michael Larsen**, University of Missouri.

Martingales and Analysis. (Code: AMS SS D1), **Joseph Max Rosenblatt**, **Renming Song**, and **Richard B. Sowers**, University of Illinois-Urbana.

Nonstandard Analysis (Code: AMS SS B1), **C. Ward Henson** and **Peter Loeb**, University of Illinois-Urbana.

Recent Progress in Elementary Geometry (Code: AMS SS A1), **John E. Wetzel**, University of Illinois-Urbana, and **Clark Kimberling**, University of Evansville.

Las Vegas, Nevada

University of Nevada-Las Vegas

April 10–11, 1999

Meeting #942

Western Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: To be announced
Program issue of *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: July 10, 1998
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Special Sessions

Control and Dynamics of Partial Differential Equations (Code: AMS SS A1), **Zhonghai Ding**, University of Nevada-Las Vegas.

Graph Theory (Code: AMS SS B1), **Hung-Lin Fu**, **Chris A. Rodger**, and **Michelle Schultz**, University of Nevada-Las Vegas.

Nonlinear PDEs—Methods and Applications (Code: AMS SS C1), **David Costa**, University of Nevada-Las Vegas.

Set Theory (Code: AMS SS D1), **Douglas Burke** and **Derrick BuBose**, University Nevada-Las Vegas.

Buffalo, New York

State University of New York at Buffalo

April 24–25, 1999

Meeting #943

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: To be announced
Program issue of *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: July 24, 1998
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Invited Addresses

Michele M. Audin, University Louis Pasteur, Strasbourg, *Title to be announced.*

Jeff Smith, Purdue University, *Title to be announced.*

Alexander A. Voronov, Massachusetts Institute of Technology, *Title to be announced.*

Gregg J. Zuckerman, Yale University, *Title to be announced.*

Special Sessions

Smooth Categories in Geometry and Mechanics (Code: AMS SS A1), **F. William Lawvere**, SUNY at Buffalo.

Melbourne, Australia

Melbourne, Australia

July 12–16, 1999

Meeting #944

First International Joint Meeting of the American Mathematical Society and the Australian Mathematical Society.
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: To be announced
Program issue of *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Providence, Rhode Island

Providence College

October 2–3, 1999

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: To be announced
Program issue of *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: January 6, 1999
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Austin, Texas

University of Texas-Austin

October 8–10, 1999

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: To be announced
Program issue of *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: January 6, 1999
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Washington, District of Columbia

Sheraton Washington Hotel and Omni Shoreham Hotel

January 19–22, 2000

Joint Mathematics Meetings, including the 106th Annual Meeting of the AMS, 83rd Meeting of the Mathematical Association of America (MAA), with minisymposia and other special events contributed by the Society for Industrial and Applied Mathematics (SIAM), and the annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM).

Associate secretary: Robert M. Fossum, pro tem
Announcement issue of *Notices*: To be announced
Program issue of *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 20, 1999
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

Lowell, Massachusetts

University of Massachusetts, Lowell

April 1–2, 2000

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: To be announced
Program issue of *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: July 1, 1999
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Notre Dame, Indiana

University of Notre Dame

April 7–9, 2000

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: To be announced
Program issue of *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: July 7, 1999
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

New Orleans, Louisiana

New Orleans Marriott and ITT Sheraton New Orleans Hotel

January 10–13, 2001

Joint Mathematics Meetings, including the 107th Annual Meeting of the AMS, 84th Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM).

Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: To be announced
Program issue of *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 11, 2000
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

Columbia, South Carolina

University of South Carolina

March 16–18, 2001

Southeastern Section
Associate secretary: Robert J. Daverman
Announcement issue of *Notices*: To be announced
Program issue of *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: June 15, 2000
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Williamstown, Massachusetts

Williams College

October 13–14, 2001

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: To be announced
Program issue of *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: January 11, 2001
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Diego, California

San Diego Convention Center

January 6–9, 2002

Joint Mathematics Meetings, including the 108th Annual Meeting of the AMS and 85th Meeting of the Mathematical Association of America (MAA).

Associate secretary: Robert J. Daverman
Announcement issue of *Notices*: To be announced
Program issue of *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 4, 2001
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

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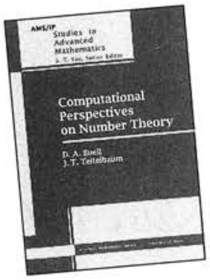

Computational Perspectives on Number Theory

Proceedings of a Conference in Honor of A. O. L. Atkin

D. A. Buell, *Center for Computing Sciences, Bowie, MD*, and **J. T. Teitelbaum**, *University of Illinois at Chicago*, Editors

This volume contains papers presented at the conference "Computational Perspectives on Number Theory" held at the University of Illinois at Chicago in honor of the retirement of A. O. L. Atkin. In keeping with Atkin's interests and work, the papers cover a range of topics, including algebraic number theory, *p*-adic modular forms and modular curves. Many of the papers reflect Atkin's particular interest in computational and algorithmic questions.

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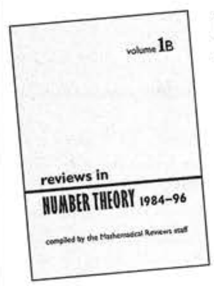

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Louisville, Kentucky; March 20–21, 1998

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AMERICAN MATHEMATICAL SOCIETY

RAMANUJAN
LETTERS *and* COMMENTARY

Bruce C. Berndt,
University of Illinois, Urbana
Robert A. Rankin,
University of Glasgow, Scotland

This commendable collection ... is a unique contribution to the history of mathematics for at least two reasons. It has brought together precious documents scattered in many places, providing the reader with a wealth of interesting matters related to one of the luminaries in the world of mathematics. Second, through brief and insightful notes and commentaries, the work throws light on many an interesting side street connecting to the grand avenue of knowledge on which we are riding. With resuscitations of some fading photographs and an impressive list of more than 300 references, this book is a very valuable addition to the literature on Ramanujan. **—*CHOICE***

Delightful reading ... a useful reference on English analysts and number theorists of Hardy's time ... has many pictures, some of them quite marvelous ... What Berndt and Rankin have done is to make a great deal of primary material available to ... scholars. **—*Zentralblatt für Mathematik***

Berndt and Rankin have produced a book that should appeal to everyone with an interest in mathematics ... what better way to understand the man behind the mathematician Ramanujan than to read letters written by him and about him? Berndt, with the experience he has gained editing Ramanujan's notebooks, and Rankin, one of the veterans in this field who knew Hardy, Littlewood, Watson, and other British contemporaries of Ramanujan, have combined perfectly to produce this book. **—*American Mathematical Monthly***

[The] filling in of details previously overlooked is one of the merits of the ... book ... Those who helped Ramanujan have our gratitude, for he found many things which we still would not have discovered without his deep insight into the structure of formulas. This book helps us realize who helped and how in more detail than was possible before reading some of the letters. **—*Mathematical Reviews***

The book is very readable, contains much material not available elsewhere and can be read at a variety of levels, so it can be highly recommended to anyone with an interest in Ramanujan. **—*Bulletin of the London Mathematical Society***

The commentary ... is marvelously thorough ... no detail escapes [the authors'] attention ... they have endeavored to put together as many letters as possible ... Berndt and Rankin's efforts at tracing the history and impact of each theorem presented by Ramanujan in his letters ... will undoubtedly be of use to those interested in Ramanujan's mathematics. **—*The India Magazine of Her People and Culture***

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Program of the Sessions

Louisville, Kentucky, March 20–21, 1998

Friday, March 20

Meeting Registration

7:30 AM – 5:00 PM **Lobby, Founder's Union Building**

Special Session on Combinatorics and Graph Theory, I

8:00 AM – 10:50 AM **Room 157, Burhans Hall**

Organizers: **Andre E. Kezdy**, University of Louisville
Grzegorz Kubicki, University of Louisville
Jenoe Lehel, University of Louisville

8:00AM (1) *Orienting ternary matroids.*
Jon Lee, University of Kentucky (931-05-125)

8:30AM (2) *On the number of elements in matroids with fixed circuit and cocircuit sizes.* Preliminary report.
Talmage J. Reid* and **Tristan M. J. Denley**, University of Mississippi (931-05-65)

9:00AM ▸ (3) *On a class of algebraically defined graphs.*
Felix Lazebnik, University of Delaware (931-05-52)

9:30AM (4) *Eigenvalues and the existence of small regular graphs of specified girth.* Preliminary report.
Allen J. Schwenk, Western Michigan University (931-05-285)

10:00AM (5) *Covering a graph with cuts of minimum total size.* Preliminary report.
Andre Kundgen, University of Illinois (931-05-184)

10:30AM (6) *Connectivity interpolation for 2-cell embeddings.*
Michael D. Plummer*, Vanderbilt University, and **Xiaoya Zha**, Middle Tennessee State University (931-05-248)

Special Session on Fractal Geometry and Related Topics, I

8:00 AM – 10:50 AM **Room 160, Burhans Hall**

Organizers: **Ka-Sing Lau**, University of Pittsburgh
Weibin Zeng, University of Louisville

8:00AM (7) *Generalized self-similar functions.* Preliminary report.
Carlos A. Cabrelli, University of Buenos Aires, **Falsetti C. Marcela**, Univ. de Gral. Sarmiento, and **Ursula M. Molter***, University of Buenos Aires (931-26-158)

8:30AM (8) *Cantor sets of bounded rates.* Preliminary report.
Carlos A. Cabrelli*, University of Buenos Aires, **Kathryn E. Hare**, University of Waterloo, and **Ursula M. Molter**, University of Buenos Aires (931-28-157)

9:00AM (9) *Second-order self-similar identities.* Preliminary report.
Sze-Man Ngai, Cornell University (931-28-131)

9:30AM (10) *The multifractal structure of convolution of Cantor measures.* Preliminary report.
Tian-Yau Hu, Univ. of Wisconsin, and **Ka-Sing Lau***, Univ. of Pittsburgh and The Chinese University of Hong Kong, H.K. (931-28-177)

10:00AM ▸ (11) *Exact Hausdorff dimensions of overlapping self-similar sets.* Preliminary report.
Yang Wang*, Georgia Institute of Technology, and **Robert Strichartz**, Cornell University (931-42-209)

10:30AM (12) *Orthonormal bases of exponentials for the n-cube.*
Jeffrey C. Lagarias* and **James Reeds**, AT&T Labs, Florham Park, NJ, and **Yang Wang**, Georgia Institute of Technology (931-46-220)

Special Session on Semigroups, Algorithms, and Universal Algebra, I

8:00 AM – 10:50 AM **Room 158, Burhans Hall**

Organizers: **Ralph N. McKenzie**, Vanderbilt University
Steven Seif, University of Louisville

8:00AM (13) *Globals of groupless groupoids.*
Kevin Blount* and **Ralph McKenzie**, Vanderbilt University (931-20-331)

8:30AM (14) *Injective completeness of certain categories of commutative regular semigroups.*
Yefim Katsov, Hanover College (931-20-115)

The time limit for each contributed paper in the sessions is ten minutes. In the Special Sessions the time limit varies from session to session and within sessions. To maintain the schedule, time limits are strictly enforced.
For papers with more than one author, an asterisk follows the name of the author who presented the paper at the meeting.
Papers flagged with a solid triangle (▸) have been designated by the author as being of possible interest to undergraduate students.
Abstracts of papers presented in the sessions at this meeting will be found in Volume 19, Issue 2 of *Abstracts of papers presented to the American Mathematical Society*, ordered according to the numbers in parentheses following the listings. The middle two digits, e.g., 897-**20**-1136, refer to the Mathematical Reviews subject classification assigned by the individual author. Groups of papers for each subject are listed chronologically in the *Abstracts*. The last one to four digits, e.g., 897-20-**1136**, refer to the receipt number of the abstract; abstracts are further sorted by the receipt number within each classification.

9:00AM (15) *Varieties with few fintely generated algebras.* Preliminary report.
Joel Berman*, University of Illinois at Chicago, and **Paweł M. Idziak**, Jagiellonian University (931-08-107)

9:30AM (16) *Second centralizers of transformations.*
Janusz Konieczny, Mary Washington College (931-20-42)

10:00AM (17) *The residual character of minimal varieties of type 5.*
Agnes Szendrei, József Attila University (931-08-251)

10:30AM (18) *Bad three-element algebras.*
George F. McNulty*, University of South Carolina, and **Ross Willard**, University of Waterloo (931-08-301)

Special Session on The Use of the History of Mathematics and Science in the University and School Classroom, I

8:00 AM – 10:30 AM **Room 15, Founder's Union Building**

Organizer: **Richard M. Davitt**, University of Louisville

8:00AM ▸ (19) *Compiling and updating an annotated bibliography concerning things mathematical.* Preliminary report.
Richard M. Davitt, Univ. of Louisville (931-01-119)

8:40AM ▸ (20) *Problems and projects from the history of mathematics in regular mathematics courses.*
Daniel J. Curtin, Northern Kentucky University (931-01-31)

9:20AM (21) *Pleasures and perils of using original sources in the history of mathematics course.*
Daniel E. Otero, Xavier University (931-98-269)

10:00AM ▸ (22) *Using history to introduce fractals.*
John E. Sasser, University of Cincinnati (931-01-327)

Special Session on Boundary Value Problems for Differential Equations, I

8:00 AM – 10:50 AM **Room 159, Burhans Hall**

Organizer: **Paul W. Eloe**, University of Dayton

8:00AM (23) *Multiple positive solutions of singular right focal boundary value problems.*
Paul Eloe, University of Dayton, **Johnny Henderson**, Auburn University, and **William K. C. Yin***, LaGrange College (931-34-108)

8:30AM (24) *Uniqueness implies existence for fourth-order Lidstone boundary value problems.*
John M. Davis* and **Johnny Henderson**, Auburn University (931-34-121)

9:00AM (25) *Boundary value problems for functional-difference equations.* Preliminary report.
Anjali G. Datta, Tuskegee University (931-34-149)

9:30AM (26) *Positive solutions for n^{th} order functional differential equations.*
Eric R. Kaufmann, University of Arkansas at Little Rock (931-34-145)

10:00AM (27) *Multiple positive solutions for a three-point boundary value problem.*
Douglas Anderson, Concordia College (931-34-135)

10:30AM (28) *Extremal properties of eigenvalues.* Preliminary report.
Charlotte A. Knotts, University of Tennessee at Knoxville (931-34-203)

Special Session on Spectral Theory, Mathematical Physics, and Disordered Media, I

8:00 AM – 10:50 AM **Room 1, Burhans Hall**

Organizers: **Peter David Hislop**, University of Kentucky
Gunter H. Stolz, University of Alabama at Birmingham

8:00AM (29) *Solutions, spectrum and dynamics of Schrödinger operators on infinite domains.*
Alexander A. Kiselev*, University of Chicago, and **Yoram Last**, Caltech (931-81-252)

8:30AM (30) *Measurable enumeration of eigenelements of self-adjoint operators.*
Alexander Y. Gordon, University of North Carolina at Charlotte (931-47-30)

9:00AM (31) *The essential spectrum of the Neumann Laplacian on a tree imbedded in a domain.*
W. D. Evans, University of School College of Cardiff, and **Yoshimi Saitō***, University of Alabama at Birmingham (931-35-214)

9:30AM (32) *Mourre theory for a Schroedinger operator on a binary tree graph.* Preliminary report.
Christine S. Allard, UBC, Vancouver (931-47-130)

10:00AM ▸ (33) *On the absolutely continuous spectrum of Jacobi matrices with power-like weights.* Preliminary report.
Jan Janas*, Institute of Mathematics, Polish Academy of Sciences, and **Serguei Naboko**, Inst. of Physics, St. Petersburg Univ. (931-47-169)

10:30AM (34) *The analyticity of semigroups generated by degenerate elliptic operators.* Preliminary report.
Jerome A. Goldstein, University of Memphis (931-47-320)

Special Session on Geometry of Affine Space, I

8:00 AM – 11:00 AM **Room 162, Burhans Hall**

Organizers: **Gene Freudenburg**, University of Southern Indiana
David Wright, Washington University

8:00AM (35) *Nonlinearizable actions of reductive groups.*
Gerald W. Schwarz, Brandeis University (931-14-237)

8:40AM (36) *Moduli of G-equivariant vector bundles over representations with two-dimensional quotient: First examples.*
Kurt Mederer, Mercersburg Academy (931-14-280)

9:10AM (37) *Non-linearizable holomorphic group actions.*
Harm Derksen*, Northeastern University, and **Frank Kutzschebauch**, University of Basel (931-14-290)

9:50AM (38) *Reductive subgroups of Aut$\mathbb{A}^3$ and Aut$\mathbb{A}^4$.*
Vladimir L. Popov, MGIEM, Moscow (931-14-68)

10:30AM (39) *Equivariant cancellation problem.* Preliminary report.
Kayo Masuda, Himeji Institute of Technology (931-14-132)

Special Session on Algebraic Combinatorics, I

8:00 AM – 10:50 AM **Room 218A, Founder's Union Building**

Organizers: **Anders Björner**, Royal Institute of Technology
Michelle L. Wachs, University of Miami

8:00AM (40) *Counting faces of cubical spheres.*
Eric K. Babson, Intitute for Advanced Study (931-05-335)

8:30AM (41) *Fiber polytopes for the projections between cyclic polytopes.*
Christos A. Athanasiadis*, University of Pennsylvania, **Jesu's A. De Loera**, The Geometry Center and University of Minnesota , **Victor Reiner**, University of Minnesota, and **Francisco Santos**, University of Cantabria (931-05-126)

9:00AM (42) *A type B associahedron.*
Rodica Simion, The George Washington University (931-05-340)

9:30AM (43) *Weights on almost-simple polytopes.* Preliminary report.
Susan Foege and **Carl W. Lee***, University of Kentucky (931-52-271)

10:00AM (44) *An upper bound theorem for rational polytopes.*
Margaret M. Bayer, University of Kansas (931-52-297)

10:30AM (45) *Rational function identities for posets and integer polyhedra.* Preliminary report.
Curtis Greene, Haverford College (931-05-350)

AMS Book Exhibit and Electronic Products Display

8:00 AM – 5:00 PM **Lobby, Founder's Union Building**

Special Session on Real Analysis, I

8:30 AM – 10:50 AM **Room 163, Burhans Hall**

Organizers: **Udayan B. Darji**, University of Louisville
Lee Larson, University of Louisville

8:30AM (46) *The Laplace derivative.* Preliminary report.
Ralph E. Svetic, University of Wisconsin – Milwaukee (931-26-19)

9:00AM (47) *The non-coincidence of ordinary and Peano derivatives.*
Zoltán Buczolich, Eötvös Loránd University, and **Clifford E. Weil***, Michigan State University (931-26-26)

9:30AM (48) *Making Borel functions seem continuous.*
Slawomir J. Solecki, Indiana University (931-26-183)

10:00AM (49) *Homeomorphy of semi-continuous functions.* Preliminary report.
Jan J. Dijkstra*, The University of Alabama, and **Jan van Mill**, Vrije Universiteit (931-26-61)

10:30AM (50) *Universally polygonally approximable functions.* Preliminary report.
Michael J. Evans*, AMS, and **Richard J. O'Malley**, UWM (931-26-57)

Special Session on Applied Probability and Actuarial Science, I

8:30 AM – 11:00 AM **Room 14, Founder's Union Building**

Organizers: **Grzegorz Rempala**, University of Louisville
Krzysztof Ostraszewski, University of Louisville
Ewa M. Kubicka, University of Louisville
Bogdan Gapinski, University of Louisville

8:30AM (51) *Evaluating the optimal solution of investment/consumption models in the presence of transaction costs.*
Richard H. Stockbridge, University of Kentucky (931-60-74)

9:10AM (52) *Actuarial aspects of the pension system reform in Poland.*
Leslaw Gajek, Technical University of Łódź (931-60-76)

9:50AM (53) *Stochastic simulation model for Social Security.*
Michael Sze, Hewitt Associates (retired) (931-60-77)

10:30AM (54) *Generalized CIR model. Martingale approach.*
Wojciech Szatzschneider*, Anáhuac University, México, and **Jose Garrido**, Concordia University (931-60-78)

Special Session on Modern Function Theory, I

8:30 AM – 10:50 AM **Room 164, Burhans Hall**

Organizers: **David Minda**, University of Cincinnati
David A. Herron, University of Cincinnati

8:30AM (55) *Fusion and separation of singularities of analytic functions.* Preliminary report.
Victor Petrovich Havin and **Ashot H. Nersessian***, McGill University (931-30-265)

9:00AM (56) *Two-point comparisons between hyperbolic and euclidean geometry on plane regions.* Preliminary report.
William Ma*, Pennsylvania College of Technology, **Fumio Maitani**, Kyoto Institute of Technology, and **David Minda**, University of Cincinnati (931-30-143)

9:30AM (57) *Real analogs of univalence criteria involving the preschwarzian.* Preliminary report.
Martin S. Chuaqui, P. Universidad Catolica de Chile (931-30-217)

10:00AM (58) *Finding complete conformal metrics to extend conformal mappings.* Preliminary report.
Martin Chuaqui, Universidad Catolica, and **Brad Osgood***, Stanford University (931-30-333)

10:30AM (59) *Biholomorphic mappings in several variables.* Preliminary report.
John A. Pfaltzgraff*, University of North Carolina, and **Ted J. Suffridge**, University of Kentucky (931-32-205)

Special Session on Functional Equations and Inequalities, I

9:00 AM – 10:50 AM **Room 156, Burhans Hall**

Organizers: **Thomas Riedel**, University of Louisville
Prasanna Sahoo, University of Louisville

9:00AM (60) *Some Cauchy-like functional equations on the natural numbers.*
Tom M. K. Davison, McMaster University (931-39-128)

9:30AM (61) *The cocycle equation on periodic semigroups.*
Thomas M. Davison, McMaster University, and **Bruce R. Ebanks***, Marshall University (931-39-188)

10:00AM (62) *Mixing vs. chaotic behavior for automorphisms of the n-torus.* Preliminary report.
A. Sklar, Chicago, IL (931-39-215)

10:30AM (63) *Rational t-norms and copulas.*
M. J. Frank, Illinois Institute of Technology, and **B. Schweizer***, University of Massachusetts (931-39-160)

Special Session on Banach Space Theory, I

9:00 AM – 10:50 AM **Room 8, Burhans Hall**

Organizers: **Patrick N. Dowling**, Miami University, Ohio

Beata Randrianantoanina, Miami University, Ohio

9:00AM (64) *The w^*-topology on ℓ_1 induced by the Bourgain-Delbaen space.* Preliminary report.
Dale E. Alspach, Oklahoma State University (931-46-264)

9:30AM (65) *Indices, convexity and concavity in some nonsymmetric spaces.*
Anna H. Kamińska, The University of Memphis (931-46-334)

10:00AM (66) *MM^* estimate for the sections of non-symmetric convex bodies.* Preliminary report.
Mark Rudelson, Texas A&M University (931-46-129)

10:30AM (67) *Bijective disjointness preserving operators.*
Yuri A. Abramovich*, Indiana University-Purdue University, Indianapolis, and **Arkady K. Kitover**, CCP (931-47-159)

Special Session on Spectral Geometry, I

9:00 AM – 10:50 AM **Room 3, Burhans Hall**

Organizers: **Ruth Gornet**, Texas Tech University
Peter Anton Perry, University of Kentucky

9:00AM (68) *The dispersionless Toda equation and Toeplitz operators.* Preliminary report.
Alejandro Uribe, University of Michigan (931-58-216)

9:30AM (69) *Vibrating strings and cylinders with variable mass density.*
Richard Snyder Laugesen, University of Illinois, Urbana-Champaign (931-35-91)

10:00AM (70) *The spectrum of the Hodge Laplacian for three manifolds with pinched negative curvature.*
Jeffrey K. McGowan*, Central Connecticut State University, and **Ruth Gornet**, Texas Tech and University of Kentucky (931-58-174)

10:30AM (71) *Heat kernel and Green function estimates on noncompact symmetric spaces.*
Lizhen Ji, University of Michigan (931-58-111)

Special Session on Low-Dimensional Topology, I

9:00 AM – 10:50 AM **Room 161, Burhans Hall**

Organizers: **Abigail A. Thompson**, University of California, Davis
Martin Scharlemann, University of California, Santa Barbara

9:00AM (72) *Arnold-type invariants of curves on surfaces and homotopy groups of the space of curves.* Preliminary report.
Vladimir V. Tchernov, Uppsala University, Sweden (931-57-87)

9:30AM (73) *Infinite Coxeter groups are virtually indicable.*
D. Cooper, **D. D. Long***, UC Santa Barbara, and **A. W. Reid**, UT Austin (931-57-13)

10:00AM (74) *Invariants of Heegaard splittings.* Preliminary report.
Doug Bullock, Boise State University, **Charles Frohman***, The University of Iowa, and **Joanna Kania-Bartoszynska**, Boise State University (931-57-84)

10:30AM (75) *Almost normal surfaces with boundary in 3-manifolds.* Preliminary report.
Michelle M. Stocking, University of Texas, Austin (931-57-40)

Invited Address

11:10 AM – NOON **Room 218, Founder's Union Building**

(76) *The combinatorial topology of graph properties.*
Anders Björner, Royal Institute of Technology, Sweden

Invited Address

1:40 PM – 2:30 PM **Room 218, Founder's Union Building**

(77) *The X, Y, Z's in the characterization problem for derivatives.*
Andrew Bruckner, University of California at Santa Barbara

Special Session on Combinatorics and Graph Theory, II

2:45 PM – 6:35 PM **Room 157, Burhans Hall**

Organizers: **Andre E. Kezdy**, University of Louisville
Grzegorz Kubicki, University of Louisville
Jenoe Lehel, University of Louisville

2:45PM (78) *The maximum number of cyclic triples in oriented planar graphs.* Preliminary report.
Sheng Bau, Inner Mongolia Finance and Economics College, and **Lowell W. Beineke***, Indiana University-Purdue University (931-05-295)

3:15PM (79) *Bicliques in graphs.*
Erich Prisner, Universität Hamburg (931-05-207)

3:45PM (80) *Decomposition of even-hole-free graphs.*
Michele Conforti, Universita di Padova, **Gerard Cornuejols** and **Ajai Kapoor**, Carnegie Mellon University, and **Kristina Vuskovic***, University of Kentucky (931-05-70)

4:15PM ► (81) *Crossings in drawings of complete graphs.* Preliminary report.
Heiko Harborth, Diskrete Mathematik (931-05-170)

4:45PM (82) *Hamiltonian graphs and arithmetic progressions of cycles.*
Tristan M. J. Denley*, University of Mississippi, and **Alex D. Scott**, University College London (931-05-213)

5:15PM (83) *Small vertex-double-covered graphs.*
Zoltán Füredi, **Dhruv Mubayi**, and **Douglas B. West***, University of Illinois (931-05-300)

5:45PM (84) *Nonrevisiting cycles on surfaces.* Preliminary report.
Hari Pulapaka, Valdosta State University (931-05-18)

6:15PM ► (85) *Tutte cycles in circuit graphs.*
Jason Gao, Carleton University, and **Xingxing Yu***, Georgia Tech (931-05-347)

Special Session on Fractal Geometry and Related Topics, II

2:45 PM – 6:35 PM **Room 160, Burhans Hall**

Organizers: **Ka-Sing Lau**, University of Pittsburgh
Weibin Zeng, University of Louisville

2:45PM (86) *Let's do analysis on fractals!* Preliminary report.
Robert S. Strichartz, Cornell University (931-35-266)

3:15PM ► (87) *Dense analytic subspaces in fractal L^2-spaces.*
Palle E. T. Jorgensen, University of Iowa (931-42-06)

3:45PM (88) *Harmonic analysis of fractal measures.*
Steen Pedersen, Wright State University (931-42-232)

4:15PM (89) *Heat kernel estimates for Laplacians on p. c. f. self-similar sets.*
Jun Kigami, Kyoto University (931-60-181)

4:45PM (90) *Complex dimensions of fractals.*
Michel L. Lapidus, University of California-Riverside (931-28-281)

5:15PM (91) *Fourier asymptotic of statistically self-similar measures.*
Christian E. Bluhm, Cornell University (931-28-153)

5:45PM (92) *Spectral analysis on infinite Sierpinski gaskets.*
Alexander Teplyaev, Cornell University (931-35-287)

6:15PM (93) *Sierpiński gasket as a Martin boundary.*
Manfred Denker, University of Göttingen, and **Hiroshi Sato***, Kyushu University (931-60-103)

Special Session on Functional Equations and Inequalities, II

2:45 PM – 5:05 PM **Room 156, Burhans Hall**

Organizers: **Thomas Riedel**, University of Louisville
Prasanna Sahoo, University of Louisville

2:45PM ▶ (94) *Surprising results on a functional equation arising from utility theory.*
János D. Aczél*, University of Waterloo, **Roman Ger**, Silesian University, and **Antal Járai**, Eötvös University (931-39-23)

3:15PM ▶ (95) *Some functional equations arising from problems in physics.* Preliminary report.
Michael D. Taylor, University of Central Florida (931-39-48)

3:45PM (96) *A Wirtinger type inequality, Pontryagin optimality principle and a three-point boundary value problem.*
Chaitan P. Gupta*, Univ of Nevada, Reno, and **Sergej I. Trofimchuk**, Nat. Acad of Sciences (931-34-43)

4:15PM (97) *On inner product spaces and Jordan derivation.* Preliminary report.
Pl. Kannappan, University of Waterloo (931-39-41)

4:45PM (98) *The aggregation equation: Solutions on cancellative monoids.*
Mark A. Taylor, Acadia University (931-39-37)

Special Session on Banach Space Theory, II

2:45 PM – 6:05 PM **Room 8, Burhans Hall**

Organizers: **Patrick N. Dowling**, Miami University, Ohio
Beata Randrianantoanina, Miami University, Ohio

2:45PM (99) *A theorem of Littlewood, a la Grothendieck.* Preliminary report.
Joe Diestel, Kent State University (931-46-348)

3:15PM (100) *Hereditarily hypercyclic operators and the hypercyclicity criterion.*
Juan P. Bes, Kent State University (931-47-69)

3:45PM (101) *On some properties of the quasi-convex bodies.*
Alexander Eugeniy Litvak, University of Alberta (931-46-293)

4:15PM (102) *Blocking of FDDs.*
Edward Odell*, University of Texas at Austin, **Helmut Knaust**, University of Texas at El Paso, and **Thomas Schlumprecht**, Texas A&M University (931-46-123)

4:45PM (103) *Higher order asymptotic structure.* Preliminary report.
Robert P. Judd*, Oklahoma State University, and **Edward Odell**, The University of Texas at Austin (931-46-259)

5:15PM (104) *Weak-* closure ordinals of convex subsets of duals of separable Banach spaces.* Preliminary report.
Douglas Mupasiri, University of Northern Iowa (931-46-336)

5:45PM (105) *Signal reconstruction via alternating projections.*
Charles Kicey, Valdosta State University, and **Chris Lennard***, University of Pittsburgh (931-46-315)

Special Session on Real Analysis, II

2:45 PM – 4:35 PM **Room 163, Burhans Hall**

Organizers: **Udayan B. Darji**, University of Louisville
Lee Larson, University of Louisville

2:45PM (106) *Some cardinal invariants related to adding functions in Baire class 1.*
Francis Edmund Jordan, West Virginia University (931-26-53)

3:15PM (107) *Darboux quasicontinuous functions.*
Harvey Rosen, University of Alabama (931-26-261)

3:45PM (108) *Extending connectivity functions.*
Jerzy Wojciechowski, West Virginia University (931-26-58)

4:15PM (109) $\kappa - to - 1$ *Darboux like functions.* Preliminary report.
Richard G. Gibson*, Columbus State University, Georgia, **Krzysztof Ciesielski**, West Virginia University, and **Tomasz Natkaniec**, Gdansk University (931-26-22)

Special Session on Semigroups, Algorithms, and Universal Algebra, II

2:45 PM – 6:35 PM **Room 158, Burhans Hall**

Organizers: **Ralph N. McKenzie**, Vanderbilt University
Steven Seif, University of Louisville

2:45PM (110) *The variety generated by tournaments.*
Jaroslav Jezek, Charles University, **Petar Markovic**, **Miklos Maroti***, and **Ralph McKenzie**, Vanderbilt University (931-08-323)

3:15PM (111) *Residually small equational classes.*
Matt Valeriote, McMaster University (931-08-226)

3:45PM (112) *A new construction for free inverse semigroups.* Preliminary report.
Olga V. Poliakova and **Boris M. Schein***, University of Arkansas (931-20-179)

4:15PM (113) *An equational characterization of residuated lattices that are subdirect products of chains.* Preliminary report.
Constantine Tsinakis, Vanderbilt University (931-06-254)

4:45PM (114) *The classification of commutative minimal clones.*
Keith A. Kearnes*, University of Louisville, and **Agnes Szendrei**, Bolyai Institute (931-08-284)

5:15PM (115) *Complexity problems for matrix rings, matrix semigroups and Rees matrix semigroups.*
Steve Seif, University of Louisville, and **Csaba Szabó***, McMaster University (931-08-223)

5:45PM (116) *Fregean logics and Fregean quasivarieties.* Preliminary report.
Don L. Pigozzi*, Iowa State University, and **Janusz Czelakowski**, Opole University (931-08-206)

6:15PM (117) *Decidability results for finite semigroups.*
Mark Sapir, Vanderbilt University (931-20-250)

Special Session on The Use of the History of Mathematics and Science in the University and School Classroom, II

2:45 PM – 5:15 PM **Room 15, Founder's Union Building**

Organizer: **Richard M. Davitt**, University of Louisville

2:45PM *Equation solving.* Preliminary report.
► (118) **Bill R. Austin**, U. Tennessee-Martin (931-01-161)

3:25PM *Teaching Euler's introduction in analys in*
► (119) *infinitorium a quarter of a millenium after.* Preliminary report.
Lin Tan, West Chester University (931-01-268)

4:05PM *Newton's Arithmetica Universalis.* Preliminary
► (120) report.
Rebecca A. Berg, Bowie State University, Bowie, Maryland (931-01-192)

4:45PM *Learning from the masters: Using original sources*
► (121) *in the classroom.*
Herbert E. Kasube, Bradley University (931-01-62)

Special Session on Boundary Value Problems for Differential Equations, II

2:45 PM – 6:05 PM **Room 159, Burhans Hall**

Organizer: **Paul W. Eloe**, University of Dayton

2:45PM *Asymptotic boundary value problems in a time*
(122) *almost periodic bistable nonlinear equation.*
Wenxian Shen, Auburn University (931-35-98)

3:15PM *On global bifurcation at infinity of variational*
(123) *inequalities.*
Vy K. Le*, University of Missouri, and **Klaus Schmitt**, University of Utah (931-35-96)

3:45PM *New developments on the Sturm-Liouville theory:*
(124) *ODEs and PDEs.*
Xue-Feng Yang, GA Tech (931-35-168)

4:15PM *Dynamics of traveling wave solutions of*
(125) *differential-difference equations.*
Erik S. Van Vleck, Colorado School of Mines (931-39-191)

4:45PM *Theta functions on degenerate hyperelliptic*
► (126) *surfaces.*
D. David McRae*, The Woodberry Forest School, and **Rudi Weikard**, University of Alabama at Birmingham (931-33-175)

5:15PM *Quenching for degenerate semilinear parabolic*
(127) *problems.*
Chiu Yeung Chan, University of Southwestern Louisiana (931-35-106)

5:45PM *Effects of heat input and output on quenching.*
(128) **S. I. Yuen**, Lakeland Community College (931-35-105)

Special Session on Spectral Geometry, II

2:45 PM – 5:35 PM **Room 3, Burhans Hall**

Organizers: **Ruth Gornet**, Texas Tech University
Peter Anton Perry, University of Kentucky

2:45PM *Locally nonisometric yet super isospectral spaces;*
(129) *the full exploration.*
Zoltan I. Szabo, Lehman College of The City University of New York (931-58-309)

3:15PM *Continuous families of isospectral Riemannian*
(130) *metrics which are not locally isometric.*
Carolyn S. Gordon, Dartmouth College, and **Edward N. Wilson***, Washington University (931-53-313)

3:45PM *The length spectrum of Riemannian two-step*
(131) *nilmanifolds.*
Maura B. Mast, University of Northern Iowa (931-58-236)

4:15PM *Riemannian foliations and eigenvalue comparison.*
(132) **Jeffrey M. Lee***, Texas Tech University, and **Ken Richardson**, Texas Christian University (931-53-224)

4:45PM *Isoperimetric problem for the curl operator.*
(133) Preliminary report.
Jason Cantarella, **Dennis DeTurck**, **Herman Gluck**, and **Mikhail Teytel***, University of Pennsylvania (931-46-95)

5:15PM *Scattering theory and hyperbolic 3-manifolds.*
(134) **David Borthwick**, Emory University (931-58-190)

Special Session on Spectral Theory, Mathematical Physics, and Disordered Media, II

2:45 PM – 5:35 PM **Room 1, Burhans Hall**

Organizers: **Peter David Hislop**, University of Kentucky
Gunter H. Stolz, University of Alabama at Birmingham

2:45PM *On the essential spectrum of some singular systems*
► (135) *of matrix- differential operator related to the MHD problems.* Preliminary report.
Sergeui Naboko, Institute of Physics, St. Petersburg University (931-47-148)

3:15PM *New models in the localization theory.* Preliminary
(136) report.
Stanislav A. Molchanov, University of North Carolina at Charlotte (931-81-219)

3:45PM *On the density of states for a periodic Schrödinger*
(137) *operator.*
Yulia Karpeshina, University of Alabama at Birmingham (931-81-241)

4:15PM *Quantum stability of Hamiltonians with decreasing*
(138) *gaps.*
James S. Howland, Univ. of Virginia (931-81-274)

4:45PM *Complex measures in random Schroedinger*
(139) *operators.*
Wei-Min Wang, Institute for Advanced Study (931-47-317)

5:15PM *On spectral properties of photonic crystals.*
► (140) **Peter Kuchment*** and **Leonid Kunyansky**, Wichita State University (931-35-270)

Special Session on Geometry of Affine Space, II

2:45 PM – 5:55 PM **Room 162, Burhans Hall**

Organizers: **Gene Freudenburg**, University of Southern Indiana
David Wright, Washington University

2:45PM *Affine rulings of rational surfaces: A reduction*
(141) *theorem.* Preliminary report.
Daniel Daigle, University of Ottawa (931-14-257)

3:25PM *Affine rulings of weighted projective planes.*
(142) Preliminary report.
Peter Russell, McGill University (931-14-258)

4:05PM *A public-key scheme with signature and master key*
► (143) *functions.*
Tzuong-Tsieng Moh, Purdue University (931-14-141)

4:45PM *Étale endomorphisms of smooth affine surfaces.*
(144) Preliminary report.
Masayoshi Miyanishi, School of Science, Osaka University (931-14-102)

5:25PM (145) *Homology planes with pencils of rational curves.* Preliminary report.
Toru Sugie, Shiga University (931-14-104)

Special Session on Algebraic Combinatorics, II

2:45 PM – 6:05 PM **Room 218A, Founder's Union Building**

Organizers: **Anders Björner**, Royal Institute of Technology
Michelle L. Wachs, University of Miami

2:45PM (146) *Algebraic shifting increases relative homology.* Preliminary report.
Art Duval, University of Texas at El Paso (931-05-239)

3:15PM (147) *Group actions on posets.*
Dmitry Kozlov, MIT (931-05-346)

3:45PM (148) *EL-shellability of rank-selected posets.* Preliminary report.
Larry Liu and **Bruce E. Sagan***, Michigan State University (931-06-311)

4:15PM (149) *Homology of monomial ideals and order dimension of lattices.*
Irena Peeva, MIT, **Vic Reiner**, University of Minnesota, and **Volkmar Welker***, Universitaet Essen (931-05-109)

4:45PM (150) *Combinatorial Laplacians of matroid complexes.*
Woong Kook, **Victor Reiner***, and **Dennis Stanton**, Univ. of Minnesota (931-05-33)

5:15PM (151) *A convolution formula for the Tutte polynomial.*
Woong Kook, **Victor Reiner**, and **Dennis Stanton***, Univ. of Minnesota (931-05-34)

5:45PM (152) *Flag matroids.* Preliminary report.
Alexandre V. Borovik, UMIST, **Israel M. Gelfand**, Rutgers University, and **Neil L. White***, University of Florida (931-05-50)

Special Session on Applied Probability and Actuarial Science, II

2:45 PM – 4:35 PM **Room 14, Founder's Union Building**

Organizers: **Grzegorz Rempala**, University of Louisville
Krzysztof Ostraszewski, University of Louisville
Ewa M. Kubicka, University of Louisville
Bogdan Gapinski, University of Louisville

2:45PM (153) *Random walks on special graphs and cryptography.*
Vasiliy A. Ustimenko, University of Kyiv-Mohyla Academy, Ukraine, and Delaware University (931-60-79)

3:25PM ► (154) *N person sequential selection of optimal contract.* Preliminary report.
Krzysztof Szajowski, Institute of Mathematics, Wrocław University of Technology (931-90-99)

4:05PM (155) *Probability of ruin with variable premium rate in a Markovian environment.* Preliminary report.
Helena Jasiulewicz, Institute of Mathematics, Wrocław University of Technology (931-90-93)

Special Session on Modern Function Theory, II

2:45 PM – 6:05 PM **Room 164, Burhans Hall**

Organizers: **David Minda**, University of Cincinnati
David A. Herron, University of Cincinnati

2:45PM (156) *Conjectures about integral means of formal complex derivatives in the plane.*
Albert Baernstein II*, Washington University, St.Louis, and **Stephen John Montgomery-Smith**, University of Missouri, Columbia (931-30-201)

3:15PM (157) *Global holomorphic dependence of quasiconformal mappings on Beltrami differentials.*
Hiroshi Yanagihara, Yamaguchi University (931-30-243)

3:45PM (158) *On pseudospheres that are quasispheres.* Preliminary report.
John L. Lewis*, University of Kentucky, and **Andrew L. Vogel**, Syracuse University (931-30-120)

4:15PM (159) *Lusin's condition (n) for locally quasisymmetric mappings from Euclidean domains.* Preliminary report.
Jeremy T. Tyson, University of Michigan (931-30-221)

4:45PM (160) *Growth of analytic functions in John Disks.*
Navah Langmeyer, Department of Defense (931-30-136)

5:15PM (161) *Quasisymmetrically thick sets.*
Susan G. Staples*, Texas Christian University, and **Lesley A. Ward**, Harvey Mudd College (931-30-152)

5:45PM (162) *Some domain constants related to quasiconformal mappings.* Preliminary report.
Shanshuang Yang, Emory University (931-30-163)

Special Session on Low-Dimensional Topology, II

2:45 PM – 5:05 PM **Room 161, Burhans Hall**

Organizers: **Abigail A. Thompson**, University of California, Davis
Martin Scharlemann, University of Califronia, Santa Barbara

2:45PM (163) *Alternating graphs.*
Colin Adams, Williams College (931-57-198)

3:15PM ► (164) *A survey of symmetric knots.* Preliminary report.
Morwen B. Thistlethwaite, University of Tennessee (931-57-86)

3:45PM (165) *Two-generator satellite links.*
Steven A. Bleiler, Portland State University, and **Amelia C. Jones***, Vassar College (931-57-67)

4:15PM ► (166) *Crossing number of thick knots.*
Jonathan K. Simon*, University of Iowa, and **Gregory R. Buck**, St. Anselm College (931-57-17)

4:45PM (167) *Pseudofree group actions on S^2xS^2.* Preliminary report.
Michael P. McCooey, Indiana University, Bloomington (931-57-344)

Saturday, March 21

Meeting Registration

7:30 AM – NOON **Lobby, Founder's Union Building**

Special Session on Combinatorics and Enumerative Geometry, I

8:00 AM – 10:50 AM **Room 2, Burhans Hall**

Organizers: **Kequan Ding**, University of Illinois, Urbana-Champaign
Chi Wang, University of Louisville

8:00AM (168) *Lusztig's conjecture and geometry of the Jantzen region.*
Brian D. Boe, University of Georgia (931-51-208)

8:30AM *Enumeration of spanning trees of the quartered*
(169) *Aztec diamond.*
Mihai A. Ciucu, Institute for Advanced Study (931-05-307)

9:00AM *Superschemes and t-vertex condition graphs.*
(170) **Jerzy Wojdylo**, Iowa State University (931-05-196)

9:30AM *Decompositions of partially ordered sets.*
▸ (171) **Louis J. Billera**, Cornell University, and **Gábor Hetyei***, University of Kansas (931-05-199)

10:00AM *Enumeration of plane m-colored cacti according to*
(172) *their vertex-degree distributions.* Preliminary report.
Miklós Bóna, **Michel Bousquet**, **Gilbert Labelle** and **Pierre Leroux***, LaCIM, Université du Québec à Montréal (931-05-222)

10:30AM *On the coefficients of binary bent functions.*
(173) **Xiang-dong Hou**, Wright State University (931-05-25)

Special Session on Combinatorics and Graph Theory, III

8:00 AM – 10:50 AM **Room 157, Burhans Hall**

Organizers: **Andre E. Kezdy**, University of Louisville
Grzegorz Kubicki, University of Louisville
Jenoe Lehel, University of Louisville

8:00AM *A random disease problem.*
▸ (174) **Jozsef Balog***, The University of Memphis, and **Gabor Pete**, JATE, U. of Szeged (931-05-277)

8:30AM *On the limit probabilities of the first order*
(175) *properties of graphs.*
Lubos Thoma, Institute for Advanced Study (931-05-343)

9:00AM *A generalization of Turán's theorem for*
▸ (176) *real-weighted graphs.* Preliminary report.
John Allen Kuchenbrod, University of Kentucky (931-05-210)

9:30AM *The stress spaces of bipartite frameworks.*
▸ (177) Preliminary report.
Kevin M. Peterson, Columbus State University (931-05-14)

10:00AM *Medians vs centroids.* Preliminary report.
▸ (178) **Peter J. Slater**, University of Alabama in Huntsville (931-05-337)

10:30AM *On k-orderable graphs.*
(179) **Jill R. Faudree**, Emory University, **Ralph J. Faudree**, University of Memphis, **Ronald J. Gould***, Emory University, **Michael S. Jacobson**, University of Louisville, and **Linda Lesniak**, Drew University (931-05-110)

Special Session on Fractal Geometry and Related Topics, III

8:00 AM – 10:50 AM **Room 160, Burhans Hall**

Organizers: **Ka-Sing Lau**, University of Pittsburgh
Weibin Zeng, University of Louisville

8:00AM *Dynamical systems on tiling spaces and self-similar*
(180) *processes with zero entropy.*
Teturo Kamae, Osaka City University (931-60-231)

8:30AM *A practical algorithm for computing the Hausdorff*
▸ (181) *dimension of boundaries of self-similar tiles in R^d.*
James E. Keesling* and **Andrew Vince**, University of Florida, and **Paul F. Duvall Jr.**, University of North Carolina at Greensboro (931-28-242)

9:00AM *Multifractal formalism for sofic measures and*
(182) *dimension spectra of self-affine sets.*
Satoshi Takahashi, Osaka University (931-28-255)

9:30AM *Extension of Hawkes' theorem on the Hausdorff*
(183) *dimension of a Galton-Watson tree.* Preliminary report.
Steven P. Lalley, University of Chicago (931-60-275)

10:00AM *On the disintegration with respect to dimension of*
(184) *measures generated by exchangeable cascades.* Preliminary report.
Stanley C. Williams, Utah State University (931-60-310)

10:30AM *Multifractal processes and long range dependence.*
(185) **Rudolf H. Riedi**, Rice University (931-28-283)

Special Session on Semigroups, Algorithms, and Universal Algebra, III

8:00 AM – 10:50 AM **Room 158, Burhans Hall**

Organizers: **Ralph N. McKenzie**, Vanderbilt University
Steven Seif, University of Louisville

8:00AM *Calculating conjugates in finite transformation*
(186) *semigroups.*
Robert B. McFadden, University of Louisville (931-20-304)

8:30AM *Polynomial time word problems and finite*
(187) *axiomatizability.*
Stanley Burris, University of Waterloo (931-08-230)

9:00AM *Variations on the theme of semidirect products of*
(188) *regular semigroups.* Preliminary report.
Peter R. Jones, Marquette University (931-20-298)

9:30AM *The restricted Quackenbush conjecture.*
(189) **R. Willard***, University of Waterloo, and **Keith Kearnes**, University of Louisville (931-08-225)

10:00AM *Circuits over algebras and complexity classes of*
(190) *parallel computations.*
Joel VanderWerf, Neologic Systems (931-08-324)

10:30AM *Finite bases for graph M-algebras.*
(191) **Dejan Delić**, University of Waterloo (931-08-227)

Special Session on The Use of the History of Mathematics and Science in the University and School Classroom, III

8:00 AM – 10:30 AM **Room 15, Founder's Union Building**

Organizer: **Richard M. Davitt**, University of Louisville

8:00AM *Change, probability, and numbers: a course for*
▸ (192) *non-majors on eighteenth-century mathematics.*
Fernando Q. Gouvea, Colby College (931-01-60)

8:40AM *On the uses of pythagoras: Whig history and*
▸ (193) *mathematical initiation in the capstone history of mathematics course.*
James A. Murdock, Iowa State University (931-01-118)

9:20AM *Using informal resources to enrich a mathematics*
▸ (194) *course for elementary and early childhood educators.* Preliminary report.
Nkechi M. Agwu, Borough of Manhattan Community College, City University of New York (931-01-278)

10:00AM *Introducing the history of math to pre-service*
▸ (195) *teachers.* Preliminary report.
Diane E. Mason, Indian Hills Community College (931-96-44)

Special Session on Spectral Theory, Mathematical Physics, and Disordered Media, III

8:00 AM – 10:50 AM **Room 1, Burhans Hall**

Organizers: **Peter David Hislop**, University of Kentucky
Gunter H. Stolz, University of Alabama at Birmingham

8:00AM (196) *Recovering asymptotics of metrics from fixed energy scattering data.*
Antonio Sa Barreto, Purdue University (931-35-288)

8:30AM (197) *Asymptotics of forced elastic waves.* Preliminary report.
Gisèle Ruiz Goldstein* and **Jerome A. Goldstein**, University of Memphis, and **Enrico Obrecht**, Università di Bologna (931-35-325)

9:00AM (198) *Bilinear optimal control of a Kirchhoff plate by means of a velocity controller.*
Mary E. Bradley*, University of Louisville, **Suzanne M. Lenhart**, University of Tennessee, and **Jiongmin Yong**, Fudan University (931-35-166)

9:30AM (199) *Rate of relaxation to fronts for the Lebowitz-Orlandi-Presutti equation.*
Eric A. Carlen, Georgia Tech (931-82-318)

10:00AM (200) *Long-time behavior of scalar viscous shock fronts in two dimensions.*
Jonathan Goodman, Courant Institute, NYU, and **Judith R. Miller***, Georgetown University (931-35-273)

10:30AM ▸ (201) *One-dimensional nonlinear diatomic particle chains.* Preliminary report.
Anna Vladimirova Georgieva, Duke University (931-82-172)

Special Session on Geometry of Affine Space, III

8:00 AM – 11:00 AM **Room 162, Burhans Hall**

Organizers: **Gene Freudenburg**, University of Southern Indiana
David Wright, Washington University

8:00AM Discussion

8:30AM (202) *Invariants for additive group actions.* Preliminary report.
James K. Deveney*, Virginia Commonwealth University, and **David R. Finston**, New Mexico State University (931-13-139)

9:10AM (203) *Local triviality of proper actions of the additive group.*
David R. Finston*, New Mexico State University, and **James K. Deveney**, Virginia Commonwealth University (931-14-137)

9:50AM (204) *Hypersurfaces invariant under a C^* action.* Preliminary report.
Ted E. Petrie, Rutgers University (931-14-171)

10:30AM (205) *Affine modifications and affine hypersurfaces with a very transitive automorphism group.*
Shulim Kaliman*, University of Miami, and **Mikhail Zaidenberg**, University of Grenoble (931-14-303)

Special Session on Algebraic Combinatorics, III

8:00 AM – 10:50 AM **Room 255, Burhans Hall**

Organizers: **Anders Björner**, Royal Institute of Technology
Michelle L. Wachs, University of Miami

8:00AM (206) *Partitions with block size bounded above, and partitions with one forbidden block size: Homotopy and homology.* Preliminary report.
Sheila Sundaram, Wesleyan University (931-05-321)

8:30AM (207) *On the Smith normal form of the Varchenko matrices.*
Phil Hanlon* and **Graham Denham**, Univ. of Michigan (931-05-100)

9:00AM (208) *Combinatorics of the cyclic Lie character.* Preliminary report.
Hélène Barcelo*, ASU, and **Volkmar Welker**, Universität GH-Essen (931-05-332)

9:30AM (209) *Discrete Morse theory for graph complexes.* Preliminary report.
John Shareshian, California Institute of Technology (931-05-185)

10:00AM (210) *Cohomology of Dowling lattices and Lie superalgebras.*
Eric Gottlieb* and **Michelle L. Wachs**, University of Miami (931-05-282)

10:30AM (211) *Polynomial time algorithms to approximate permanents of non-negative matrices.*
Alexander Barvinok, University of Michigan (931-05-244)

Special Session on Modern Function Theory, III

8:00 AM – 10:50 AM **Room 164, Burhans Hall**

Organizers: **David Minda**, University of Cincinnati
David A. Herron, University of Cincinnati

8:00AM (212) *Uniform norms of products of polynomials over compact sets in the complex plane.*
Igor E. Pritsker, Case Western Reserve University (931-30-35)

8:30AM (213) *On hyperbolically convex functions.*
Diego Mejia*, Universidad Nacional de Colombia, and **Christian Pommerenke**, Technische Universitat, Berlin (931-30-308)

9:00AM (214) *Complex linear combination of extremal slit mappings.* Preliminary report.
Masakazu Shiba, Hiroshima University, Japan (931-30-211)

9:30AM ▸ (215) *On generalizations of approximations to the arc length of an ellipse.* Preliminary report.
Roger W. Barnard*, **Kent Pearce**, and **Lawrence Schovanec**, Texas Tech University, and **Kendall C. Richards**, Southwestern University (931-33-314)

10:00AM (216) *Analytic continuation of Dirichlet series.*
James Milne Anderson, University College London, **Dmitry Khavinson***, University of Arkansas, and **Harold S. Shapiro**, Royal Institute of Technology (931-30-85)

10:30AM (217) *Conformal structures of Riemann surfaces via circle packing.*
Philip L. Bowers, Florida State University, and **Kenneth Stephenson***, University of Tennessee (931-30-133)

AMS Book Exhibit and Electronic Products Display

8:00 AM – NOON **Lobby, Founder's Union Building**

Special Session on Functional Equations and Inequalities, III

8:30 AM – 10:50 AM **Room 156, Burhans Hall**

Organizers: **Thomas Riedel**, University of Louisville
Prasanna Sahoo, University of Louisville

8:30AM (218) *The dilation equation and iterated function system.* Preliminary report.
Ka-Sing Lau*, University of Pittburgh, and The Chinese University of Hong Kong, and **Sze-Man Ngai**, Cornell University (931-26-178)

9:00AM (219) *Inequalities for maximum modulus of rational functions with prescribed poles.* Preliminary report.
Narendra K. Govil*, Auburn University, and **Ram N. Mohapatra**, University of Central Florida (931-30-24)

9:30AM (220) *Fixed point theorems and applications.* Preliminary report.
Sankatha Singh, Memorial University (931-47-200)

10:00AM (221) *Uncertainty due to imprecise measurements and the Cauchy functional equations.* Preliminary report.
Elias Y. Deeba*, **Andre De Korvin** and **Shishen S. Xie**, University of Houston-Downtown (931-39-07)

10:30AM (222) *On a class of functional equations in distribution.* Preliminary report.
Elias Y. Deeba, University of Houston-Downtown, **Prasanna K. Sahoo**, University of Louisville, and **Shishen S. Xie***, University of Houston-Downtown (931-39-08)

Special Session on Banach Space Theory, III

8:30 AM – 10:50 AM **Room 8, Burhans Hall**

Organizers: **Patrick N. Dowling**, Miami University, Ohio
Beata Randrianantoanina, Miami University, Ohio

8:30AM (223) *Sobolev inequalities of exponential type.* Preliminary report.
David E. Edmunds, University of Sussex, U.K., and **Ritva M. Hurri-Syrjanen***, University of Helsinki, Finland (931-46-256)

9:00AM (224) *On non-surjective approximate isometries.*
Stephen J. Dilworth, University of South Carolina (931-46-235)

9:30AM (225) *Representing ℓ_p in quotients of Banach spaces.*
Petr Habala*, University of Texas at Austin, and **Nicole Tomczak-Jaegermann, FRSC**, University of Alberta, Canada (931-46-267)

10:00AM (226) *Remarks on Legendre polynomials.* Preliminary report.
Nigel J. Kalton, University of Missouri (931-46-182)

10:30AM (227) *Quasi-linear maps between Orlicz spaces.* Preliminary report.
Costantin Dan Cazacu* and **Nigel J. Kalton**, University of Missouri, Columbia (931-46-66)

Special Session on Boundary Value Problems for Differential Equations, III

8:30 AM – 10:50 AM **Room 159, Burhans Hall**

Organizer: **Paul W. Eloe**, University of Dayton

8:30AM ▸ (228) *Periodic solutions for nonlinear Volterra difference equations with infinite delay.*
Youssef Raffoul, Tougaloo College (931-39-151)

9:00AM ▸ (229) *Groebner bases for discrete isoperimetric problems.* Preliminary report.
Betty Jean Harmsen, Omaha, NE (931-39-146)

9:30AM (230) *Direct and inverse scattering in a layered or anisotropic medium.* Preliminary report.
Joseph F. Coyle, University of Delaware (931-65-238)

10:00AM (231) *Existence, uniqueness, and properties of Azimuthal shear solutions in compressible nonlinear elasticity.*
Joseph E. Paullet*, Penn State, Erie, **Debra A. Polignone**, University of Tennessee, and **Paul G. Warne**, Maryville College (931-34-55)

10:30AM (232) *Wellposedness, regularity, and stabilization of shells.*
Christine A. McMillan, Virginia Tech (931-49-349)

Special Session on Spectral Geometry, III

8:30 AM – 10:50 AM **Room 3, Burhans Hall**

Organizers: **Ruth Gornet**, Texas Tech University
Peter Anton Perry, University of Kentucky

8:30AM (233) *Spectral asymptotics for compactly supported perturbations of the Laplacian on Euclidian space.*
Tanya J. Christiansen, University of Missouri (931-35-142)

9:00AM (234) *Spectral clustering of the Dirac operator on spheres.* Preliminary report.
Mary R. Sandoval, Purdue University (931-58-162)

9:30AM (235) *Spectral geometry of G-manifolds and foliations.*
Ken Richardson, Texas Christian University (931-58-154)

10:00AM (236) *Asymptotic estimates of Husimi distributions centered near critical points.* Preliminary report.
Mariah Birgen, Wartburg College (931-58-312)

10:30AM (237) *Asymptotics of powers of positive line bundles over Kahler manifolds.*
Steve Zelditch IV, Johns Hopkins University (931-32-164)

Special Session on Applied Probability and Actuarial Science, III

8:30 AM – 11:00 AM **Room 14, Founder's Union Building**

Organizers: **Grzegorz Rempala**, University of Louisville
Krzysztof Ostraszewski, University of Louisville
Ewa M. Kubicka, University of Louisville
Bogdan Gapinski, University of Louisville

8:30AM (238) *Nonparametric test of assets performances.*
Grzegorz A. Rempala* and **Krzysztof M. Ostaszewski**, University of Louisville (931-62-289)

9:10AM (239) *A statistical analysis of tidal data.* Preliminary report.
Michael Sherman, Texas A&M University (931-60-155)

9:50AM (240) *Estimation under asymmetric loss functions.*
Michael I. Baron, University of Texas at Dallas (931-60-80)

10:30AM (241) *Matrix means and permanents.*
Gabor Szekely, Eotvos L. University, Budapest, and Bowling Green State University (931-60-75)

Special Session on Real Analysis, III

9:00 AM – 10:50 AM **Room 163, Burhans Hall**

Organizers: **Udayan B. Darji**, University of Louisville
Lee Larson, University of Louisville

9:00AM (242) *Chebyshev foam.*
Gordon G. Johnson, University of Houston (931-26-263)

9:30AM (243) *Further properties of an extremal set of uniqueness.*
Matt Insall and **David E. Grow***, University of Missouri - Rolla (931-43-165)

10:00AM (244) *Green's theorem with no differentiability.* Preliminary report.
Isidore Fleischer, Centre de recherches mathématiques (931-26-56)

10:30AM (245) *On sup-measurable functions problem.*
Krzysztof Ciesielski, West Virginia University (931-26-38)

Special Session on Low-Dimensional Topology, III

9:00 AM – 10:50 AM **Room 161, Burhans Hall**

Organizers: **Abigail A. Thompson**, University of California, Davis
Martin Scharlemann, University of California, Santa Barbara

9:00AM (246) *Torsion in the Kauffman bracket skein module of a 3-manifold and use of a homology group and hyperbolic structure in torsion detection.* Preliminary report.
Józef H. Przytycki, George Washington University (931-57-64)

9:30AM (247) *Examples of foliation cones.* Preliminary report.
John Cantwell*, Saint Louis University, and **Lawrence Conlon**, Washington University (931-57-21)

10:00AM (248) *Genuine laminations and group negative curvature.*
William H. Kazez*, University of Georgia, and **David Gabai**, California Insitute of Technology (931-57-10)

10:30AM (249) *Small Seifert group actions on R.*
Rachel Roberts*, Washington University, and **Melanie Stein**, Trinity College (931-57-45)

Invited Address

11:10 AM – NOON **Room 218, Founder's Union Building**

(250) *Recognizing the 3-sphere.*
Abigail Thompson, University of California at Davis

Invited Address

1:40 PM – 2:30 PM **Room 218, Founder's Union Building**

(251) *Folding and coloring problems in mathematics and physics.*
Philippe DiFrancesco, University of North Carolina at Chapel Hill

Special Session on Combinatorics and Enumerative Geometry, II

2:45 PM – 5:35 PM **Room 2, Burhans Hall**

Organizers: **Kequan Ding**, University of Illinois, Urbana-Champaign
Chi Wang, University of Louisville

2:45PM (252) *q-Rook polynomials and matrices over finite fields.*
James B. Haglund, MIT (931-05-234)

3:15PM (253) *Toughness, trees and walks.*
Mark Ellingham, Vanderbilt University, and **Xiaoya Zha***, Middle Tennessee State University (931-05-305)

3:45PM ▸ (254) *On the number of rational points over finite field of the unipotent partial flag variety.*
Anatol N. Kirillov (931-05-319)

4:15PM (255) *Quadratic algebras in Schubert calculus.*
Sergey Fomin*, MIT, and **Anatol N. Kirillov**, CRM, U. de Montreal (931-05-328)

4:45PM (256) *A Pieri-type formula for the symplectic flag manifold.*
Nantel Bergeron, York University, and **Frank Sottile***, University of Toronto (931-14-299)

5:15PM (257) *The Terwilliger algebras of bipartite p- and q-polynomial association schemes.* Preliminary report.
John S. Caughman IV, University of Wisconsin (931-05-351)

Special Session on Combinatorics and Graph Theory, IV

2:45 PM – 6:05 PM **Room 157, Burhans Hall**

Organizers: **Andre E. Kezdy**, University of Louisville
Grzegorz Kubicki, University of Louisville
Jenoe Lehel, University of Louisville

2:45PM (258) *Essentially finite colorings.* Preliminary report.
Bela Bollobás and **Richard H. Schelp***, University of Memphis, and **Yoshi Kohayakawa**, Universidade de São Paulo (931-05-94)

3:15PM ▸ (259) *Colorings of complete graphs and rainbow subgraphs.* Preliminary report.
Ralph J. Faudree, University of Memphis (931-05-180)

3:45PM (260) *Forcing concepts in graph theory.*
Frank Harary, New Mexico State University (931-05-89)

4:15PM (261) *Cographs as intersection graphs and intersections of graphs.*
Terry A. McKee, Wright State University (931-05-83)

4:45PM ▸ (262) *Partitioning vertices of a tournament into independent cycles.*
Guantao Chen, Georgia State University (931-05-294)

5:15PM ▸ (263) *Domination in oriented graphs.*
Bela Bollobas and **Tamas Szabo***, The University of Memphis (931-05-276)

5:45PM (264) *The Ramsey numbers $r(C_4, G)$ and $r(C_5, G)$ for all graphs G of order six.*
Chula J. Jayawardene* and **Cecil C. Rousseau**, The University of Memphis (931-05-342)

Special Session on Discrete Mathematics, Classification Theory and Consensus

2:45 PM – 5:35 PM **Room 156, Burhans Hall**

Organizer: **Robert C. Powers**, University of Louisville

2:45PM ▸ (265) *Resolving arrow's theorem and voting paradoxes.*
Donald G. Saari, Northwestern University (931-90-47)

3:15PM (266) *Arrow-like theorems for closed systems of sets.* Preliminary report.
Gary D. Crown, Wichita State University, and **Melvin F. Janowitz***, University of Massachusetts (931-05-112)

3:45PM ▸ (267) *A unifying approach to arrow's theorem.*
Richard A. Cramer-Benjamin, University of Massachusetts (931-06-88)

4:15PM ▸ (268) *An axiomatic approach to centrality functions on graphs.* Preliminary report.
Fred R. McMorris, University of Louisville (931-05-117)

4:45PM (269) *Median with respect to the minimum-element-moves metric.*
Kaddour Boukaabar, California University of Pennsylvania (931-06-90)

5:15PM *Clique consensus methods with polynomial time*
(270) *algorithms.*
David J. Bryant, Centre de Recherches Mathematiques (931-05-140)

Special Session on Fractal Geometry and Related Topics, IV

2:45 PM – 5:35 PM **Room 160, Burhans Hall**

Organizers: **Ka-Sing Lau**, University of Pittsburgh
Weibin Zeng, University of Louisville

2:45PM *On packing measure and packing dimension.*
(271) **Gerald A. Edgar**, The Ohio State University (931-28-20)

3:15PM *Koebe type distortion theorem for nonconformal*
► (272) *semigroups.*
Yunping Jiang, Queens College, CUNY (931-32-212)

3:45PM *Parabolic iterated function systems.* Preliminary
(273) report.
R. Daniel Mauldin* and **Mariusz Urbanski**, University of North Texas (931-58-144)

4:15PM *Dimensions and measures for a curvilinear*
(274) *Sierpinski gasket or Apollonian packings.*
Mariusz Urbanski* and **R. Daniel Mauldin**, University of North Texas (931-28-156)

4:45PM *Invariant measures on Julia sets via iterated*
(275) *function systems.* Preliminary report.
Russell K. Jackson, Brown University, and **Karl E. Petersen***, University of North Carolina (931-30-97)

5:15PM *Approximation of invariant measures for iterated*
(276) *function systems.*
Anders Oberg, Umeå University and Uppsala University (931-28-233)

Special Session on Banach Space Theory, IV

2:45 PM – 6:05 PM **Room 8, Burhans Hall**

Organizers: **Patrick N. Dowling**, Miami University, Ohio
Beata Randrianantoanina, Miami University, Ohio

2:45PM *Some fixed point results in* ℓ^1 *and* c_0.
(277) **Patrick N. Dowling**, Miami University, **Christopher J. Lennard**, Univ. of Pittsburgh, and **Barry Turett***, Oakland University (931-46-306)

3:15PM *On asymptotic* ℓ_1 *Banach spaces.* Preliminary
(278) report.
George Androulakis, University of Missouri-Columbia (931-46-260)

3:45PM *Relative complementation property.* Preliminary
► (279) report.
William B. Johnson and **Timur Oikhberg***, Texas A&M University (931-46-246)

4:15PM *Every frame is a sum of three (but not two)*
(280) *orthonormal bases - and other frame representations.*
Peter G. Casazza, U. of Missouri (931-46-72)

4:45PM *Genus N Banach spaces.* Preliminary report.
(281) **Peter G. Casazza**, University of Missouri, and **Mark C. Lammers***, University of North Carolina-Wilmington (931-46-187)

5:15PM *Remarks about Schlumprecht space.* Preliminary
(282) report.
Denka Kutzarova, Bulgarian Academy of Sciences (931-46-150)

5:45PM *Operators on spaces of analytic functions in the*
(283) *Dixmier class.*
Mark C. Ho, National Sun Yat-Sen University (931-47-15)

Special Session on Real Analysis, IV

2:45 PM – 4:05 PM **Room 163, Burhans Hall**

Organizers: **Udayan B. Darji**, University of Louisville
Lee Larson, University of Louisville

2:45PM *Shades of the Cauchy functional equation.*
(284) **Rick Mabry**, Louisiana State University in Shreveport (931-26-32)

3:15PM *Continuity of symmetrically continuous functions.*
(285) **Marcin Szyszkowski**, West Virginia University (931-26-296)

3:45PM *Absolute summability factors of infinite series.*
(286) **Syed M. Mazhar**, Kuwait University (931-40-39)

Special Session on Semigroups, Algorithms, and Universal Algebra, IV

2:45 PM – 6:35 PM **Room 158, Burhans Hall**

Organizers: **Ralph N. McKenzie**, Vanderbilt University
Steven Seif, University of Louisville

2:45PM *Homotopy and semisymmetry.*
(287) **Jonathan D. H. Smith**, Iowa State University (931-20-229)

3:15PM *Posets whose monoids of order-preserving maps are*
(288) *abundant.*
M. E. Adams*, State University of New York at New Paltz, and **Matthew Gould**, Vanderbilt University (931-06-245)

3:45PM *Categorical equivalence of modes.*
(289) **Clifford H. Bergman***, Iowa State University, and **Joel Berman**, University of Illinois at Chicago (931-18-138)

4:15PM *Priestley duality for distributive and Brouwerian*
(290) *semilattices.*
Jonathan D. Farley, Vanderbilt University (931-08-329)

4:45PM *Transformation semigroups and associated*
(291) *permutation groups.*
Inessa Levi, University of Louisville (931-20-249)

5:15PM Discussion

5:45PM *Lattices with large minimal extensions.* Preliminary
(292) report.
Ralph Freese, University of Hawaii, **Jaroslav Jezek**, Charles University, Prague, and **J. B. Nation***, University of Hawaii (931-06-341)

6:15PM *Unsolved and unsolvable problems in finite algebras*
(293) *and semigroups.*
Ralph McKenzie, Vanderbilt University (931-08-302)

Special Session on Boundary Value Problems for Differential Equations, IV

2:45 PM – 5:05 PM **Room 159, Burhans Hall**

Organizer: **Paul W. Eloe**, University of Dayton

2:45PM *Eigenfunction decay.* Preliminary report.
(294) **Suzanne E. Collier**, Arkansas State University (931-34-291)

3:15PM *Spatial analyticity for the nonlinear heat equation*
(295) *in a bounded domain.*
Zoran Grujic*, Indiana University, and **Igor Kukavica**, University of Southern California (931-35-101)

3:45PM *Summation of functional series.*
► (296) **Andriy Mikolaevich Blazhievskiy**, Technological University of Podillia, Khmelnitsky, Ukraine (931-35-12)

4:15PM *Control and stabilization of elastic systems.*
(297) **Mary Ann Horn**, Vanderbilt University (931-35-352)

4:45PM *The solution of the plane elasticity problems for the*
(298) *cuts with cusps and for slits.*
Elena Shirokova, Kazan State University (931-34-05)

Special Session on Spectral Geometry, IV

2:45 PM – 5:05 PM **Room 3, Burhans Hall**

Organizers: **Ruth Gornet**, Texas Tech University
Peter Anton Perry, University of Kentucky

2:45PM *Sharp constant in the Trudinger-Moser-Adam*
(299) *inequality.* Preliminary report.
Sun-Yung A. Chang, UCLA (931-53-240)

3:15PM *Hausdorff dimension and limits of Kleinian groups.*
(300) **Richard D. Canary**, University of Michigan, and **Edward C. Taylor***, University of Kentucky (931-58-27)

3:45PM *Length spectra of graphs.* Preliminary report.
▸ (301) **Gregory T. Quenell**, Oberlin College (931-05-173)

4:15PM *Hill's equation for a regular graph.*
(302) **Robert C. Carlson**, University of Colorado at Colorado Springs (931-34-63)

4:45PM *Spectral theory of Toeplitz operators on manifolds.*
(303) **Victor W. Guillemin**, Massachusetts Institute of Technology, and **Kate Okikiolu***, University of California, San Diego (931-47-345)

Special Session on Spectral Theory, Mathematical Physics, and Disordered Media, IV

2:45 PM – 5:35 PM **Room 1, Burhans Hall**

Organizers: **Peter David Hislop**, University of Kentucky
Gunter H. Stolz, University of Alabama at Birmingham

2:45PM *Eigenvalue estimates in the semi-classical limit for*
(304) *Pauli and Dirac operators with a magnetic field.*
W. D. Evans, University of Wales, Cardiff, and **Roger T. Lewis***, University of Alabama at Birmingham (931-81-218)

3:15PM *An improved Feynman-Kac-Itô formula.*
(305) **Dirk Hundertmark**, Princeton university (931-60-279)

3:45PM *Bohr-Sommerfeld quantization rules and Rydberg*
▸ (306) *states of hydrogen.*
George A. Hagedorn*, Virginia Polytechnic Institute and State University, and **Sam L. Robinson**, William Paterson University of New Jersey (931-81-176)

4:15PM *On moments of negative eigenvalues for the Pauli*
(307) *operator.*
Zhongwei Shen, University of Kentucky (931-35-286)

4:45PM *Eigenvalues of Schrödinger operators with*
(308) *potentials depending on curvature.*
Evans M. Harrell II* and **Michael Loss**, Georgia Institute of Technology (931-81-167)

5:15PM *Spectral and scattering theory for Kleinian groups.*
(309) Preliminary report.
Peter A. Perry, University of Kentucky (931-35-228)

Special Session on Geometry of Affine Space, IV

2:45 PM – 5:55 PM **Room 162, Burhans Hall**

Organizers: **Gene Freudenburg**, University of Southern Indiana
David Wright, Washington University

2:45PM *Analytic desingularization in characteristic zero.*
(310) **Shreeram S. Abhyankar**, Purdue University (931-14-92)

3:25PM *Local factorization of birational morphisms.*
(311) **Steven Dale Cutkosky**, Univ. Missouri (931-14-186)

4:05PM *Testing sets for the properness of polynomial*
(312) *mappings.*
Zbigniew Jelonek, Jagiellonian University, Krakow (931-14-292)

4:45PM *From ind-affine varieties to the Jacobian problem.*
(313) Preliminary report.
Tac Kambayashi, Tokyo Denki University (931-14-134)

5:25PM *Stably tameness of a new class of automorphisms.*
(314) Preliminary report.
David L. Wright*, Washington University, and **Engelbert Hubbers**, University of Nijmegen (931-13-326)

Special Session on Algebraic Combinatorics, IV

2:45 PM – 6:05 PM **Room 255, Burhans Hall**

Organizers: **Anders Björner**, Royal Institute of Technology
Michelle L. Wachs, University of Miami

2:45PM *Mixed Bruhat operators.*
(315) **Sergey Fomin***, MIT, and **Francesco Brenti**, University of Rome (931-05-330)

3:15PM *The partial order of dominant weights.*
(316) **John R. Stembridge**, University of Michigan, Ann Arbor (931-05-71)

3:45PM *Pattern avoidance and rational smoothness of*
(317) *Schubert varieties.*
Sara C. Billey, MIT (931-05-127)

4:15PM *What does skew-symmetric functions, F_w Stanley*
(318) *symmetric functions, skew-Schubert functions all have in common?* Preliminary report.
Nantel Bergeron*, York University, and **Frank Sottile**, University of Toronto (931-05-116)

4:45PM *A recursion for charge on words.* Preliminary report.
(319) **Kendra Killpatrick** and **Dennis E. White***, University of Minnesota (931-05-51)

5:15PM *Antiautomorphisms of subgroup lattices and*
▸ (320) *involutions on tabloids.* Preliminary report.
Noel Watson, The Wharton School of the University of Pennsylvania, **Lynne Butler*** and **Curtis Greene**, Haverford College (931-05-339)

5:45PM *Some remarkable families of multiple regular*
(321) *representations of S_n.*
François Bergeron, L'Université du Québec à Montréal, **Adriano M. Garsia*** and **Glenn P. Tesler**, University of California, San Diego (931-05-253)

Special Session on Modern Function Theory, IV

2:45 PM – 5:35 PM **Room 164, Burhans Hall**

Organizers: **David Minda**, University of Cincinnati
David A. Herron, University of Cincinnati

2:45PM *Uniform densities of regular sequences in the unit*
(322) *disk.* Preliminary report.
Peter Duren*, University of Michigan, **Alexander P. Schuster**, Washington University, and **Kristian Seip**, Norwegian University of Science and Technology (931-30-272)

3:15PM *Doubling measures with different bases.*
(323) **Jang-Mei Wu**, University of Illinois (931-28-204)

3:45PM (324) *Extremal lengths of homology classes on Riemann surfaces.*
Makoto Masumoto, Yamaguchi University, Japan (931-30-147)

4:15PM (325) *On the zeros of entire functions of small positive order and their derivatives.*
Joseph Miles, University of Illinois, and **John F. Rossi***, Virginia Tech (931-30-113)

4:45PM (326) *Jørgensen's inequality for discrete convergence groups.*
Petra Bonfert-Taylor (931-08-189)

5:15PM (327) *Interpolation by Bloch functions.*
Alexander P. Schuster, Washington University in St. Louis (931-30-195)

Special Session on Low-Dimensional Topology, IV

2:45 PM – 5:05 PM **Room 161, Burhans Hall**

Organizers: **Abigail A. Thompson**, University of California, Davis
Martin Scharlemann, University of Califronia, Santa Barbara

2:45PM (328) *Counting annuli and tori.*
Martin G. Scharlemann, UCSB, and **Jennifer C. Schultens***, Emory University (931-57-16)

3:15PM (329) *Annular and boundary reducing Dehn fillings.*
Cameron McA. Gordon*, The University of Texas at Austin, and **Ying-Qing Wu**, University of Iowa (931-57-82)

3:45PM (330) *Extension of incompressible surfaces on the boundary of 3-manifolds.*
Michael Freedman and **Hugh Howards**, UCSD, and **Ying-Qing Wu***, University of Iowa (931-57-81)

4:15PM (331) *Heegaard diagrams and handlebody groups.*
Feng Luo, Rutgers University (931-57-73)

4:45PM (332) *Proof of Arnold's conjectures about plane curves with double points.*
Chenghui Luo, Fraunhofer CRCG, Inc. (931-55-11)

Session for Contributed Papers

2:45 PM – 4:25 PM **Room 9, Burhans Hall**

2:45PM (333) *Der bunte Hahn.*
▸ **Klaus Leeb**, Universitaet Erlangen (931-06-09)

3:00PM (334) *The shells of Vaggione: Some comments and questions.*
Arthur Knoebel, Vanderbilt University (931-08-338)

3:15PM (335) *Cancellation and embedding theorems for compact uniquely divisible semigroups.* Preliminary report.
Kirk Benningfield, McNeese State University (931-22-28)

3:30PM (336) *A characterization of compact regular semigroups with the ideal extension property.* Preliminary report.
Karen Dommert Aucoin* and **Kirk Benningfield**, McNeese State University (931-22-29)

3:45PM (337) *Hilbert's space filling curve and Hausdorff dimension.*
Mark C. McClure, UNC - Asheville (931-26-54)

4:00PM (338) *Subdivisions of two-dimensional point sets with few interior points.* Preliminary report.
Wendy A. Weber, University of Kentucky (931-52-262)

4:15PM (339) *Recursive C++ algorithm for multiple integrals.*
▸ **Clinton P. Fuelling**, Ball State University (931-65-36)

Robert J. Daverman
Associate Secretary
Knoxville, Tennessee

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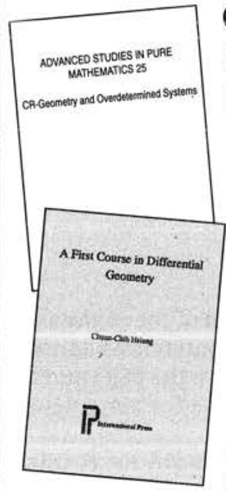
New in Geometry and Topology



CR-Geometry and Overdetermined Systems

Takao Akahori, *Himeji Institute of Technology, Hyogo, Japan*, **Gen Komatsu**, *Osaka University, Japan*, **Kimio Miyajima**, *Kagoshima University, Kagoshima-shi, Japan*, **Makoto Namba**, *Osaka University, Japan*, and **Keizo Yamaguchi**, *Hokkaido University, Sapporo, Japan*, Editors

This volume consists of survey articles and research papers on the most recent developments of CR-geometry and overdetermined systems. Some of the papers are based on the lectures delivered at a conference of the same title. The volume contains notes from three lectures on the invariant theory of the Bergman kernel, and on the deformation of CR structures with applications. Other papers, original or expository, are recent contributions on important problems in complex geometry of differential geometric aspects of analysis, and many of them are related to CR geometry. This volume offers timely and useful information on the subject.

Advanced Studies in Pure Mathematics is published for the Mathematical Society of Japan by Kinokuniya, Tokyo, and distributed worldwide, except in Japan, by the AMS.

Advanced Studies in Pure Mathematics, Volume 25; 1997; 418 pages; Hardcover; ISBN 4-314-10127-X; List $76; Individual member $46; Order code ASPM/25NA

A First Course in Differential Geometry

Chuan C. Hsiung, *Lehigh University, Bethlehem, PA*

This book is designed to introduce differential geometry to beginning graduate students and advanced undergraduates. The text covers the traditional topics: curves and surfaces in a three-dimensional Euclidean space. Unlike most classical books on the subject, however, the author pays more attention to the relationships between local and global properties rather than to local properties only.

Most global theorems for curves and surfaces in the book can be extended to either higher-dimensional spaces or more general curves and surfaces or both. Geometric interpretations are given along with analytic expressions. This enables students to make use of geometric intuition—a precious tool for studying geometry and related problems.

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International Press; 1997; 343 pages; Hardcover; ISBN 1-57146-046-2; List $45; All AMS members $36; Order code INPR/24NA

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Meetings and Conferences of the AMS

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The Meetings and Conferences section of the *Notices* gives information on all AMS meetings and conferences approved by press time for this issue. Please refer to the page numbers cited in the table of contents on this page for more detailed information on each event. Invited Speakers and Special Sessions are listed as soon as they are approved by the cognizant program committee; the codes listed are needed for electronic abstract submission. For some meetings the list may be incomplete. Up-to-date meeting and conference information is available on the World Wide Web at www.ams.org/meetings/.

Meetings:

1998		
March 20–21	Louisville, Kentucky	p. 657
March 27–28	Manhattan, Kansas	p. 657
April 4–6	Philadelphia, Pennsylvania	p. 657
April 25–26	Davis, California	p. 657
September 12–13	Chicago, Illinois	p. 658
October 9–10	Winston-Salem, No. Carolina	p. 659
October 24-25	State College, Pennsylvania	p. 659
November 14–15	Tucson, Arizona	p. 660
1999		
January 13–16	San Antonio, Texas Annual Meeting	p. 660
March 12–13	Gainesville, Florida	p. 660
March 18–21	Urbana, Illinois	p. 660
April 10–11	Las Vegas, Nevada	p. 661
April 24–25	Buffalo, New York	p. 661
July 12–16	Melbourne, Australia	p. 661
October 2–3	Providence, Rhode Island	p. 661
October 8-10	Austin, Texas	p. 662
2000		
January 19–22	Washington, DC Annual Meeting	p. 662
April 1–2	Lowell, Massachusetts	p. 662
April 7-9	Notre Dame, Indiana	p. 662
2001		
January 10-13	New Orleans, Louisiana Annual Meeting	p. 662
March 16–18	Columbia, South Carolina	p. 663
October 13-14	Williamstown, MA	p. 663
2002		
January 6-9	San Diego, California Annual Meeting	p. 663

Important Information Regarding AMS Meetings

Potential organizers, speakers, and hosts should refer to page 150 in the January 1998 issue of the *Notices* for general information regarding participation in AMS meetings and conferences.

Abstracts

Several options are available for speakers submitting abstracts, including an easy-to-use interactive Web form. No knowledge of TeX is necessary to submit an electronic form, although those who use plain TeX, AMS-TeX, LaTeX, or AMS-LaTeX may submit abstracts with TeX coding. To see descriptions of the forms available, visit http://www.ams.org/abstracts/instructions.html or send mail to abs-submit@ams.org, typing help as the subject line, and descriptions and instructions on how to get the template of your choice will be e-mailed to you.

Completed abstracts should be sent to abs-submit@ams.org, typing submission as the subject line. Questions about abstracts may be sent to abs-info@ams.org.

Paper abstract forms may be sent to Meetings & Conferences Department, AMS, P.O. Box 6887, Providence, RI 02940. Note that all abstract deadlines are strictly enforced. Close attention should be paid to specified deadlines in this issue. Unfortunately, late abstracts cannot be accommodated.

Conferences: (See http://www.ams.org/meetings/ for the most up-to-date information on these conferences.)

1998:

June 21–July 23: Joint Summer Research Conferences in the Mathematical Sciences, South Hadley, MA. See pp. 1412–1416 (November 1997) and pp. 148–149 (January 1998) for details.

Mathematics from Oxford

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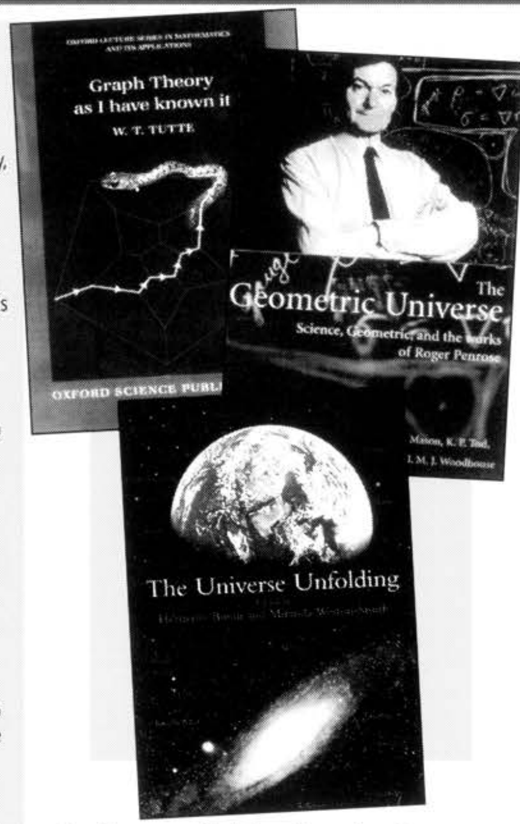

Codes and Algebraic Curves

Oliver Pretzel, Imperial College, London

An updated and extended version of the last part of *Error Correcting Codes and Finite Fields*, also by Pretzel, this book provides an introduction to the geometry of curves over finite fields and uses the theory for a detailed investigation of geometric Goppa codes.

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This book is a collection of articles from several world-class researchers, and is inspired by Sir Roger Penrose's work. The volume collects together ideas from across the physical sciences, and indicates the many applications of geometrical ideas and techniques across mathematics and mathematical physics.

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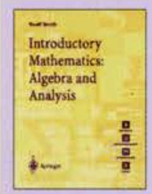

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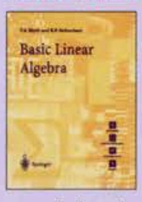

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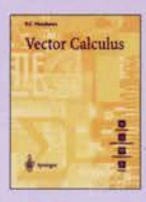

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