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Articles

How We Got Where We Are: An International Overview of Mathematics in National Contexts (1875-1900)
Karen Parshall

The number of recent centennial celebrations indicates great happenings at the end of the last century. The forces leading to these events and the birth of the modern mathematical community are described in this article.

Crossing the Interface between Chemistry and Science
George A. Hagedorn

New problems and progresses in theoretical and computational chemistry lead to significant opportunities for interaction among chemists and mathematicians.

Downsizing at Rochester: Mathematics Ph.D. Program Cut
Allyn Jackson

A major restructuring plan at the University of Rochester has called for the elimination of its graduate program in mathematics and a sizeable reduction in mathematics faculty. This article examines what happened at Rochester and why.

Demotion of Mathematics at Rochester Meets Groundswell of Protest
Arthur Jaffe, Salah Baouendi, and Joseph Lipman

The cuts in the mathematics department at Rochester sounded alarm bells throughout the mathematical community and beyond. Quoting from the many letters of protest sent to the Rochester administration, this article discusses the reaction to the cuts.

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From the AMS

Committee on the Profession 1995 Annual Report
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The Mathematician as Communicator

Several years ago I attended a dinner at the governor's mansion celebrating that year's recipients of the state's Medal of Science. I sat next to the congressman from my district and across the table from a prominent member of the Department of Mechanical Engineering, one of the recipients of the medal. His laboratory had just received two large-scale fundings for the further development of automata, one from the Department of Energy and the other from the Disney Corporation. He explained, much to the congressman's delight, how he "trains" his robots: electrodes attached to a human hand at one end and to the robot at the other (with a computer between) allow the robot to instantaneously reproduce the motions of the human hand. An artificial hand on the moon or at the bottom of the ocean could be so directed to simulate the action of a real hand. Further, this information can be stored on a CD for later use: thus his robots can act on the stage at Disneyland, reacting to instructions prepared months ago in his laboratory. My fascination with this description was broken when the congressman turned to me and asked me about my research. Several scenarios flashed before my eyes almost simultaneously:

MC: ... and what is your research concerned with, Professor Rossi?

HR: Well, Congressman, there is not the remotest possibility that it could have anything to do with anything you might be interested in, and if it did, you simply do not have the intellectual capacity to understand it.

or

HR: The singular beauty of my research is that it has nothing at all to do with reality.

or

HR: Let X be a scheme over an algebraic number field—you can consider it complete if you wish ...

or

HR: My research delves into the most profound depths of intellectual curiosity ...

or

HR: I work on sheaves of sections of fiber bundles over new kinds of varieties of ...

MC: How interesting! I am pleased to see a mathematician's interest in our agriculture.

None of these scenarios came to pass. Instead I explained that my research is in analytic geometry, a field which translates geometric information into analytic and thus, ultimately, digital information. In particular, we are interested in the movement of geometric bodies through space and in time. When, however, my colleague's human hand moves, the electronic impulses so generated are transformed into code for the computer; this act of transformation is accomplished by the branch of mathematics in which I work. Then, there is the inverse problem: to transform this digital information into the robot's action ...

So, I Bed. But, on the other hand, the congressman seemed to understand something of the role of mathematics in what he was interested in, and it helped his disposition toward mathematicians.

Why is it so hard for us to explain to diverse audiences what we do—especially those whose actions have effect on the future of science and mathematics? Do we fear sacrificing a little bit of the truth in order to simply convey an idea? Once I heard Phil Griffiths give a talk at a conference, where he stated a theorem and then said, "I am going to give you an argument for this theorem which doesn't work, but shows the idea of the proof." Some observers objected: "If it doesn't work, it's not the idea of the proof." Good point. Proof is good; it is the very backbone of our discipline. But it has its place. This "faulted" argument of Griffiths's played a role in some of my own subsequent work. My advisor, I. Singer, never gave a proof in any course or seminar I took from him—he just gave us a few ideas, and we went home to work out our own proofs. Don Spencer hardly ever discussed a proven theorem in his classes at Princeton, and if he did, he probably got it wrong. But Don was one of the most productive educators of this half-century. Whether we present our mathematics to our children, a party-goer, our congressman, our students, our colleagues, a colloquium, or the mathematical record, the aim is to communicate ideas and their implications. This requires a tangible awareness of our audience: we would not tell our children or our congressman what we put down for the research record. This more or less obvious assertion is often missed by us mathematicians, and our achievements are made unnecessarily obscure by this loss.

—Hugo Rossi
Letters to the Editor

Steven Krantz versus Calculus&Mathematica

Notices editor Steven Krantz seems to have a real peeve with the Calculus&Mathematica course (Addison-Wesley, 1994) of which I am co-author. In his book (How to Teach Mathematics, AMS, 1993), Krantz attacked Calculus&Mathematica by citing nonexistent studies and a nonexistent quotation. In his lead Notices editorial (“Math for Sale”, October 1995), he launched a sarcastic personal attack on one of the Calculus&Mathematica authors (probably me). I have had enough of this, so I am responding.

Calculus&Mathematica (C&M) is a computer-based course written by research mathematicians William J. Davis, Horacio Porta, and me. Our goal in C&M is to ignite students' mathematical passions by putting students in the position of doing calculus in a way very much like the way some research mathematicians do their work.

The course runs on an entirely interactive computer-based text in which each example is as many examples as a student wants. C&M students see calculus as a course in scientific measurement, calculation, and modeling; and they also see calculus as a visual, often experimental, scientific endeavor. The heart of the course is the “Give It a Try” section, in which students use calculations, graphics, and word processing to work and write up assigned problems and projects. Many of these problems involve interactive graphics chosen to drive home a mathematical idea. Other problems involve graphics whose meaning the student must explain. Still other problems deal with a rich selection of real-world applications of calculus. No C&M student has ever asked the question, What's this stuff good for?

Recently a professor who has never taught Calculus&Mathematica visited a lab full of C&M students and reported as follows: “I feel inspired. ... I went by a C&M lab just to see what was going on. The room was filled to overflowing with students and abuzz with, how to describe it—engagement, enthusiasm, inquiry—dare I call it the sound of thinking? ... This sight, especially on a gorgeous Friday afternoon, must bring enormous satisfaction to the C&M authors. Sure would for me.”

It sure does.

Now, with this brief account of our course and the book based on that course as a backdrop, I shall respond, line by line, to a paragraph in Krantz's book about C&M.

Krantz: Some of the federally funded projects have been teaching the entire calculus sequence from Mathematica notebooks.

Response: The only such project is Calculus&Mathematica.

Krantz: The principal investigators in these projects claim that they can take students with no particular interest in mathematics, who have done poorly in their mathematics courses, and ignite in them a spark for the subject using these notebooks. They claim students get excited from interacting with the machine.

Response: Yes, we do make that claim. And, to our personal joy, we and many instructors see it reinforced every day by Calculus&Mathematica students whose math passions and curiosities are ignited by our course.

Krantz: And students who have never before received a good math grade end up getting an “A” in the course.

Response: Some do. This is especially vivid in the special sections of Calculus&Mathematica called "Bio/Cale", which are taught for life science students at Illinois under joint sponsorship of the School of Life Sciences and the Department of Mathematics.

Krantz: However, followups have been done on these students, and it has been determined that the majority of them have no comprehension of the subject and little retention. When confronted with this information, one principal investigator has said, “I think that the concept of ‘understanding’ has traditionally been overemphasized.”

Response: I have neither seen nor heard of the followup studies Krantz mentions. I believe that they do not exist and challenge Krantz to produce them. The quotation Krantz attributes to one of the C&M authors is totally bogus.

On the other hand, professionally done studies confirm that Calculus&Mathematica students have a deeper conceptual understanding than do students in the standard course. For instance, the study by Kyumee Park and Kenneth Travers (“A Comparative Study of a Computer-Based and a Standard College Calculus Course, Research in Collegiate Mathematics Education” (to appear)) states: “Generally, the findings were all favorable to C&M students. The C&M group obtained a higher level of conceptual understanding than did the standard group without much loss of [hand] computational proficiency. ... This research found that the C&M course allowed the students to spend less time on computations and better direct themselves to conceptual understanding. Accordingly there was an increase in the students' conceptual achievement without a serious decrease in computational achievement. ... Furthermore, the C&M group's disposition toward mathematics and the computer was far more positive than that of the standard group. ... The C&M
group seemed to more clearly understand the nature of the derivative and the integral than did the standard group. ...A positive side effect of the [computer] lab was the rapport that was established among the students. When students gathered around the computer, worked together, and shared and developed ideas, a great deal of mathematics was learned. ...[Computer] capabilities helped students discover and test mathematical results in much the same way that a physics or chemistry student uses the laboratory to discover and test scientific laws. Those capabilities provided the opportunities for the students to consider more open-ended questions and to encounter more realistic problems than often found in traditional calculus texts."

My opinion is that Krantz is infuriated by the fact that the student-centered, computer-based course Calculus&Mathematica is successful in spite of violating nearly all of the teacher-centered rules Krantz gives in his book for teaching mathematics and for using computers in the mathematics classroom. Knowing very little about the C&M course, Krantz is free to dig into his gross ignorance and his monumental biases instead of the facts. I have found that the most vigorous critics of C&M are those with the least knowledge of it. Krantz is no exception.

There is another issue vastly more important than my gripe with Krantz and his attacks: In his editorial, "Math for Sale", Krantz gives the strong message that research mathematicians who want to make new contributions to mathematics education are defectors because they have violated the noble cause of pure, rigid mathematics as it was presented years ago. On the contrary, research mathematicians have the potential to reinvigorate undergraduate mathematics by trying to make classroom mathematics more like the mathematics that research mathematicians actually do. Professional textbook authors will never be able to carry this off as they write on what Tom Tucker calls "automatic pilot".

Invite research mathematicians to join Davis, Porta, me, and other research mathematicians such as Douglas, Gleason, Lax, Manfredi, McCallum, Moore, Mumford, Osgood, Strang, Stryan, and Wattenberg in our efforts to promote mathematical excitement and understanding at the undergraduate level. The effort is immensely intellectually rewarding as well as great fun. And in so doing we can help to renew an infrastructure that will support research mathematics and mathematics education into the next century while Krantz and other defenders of the past sputter and wonder what happened.

J. J. Uhl
University of Illinois at Urbana-Champaign
(Received November 2, 1995)

On Electronic Journals
Mark Steinberger (January 1996 Notices) gives a good description of the services provided by the electronic New York Journal of Mathematics and by electronic mathematical journals in general. However, within a few years, most traditional paper journals will probably provide essentially the same electronic services as the new purely electronic journals. The difference will lie in the existence of the additional published paper version (obviously) and the greater cost of the traditional journals. The question is whether both types of mathematical journals will coexist for any length of time and whether a distinction will develop in the type of articles published and in standards.

H. Schneider
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(Received December 1995)

The Euler Institute in St. Petersburg
Information published in Science (vol. 23, June 1995, p. 1695) and received recently from friends in Russia indicates that the Euler International Mathematical Institute (EIMI) in St. Petersburg—which for many years existed as a separate unit similar to such institutes as the Banach Center in Warsaw; Oberwolfach in Germany; and DIMACS, IMA, and MSRI in the U.S.—may soon be subsumed into a department of the St. Petersburg Branch of the Steklov Mathematical Institute (POMI), Russian Academy of Sciences.

To the best of our knowledge, the decision to fold EIMI into POMI resulted from a conflict between the director of EIMI, Ludwig Faddeev (who is also deputy director of the Steklov Mathematical Institute in charge of the St. Petersburg Branch), and his deputy in EIMI, Sergei Khrushchev. Faddeev claims that folding EIMI into POMI is in the best interests of St. Petersburg mathematicians, while Khrushchev, who is losing his job at EIMI, says that placing it under the control of POMI will destroy EIMI as a center of international cooperation in mathematical research.

While the final decision on the fate of EIMI rests in the hands of our Russian colleagues, we mathematicians in the West also have an interest in preserving EIMI and so have the right to at least make a suggestion and to add some thoughts to the discussion. We would like to see EIMI continue as a separate unit, with its own budget, run by an executive director—a capable scientist and administrator—who, however, serves at the pleasure of a Board of Trustees which is independent of all other institutions, in the western style.

A number of western organizations (the Soros Foundation, AMS, the European Mathematical Union, etc.) are providing, in different forms, financial support to the Russian mathematical community. It is thus reasonable to have, say, one trustee from the United States and one from Europe on the Board. Besides being instrumental in fundraising for EIMI, the western trustees will bring to the Board needed expertise and independence.

Abram M. Kagan
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College Park
Lawrence A. Shepp
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(Received January 4, 1996)
How We Got Where We Are:  
An International Overview of Mathematics in National Contexts (1875-1900)

Karen Hunger Parshall

In the last thirty years or so the mathematical community internationally has observed a remarkable number of centennials. To name just a few, the Moscow Mathematical Society entered a new century in 1964, with the London Mathematical Society (LMS) following one year later; the Mathematische Annalen turned one hundred in 1968 four years before the Sociète Mathématique de France (SMF); the American Journal of Mathematics and the Circolo Matematico di Palermo (CMP) reached their century marks in 1978 and 1984, respectively; and the American Mathematical Society (AMS) celebrated its centenary in 1988 just two years before the Deutsche Mathematiker-Ver einigung (DMV).\(^1\)

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A version of this paper was delivered at the International Congress of Mathematicians in Zürich in 1994. An abbreviated text of that talk has just appeared in the Congress Proceedings published by Birkhäuser Verlag. I thank Birkhäuser Verlag for permission to publish the version presented here.

\(^1\)For publications honoring the centennials of the LMS, AMS, and DMV, see [6], [8], and [11], respectively. Hélène Gispert detailed the history of the SMF from 1872 to 1914 in her book [12], while Aldo Brigaglia and Guido Masotto chronicled the early history of the CMP in [5].

At the very least, these milestones suggest that the mathematical endeavor developed in important ways in diverse national settings during the closing quarter of the nineteenth century, but ... how? How did we get where we are? How did we become an international mathematical community, working together across political boundaries on common problems using shared techniques?

Prior to the nineteenth century, scientists (as opposed to the modern notion of “specialists”), formed communities centered around institutions like the Royal Society of London or the Académie des Sciences in Paris. These institutions, together with the courts of various monarchs and the salons of wealthy patrons, encouraged research, sponsored general journals like the Philosophical Transactions, and supported scientific communications. The universities, on the other hand, taught an essentially medieval “liberal arts” curriculum within the context of faculties of philosophy, law, and medicine. Euclid’s mathematics formed a key part of this curriculum, with the calculus added on at some universities in the eighteenth century, but the emphasis was on imparting a body of knowledge, not on imparting a body of knowledge in order to further knowledge, not on imparting the “latest” knowledge in the field, and not on actively training others to make original research contributions. These latter ideals, so character-
The importance of pure research over the utilitarian concerns perceived as dominant within the post-Revolutionary educational system in France. This emphasis on research accompanied and complemented a strong insistence on academic freedom which developed into the ideals of Lehr- und Lernfreiheit, that is, the freedom to teach and to learn without political or religious interference. Such educational reforms aimed not only to support the faculty’s search for new knowledge but also to train independent-minded, creative, and original thinkers within an atmosphere of disinterested, scholarly pursuit.

Although the full philosophical range of von Humboldt’s educational vision was never realized, the latter, more immediate aims became characteristic of the Prussian system. Beginning with philosophy and soon extending to the natural sciences, mathematics, and other developing disciplines, teaching and research defined the university professor’s mission. As Gert Schubring has argued, “[t]he transition from laying the main emphasis on teaching, which compelled the teachers to seek additional part-time teaching posts, to a dual activity in which teaching comprised only the lesser part of the remunerated activity marks the decisive step towards professionalization” [23, p. 123]. In the case of mathematics, moreover, this research ethic ultimately brought with it increasing specialization in the field, as mathematicians and mathematicians-to-be tended to focus their studies in an effort to make their own personal contributions. At the same time, the emphasis on disinterested—as opposed to more applications-oriented—research resulted in the evolution of a fundamentally purist approach to the discipline.4 Perhaps nowhere were these interrelated aspects of the development of mathematics in Germany more in evidence early on than at the University of Berlin.

Under the influence of Dirichlet beginning in the 1830s, the University rather swiftly established itself as the dominant force in mathematics in the German-speaking world.5 This domi-

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2 As Gert Schubring has pointed out [24], there was, in fact, no one German model. Observers from other countries actually focused on the Prussian model, as defined not only by the policies of the Prussian Ministry of Education but also by the specific programs in place at universities like Berlin and, after 1866 when it became part of Prussia, Göttingen. After the German unification, this model increasingly influenced the very different educational environment which had developed in the predominantly Catholic southern German states.

3 This panoply of issues has also been thoroughly examined. See, for example, the references provided in [18, pp. 24–26] and [23]. Wilhelm von Humboldt was both an influential statesman within the Prussian government and a philologist, aestheticist, and philosopher.

4 The processes underlying these developments as well as the interrelations between pure and applied mathematics are, however, much more complicated than these statements might suggest. See, for example, [23] and [24].

5 Just as American would-be mathematicians traveled abroad in the near absence of high-level training at the end of the nineteenth century, Dirichlet had journeyed to Paris in the 1820s for his mathematical education. From 1800 to the 1830s at least, France was Europe’s acknowledged leader in mathematical research. For more on the unparalleled strength of the French mathematical community in the opening decades of the nineteenth century, see [14]. France, however, lost its place to Germany after midcentury. See below.
In the context of German mathematical developments in the nineteenth century opened with a mention of educational reform. Changes in higher education and in its overall objectives naturally spurred changes at the level of the individual disciplines. Educational reform also tended to affect mathematics all the more directly, since one of the key features distinguishing the mathematical endeavor of the nineteenth century from that of the preceding hundred-year period was its venue, namely, the university as opposed to an academy of sciences, a royal court, or elsewhere. Its effects were not always positive relative to the development of research-level mathematics in a given national setting. For example, as a comparison of the situations in Italy and France with those in Spain and England underscores.

Prior to the diplomatic recognition in 1861 of a unified Italy, several of the Italian states had supported schools with mathematicians whose research attracted the attention and earned the respect of those whom they viewed as standard-bearers in the field in France, Germany, and Great Britain. In the 1850s, for example, Enrico Betti pursued researches in Pisa on questions in both Galois theory and the theory of substitutions which favorably impressed Charles Hermite, while Francesco Briot and Brioschi did work in Pavia on the theory of determinants and, more generally, on the theory of forms which met with approval from James Joseph Sylvester. These two
cases suggest, and a look at the publications in Barnaba Tortolini’s *Annali* confirms, that the 1850s had already witnessed a certain concentration in Italy on algebraic research at a high level [4, pp. 272]. A sense of the importance and desirability of research was only strengthened further in the mathematical circles surrounding Betti, Brioschi, and Felice Casorati after these three mathematicians returned from their 1858 pilgrimage to the mathematical centers of Göttingen, Berlin, and Paris.

Following Italy’s political unification, a number of mathematicians, but most notably Brioschi, held posts within the new government which allowed them to influence developments in politics generally and in education specifically. As the general secretary of the Ministry of Public Instruction from 1861 to 1862 and as a member of that Ministry’s Executive Council for some thirty years, Brioschi exercised his influence in the decision-making process regarding educational reform at all levels. In particular, beginning in 1863, he guided Milan’s newly founded Istituto Tecnico Superiore in its educational mission of training engineers and brought to its faculty not only Casorati and himself but also his former student Luigi Cremona from 1867 to 1873. Brioschi fostered an atmosphere conducive to research within this academic setting—as evidenced by Casorati’s work in Riemannian function theory as well as by Cremona’s continuing work in algebraic geometry—at the same time that the school itself provided new job opportunities for those who could meet the challenges of both teaching and research [4, pp. 275–276].

Similarly, at Pisa’s Scuola Normale Superiore, an institution founded in 1808 by Napoleon on the model of Paris’s École Normale Supérieure, Betti animated an active circle of researchers during his almost thirty-year-long tenure as the school’s director through his promotion especially of Riemann’s ideas in complex function theory and in the geometry of *n*-dimensional space. The group of mathematicians influenced by Betti at Pisa included, among others, his student and later colleague Ulisse Dini as well as Vito Volterra, Salvatore Pincherle, and Federigo Enriques [4, pp. 279–280]. Although changes such as these were taking place at certain schools under the sway of specific individuals, it was not until 1875 that the minister of education, Ruggiero Bonghi, officially introduced reforms aimed explicitly at bringing Italy’s institutions of higher education closer to the German model with its emphasis on teaching, research, and graduate training. His successor, Michele Coppino, rolled back these reforms to a large extent, but the ideals they reflected were—thanks to the efforts of Brioschi, Betti, and others—already fairly firmly entrenched at the faculty level throughout much of Italy by the closing quarter of the nineteenth century.

These developments in Italy did not go unnoticed elsewhere in Europe. In a France awakened from complacency by its loss of the Franco-Prussian War in 1870-1871, Gaston Darboux had already had cause to remark that “we need to mend our [system of] higher education. The Germans get the better of us there as elsewhere. I think that if that continues, the Italians will surpass us before too long” [12, p. 19]. In fact, spurred largely by the military defeat and its implication that the so-called *grandes écoles* were perhaps not grand enough to prepare the French adequately for times of crisis, leaders of the newly formed Third Republic sought to strengthen their political position, at least in part, by fostering an intellectual elite associated not with the *grandes écoles* as had been the case with previous regimes but with alternate institutions of higher education. In order to realize this objective, these other institutions, principally the *facultés* in each of France’s administrative regions, needed a new focus, which the French politicians and educational reformers found in the German model [25, pp. 302–303].

In a series of major reforms which took place between 1876 and 1900, the French, first, instituted a scholarship program in order to encourage a greater number of strong students to enroll in the *facultés*; second, established new chairs in the various scientific disciplines, including mathematics, as well as the salaried position of *maître de conférence* for both the support of more junior scholars and the enhancement of the overall graduate training program; and third, weakened the traditional ties between the *facultés* and the secondary system of education, thereby allowing for and fostering a commitment to teaching and research. The reformers believed that by consciously adapting various aspects of the German model to the French setting, “the French science faculties could out-perform the German institutions” [25, p. 303]. Indeed, the creation of new jobs (particularly in the provinces), the loosening of the old

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7 Tortolini founded the *Annali di Scienze Matematich e Fisiche* in 1850. In 1858 the journal changed its name to the *Annali di Matematica Pura ed Applicata* in emulation of Crelle’s German journal and Liouville’s French publication of the same name.

8 All translations of quotations originally in languages other than English presented here are my own.
disciplinary boundaries through the creation of chairs in various subdisciplines (as exemplified by Camille Jordan’s chair, not in mathematics but in higher algebra per se), and the adoption of research productivity as a criterion for determining salary, all contributed to the rise of a more specialized, research-oriented mathematical profession in France on a par by 1900 with that in place in Germany [12, pp. 59–63]. As Hélène Gispert has characterized it in her study of the Société Mathématique de France, France, which had entered the Dark Ages relative to mathematics during the decades from 1830 to 1870, experienced an emergent period between 1870 and 1900 that resulted in a new golden age after the turn of the twentieth century [12, p. 113]. That new golden age owed, in large measure, to the stimulus provided by educational reform.

Still, such reform did not necessarily have a positive impact relative to the development of mathematics at the research level. In 1857 Spain adopted a centralized educational system modeled on the one put in place in France under Napoleon around the turn of the nineteenth century. Under Madrid’s firm control, further change came only slowly. In mathematics, that control translated into the dominance of the curriculum of the projective geometry which Karl von Staudt had developed around midcentury and which Madrid’s Eduardo Torroja y Cabrallé embraced beginning in the 1870s. Although Torroja did advocate doing mathematics in his courses at Madrid, he clung doggedly to an area which, over the closing decades of the nineteenth century, grew increasingly distant from, for instance, the more purist Riemannian frontiers of geometrical research [13, p. 1508]. In so doing, Torroja and his adherents in Madrid obstructed the efforts of others in Spain, like García de Galdeano [15, pp. 112–114], to encourage the sort of mathematics being done elsewhere in Europe and particularly in Germany, France, and Italy [1, pp. 162–163].

In England, on the other hand, educational reforms in 1858, 1871, and 1877 brought an increased number of professorships, the advent of fellowships based purely on merit, and the end of the religious tests for faculty members and students. They also resulted in the strengthening of the university structure from the resources of the associated colleges, with an eye specifically toward improving training in the sciences. Despite such changes, the fundamental goal of the English system remained the liberal education of gentleman- (and, beginning in the 1870s, lady-) scholars, and the pedagogical emphasis still lay largely on the passing of set examinations. Throughout the nineteenth century, the English educational system continued to focus primarily on the diffusion and not the advancement of knowledge, and, in mathematics as in the other sciences, this tended to militate against the definition of a mathematical profession in terms of teaching and research.

As the examples of Italy, France, Spain, and England illustrate, widespread educational reforms in the last quarter of the nineteenth century affected the development of mathematics in countries throughout Europe (and the United States could be cited here as an example as well). The creation of new academic chairs and institutions, the addition of new grades of instructors, the direct emulation of the German ideals linking teaching, research, and the production of future researchers—these aspects of reform complemented one another in those countries where mathematics at the research level came to define the professional standard. The absence of one or more of them, however, tended to thwart that sort of development.

### The Production of Future Researchers

In turn-of-the-century France, Émile Picard summarized well the key role educational reforms had played in the professionalization of high-level mathematics. “Beyond their mission of making the sciences known and understood,” he wrote, “the institutions of higher education ... have another [mission], just as noble as all the others, that of advancing science and of continually initiating new generations of researchers to the methods of invention and of discovery” [12, p. 60]. As he clearly stressed, a sense of the importance of the training of future researchers represented one crucial byproduct of these Ger-
American Eliakim Hastings Moore and the two Germans, Oskar Bolza and Heinrich Maschke, implemented a training program in mathematics at Chicago which rivaled that of many of their German competitors. Thus, educators and mathematicians in other countries who looked toward Germany and France for their inspiration and guidance in the final quarter of the nineteenth century increasingly conceived of this “noble mission” as an integral part of their endeavor. The United States and Russia provide just two of a number of examples of this sort of influence.

The years between 1875 and 1900 represented a period of growth and financial prosperity in the United States which had important repercussions in higher education. As great fortunes were made on the railroads, the telegraphs, and industrial expansion in general, individuals like Johns Hopkins and John D. Rockefeller endowed universities through their private philanthropy. The presidents of these new schools, well aware of the educational scenes abroad and especially in Germany, France, and Great Britain, crafted their new institutional philosophies informed by the examples of those foreign systems. In particular, many of them adopted the production of research and of future researchers as explicit missions for their faculties and schools [18, pp. 261–294].

At the University of Chicago, for example, a university financed by Rockefeller and opened in 1892, a strong emphasis was placed from the very beginning on securing a talented research faculty. In the words of the university’s first president, William Rainey Harper, this faculty would seek “not to stock the student’s mind with knowledge of what has already been accomplished in a given field, but rather to train him that he himself may be able to push out along new lines of investigation” [18, p. 278]. In mathematics, Harper succeeded in bringing together three men who embodied these same ideals.

The American Eliakim Hastings Moore and the two Germans, Oskar Bolza and Heinrich Maschke, implemented a training program in mathematics at Chicago which rivaled that of many of their German competitors [18, p. 367]. This comes as no surprise in light of the facts that Bolza and Maschke had learned their trade from Felix Klein and that Moore had spent a year abroad studying mathematics in Göttingen and Berlin. In addition to the regular lecture courses they offered in the established areas of late nineteenth-century mathematics—Invariant theory, the theory of substitutions, elliptic function theory, among others—the Chicago mathematicians also incorporated the seminar into their overall pedagogical approach. As especially Bolza and Maschke knew from firsthand experience, the seminar served as a fertile seedbed for the germination of new mathematical ideas along more specialized lines. The Chicagoans further augmented this learning device with what they called the “Mathematical Club”, a series of biweekly meetings throughout the academic year in which speakers, both faculty and students, presented expositions of the recently published results of other mathematicians or of their own evolving ideas. The atmosphere fostered by this faculty and through these means produced in short order a number of first-rate mathematicians, notably Leonard E. Dickson, Oswald Veblen, Robert L. Moore, and George D. Birkhoff (see [18, pp. 372–393] for a brief overview of some of the research these mathematicians did within this mathematical environment).

Although the broader cultural and political circumstances in Moscow could perhaps not have been more different than those in the Chicago of the late nineteenth century, Moscow University, like the University of Chicago, supported a mathematics program under an activist influenced by contemporaneous mathematical developments in both Germany and France. Nikolai Vasilevich Bugaev journeyed to Berlin in 1863, where he studied under Kummer and Weierstrass, and then continued on to Paris to hear the lectures of Liouville, Chasles, Serret, and others. After some two and a half years abroad, Bugaev returned to Moscow, where he took a professorship in 1867, the year after earning his doctorate there for work on numerical identities involving the exponential function e^x. From 1867 until his death in 1903, he continued his work in number theory, striving in particular to develop general methods in a subject given to clever solutions of often limited applicability [16, pp. 198–200].

Bugaev, however, did more at Moscow than his own mathematical research. He influenced a corps of colleagues and students through his broader conception of mathematics. For Bugaev, mathematics involved communication, which he fostered through his vigorous support of the Moscow Mathematical Society and, after 1866, of its journal, Matematicheskii Sbornik. It also hinged on its university setting, which he worked to strengthen and enhance at Moscow through his efforts first as secretary and then as dean of its faculty of physics and mathematics. Most importantly, it depended on training students
capable of contributing to its further development. To the latter end, Bugaev taught a wide range of courses—in, for example, number theory, the theory of elliptic functions, the calculus of variations, and the theory of analytic functions—which aimed to introduce his students to these subjects at the research level. He also fostered and contributed to a philosophical atmosphere in which mathematics was interpreted essentially as a theory of functions and where the theory of discontinuous functions played a key role. This conception not only proved conducive to the acceptance of Georg Cantor’s novel set-theoretic ideas but also served as the foundation of the Moscow school of function theory, spearheaded in the early decades of the twentieth century by Bugaev’s student, D. F. Egorov [7], and perpetuated by Egorov’s disciple, N. N. Luzin. This school, which also included such influential twentieth-century mathematicians as P. S. Aleksandrov, A. Ya. Khinchin, and D. E. Menshov, made seminal contributions to the advancement of measure theory and the general theory of functions of a real variable [19].

The cases of both Moscow University and the University of Chicago drive home the obvious point that the success of the mathematical endeavor in a given national context depends crucially on the process of training talented students in areas rich in interesting open questions. At its core, mathematics undeniably involves proving theorems, and these students not only learned how to carry out that creative process successfully but also embraced the belief that they should pass on their insights to a subsequent generation. As they had been trained, so should they train—this philosophy came to characterize the mathematical mission internationally in the latter quarter of the nineteenth century. Moreover, in concert with the other factors examined here, it encouraged the formation of self-sustaining mathematical communities, that is, interacting groups of people linked by common interests.

The Establishment of Lines of Communication

The formation of a community, however, also turns upon the ability of its members to communicate effectively. The time period 1875-1900—one in which telegraphy, railroad systems, steamships, and the printed word linked nations internally and with each other—witnessed the widespread creation of at least two sorts of communications vehicles dependent on this new level of mobility: the mathematical society and the specialized mathematical journal.

Although the Moscow Mathematical Society predated it, the London Mathematical Society, which first met under that name in January of 1865, served as a model for mathematical organizers throughout Europe and in the United States. Not only did it bring together mathematicians in and around London and eventually throughout England for the presentation and discussion of mathematical results, but it also published from the outset the Proceedings of the LMS for the further dissemination of original research [20; and 6, pp. 577–581].

Looking across the Channel, the Society’s first foreign member, Michel Chasles, called for his own countrymen to follow the British example. In his 1870 report on the progress of mathematics in France, Chasles strongly advocated the formation of a society specifically for mathematicians, in contradiction to one in which mathematicians represented only one of the scientific constituencies. Such an organization would serve to focus mathematicians on their discipline per se, its technical development as well as its broader structural needs. He also underscored the importance of liberal membership policies which would permit all mathematicians to join and participate. In his view, the elitist and exclusionary membership policies of institutions like the Académie des Sciences did little to promote the overall French mathematical endeavor. Moreover, the extant journals—the Comptes Rendus of the Académie, the Annales Scientifiques of the École Normale Supérieure, and even Liouville’s Journal des Mathématiques Pures et Appliquées—all limited access to publication for reasons independent of mathematical quality. A French mathematical society could provide, in a sense, a free and independent outlet for the publication of its members’ work [12, pp. 14–17]. The institutional void which Chasles sensed in French math-
The time period 1875–1900... witnessed the...creation of two sorts of communication: the mathematical society and the specialized mathematical journal.

The time period 1875–1900... witnessed the...creation of two sorts of communication: the mathematical society and the specialized mathematical journal.

10Here, we could clearly also cite many examples of journals founded during this time period which were independent of the mathematical societies formed: the Mathematische Annalen founded by Alfred Clebsch in Germany in 1868, Gaston Darboux's Bulletin des Sciences Mathématiques started in 1870, and the American Journal of Mathematics begun by James Joseph Sylvester in the United States in 1878, to name just three of the earlier periodicals.

11For a quantitative sense of the depth of the American mathematical research community, see, for example, [9] and [10]. [12] provides an analysis of the broader French mathematical constituency, and [17] gives some indication of the situation in Spain.
creasingly specialized terms. Universities split their chairs of mathematics and physics or of mathematics and astronomy and even created chairs in specific mathematical areas such as geometry and higher algebra. This specialization resulted both in the sharpening definition of subdisciplines within mathematics and in an increase in the number of positions available in the field. This latter aspect of the evolution of a profession was also influenced by the establishment of new grades of instructors under the professor (Dozenten, maîtres de conférences, assistant and associate professors, etc.). As individuals sought out this graduate training, as they assumed these new positions, as they adopted these values of teaching and research, they banded together in national or broadly based mathematical societies and shared their new research through specialized journals targeted at an appreciative and understanding audience. The individual nationalization of mathematics was thus well under way by the end of the nineteenth century; and since the model emulated was largely the same in the various national contexts, this implies that the internationalization of the field was likewise in process. Perhaps no one piece of evidence supports this latter conclusion better than the fact that Zürich hosted the first International Congress of Mathematicians in 1897.

An international perspective on the development of mathematics over the period from roughly 1875 to 1900 thus uncovers a number of factors common to particular national settings which strictly nationally oriented studies tend perhaps to obscure. It also provides at least a sense of the complexity of the process of the internationalization of mathematics. Mathematicians today tend to take the international nature of the field for granted, but it is really an aspect of the discipline that has come about primarily in the twentieth century as a result of dynamic changes, especially during the closing quarter of the nineteenth century.

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Crossing the Interface between Chemistry and Mathematics

George A. Hagedorn

Numerous researchers have crossed the boundary between mathematics and physics, and the resulting interaction has benefited both disciplines. In contrast, there has been relatively little interaction between mathematicians and chemists.

There are many reasons for this. Historically, the typical chemist has not been interested in problems that have led to tractable mathematical questions. Chemists have traditionally spent the bulk of their time in a laboratory, and the discipline of theoretical chemistry has evolved only recently.

During the last few decades, the situation in chemistry has been changing, largely because of the development of powerful computers. Large-scale numerical computations have been extremely useful in chemistry, and there are now significant numbers of theoretical and computational chemists.

These scientists are working on problems that are very different from those of traditional laboratory chemistry. Many of their questions and techniques are mathematical in nature, and research opportunities now exist that span the boundaries between chemistry and mathematics. Several such opportunities are described in a report, *Mathematical Challenges from Theoretical/Computational Chemistry*, published by the National Academy Press, which is available on the Internet from the World Wide Web site http://www.nas.edu/. This report contains descriptions of many diverse areas in theoretical/computational chemistry where significant mathematical problems have arisen.

Several audiences are addressed in the report, such as individual researchers, funding agencies, professional societies, editors, and college departments of chemistry and mathematics. The report contains descriptions of cultural and institutional barriers to interdisciplinary research, as well as several ideas to improve communication and to foster collaboration between chemists and mathematicians. One suggestion is to encourage students in the disciplines to take courses in the other discipline. Another is for editors to solicit review articles that will help researchers bridge the gap between the subjects. Yet another suggestion is to have more interdisciplinary conferences or simply to have speakers from one discipline occasionally present seminars in the other department.
The report contains specific examples of successful collaborations between mathematicians and chemists. It also contains descriptions of a large number of diverse areas in chemistry that would benefit from input from mathematicians. A small subset of these areas includes: strategies for the design of new drugs and agricultural chemicals, development of molecular dynamics algorithms, optimization problems, folding of proteins, transport across biological membranes, coiling and uncoiling of DNA, the structure of crystals and quasicrystals, the relationship between quantum mechanics and simpler approximate models, and a wide range of numerical analysis problems. It is conceivable that essentially any area of mathematics could be applied somewhere in theoretical/computational chemistry. In fact, page 44 of the report has a chart in which the authors indicate their guesses as to which areas of mathematics are most likely to make contributions in various areas in chemistry.

A mathematician who wishes to begin working in the area would be best advised to attend appropriate conferences and to consult researchers who are active in the particular subfield of interest. Although the report might serve as a starting point for a newcomer to the area, one should be forewarned that parts of it are superficial, and it does not review all aspects of the subject.

For example, the report does not mention one very successful interaction between mathematicians and chemists that concerns the study of quantum mechanical resonances. Physically, resonances are states with long but finite lifetimes. They play very important roles in chemical reactions.

In the early 1970s, mathematicians working in Schrödinger operators developed a technique that involved embedding certain quantum Hamiltonian operators in analytic families of unbounded operators. Their original motivations involved spectral and scattering theory, and they eventually settled on the name of “dilation analyticity” for the whole process. Among other things, dilation analyticity provided an alternative mathematical definition for resonances. After a few years, some chemists used dilation analytic ideas to develop numerical algorithms for computing resonances, and they gave the process the new name “complex coordinate rotation”. These algorithms were very successful, and the chemists tried to use them in certain circumstances where the original dilation analytic theory did not apply. One of these circumstances involved quantum systems in constant electric fields. Prodded by the chemists, mathematicians studied this situation, which led to interesting new mathematical results. They concluded that one could indeed use dilation analytic ideas to study resonances in such problems, although the analysis was very subtle. One small surprise that emerged was the realization that the operator

\[-\frac{\partial^2}{\partial x^2} + \lambda x,\]

defined on a suitable domain in $L^2(\mathbb{R})$, had no spectrum if $\lambda \in \mathbb{C}$ was not real. (For real $\lambda$, the operator is self-adjoint; when $\lambda = 0$, the spectrum is $[0, \infty]$; when $\lambda$ is real but nonzero, the spectrum is the whole real line.)

Another circumstance where the chemists could not use the original dilation analytic theory involved fixing the positions of the nuclei in a molecule and trying to apply dilation analyticity ideas to the Hamiltonian for the electrons. No one was able to make this work directly, but mathematicians developed a replacement technique for this situation that is usually called “exterior complex scaling”. This technique is much more general than the original dilation analyticity, and the chemists have used it as the basis of successful numerical algorithms. Readers who are interested in this topic should consult Chapter 8 of [3] and [2, 4, 5, 6, 8] for chemistry, mathematics, and physics review articles.

This interchange, which benefited both mathematics and chemistry, was driven by the efforts of a few individuals. Personal contacts played an important role, as did conferences that were attended by both mathematicians and chemists. However, one can see the presence of several barriers to interdisciplinary research. The mathematicians published their articles in mathematics journals; the chemists published theirs in chemistry journals. The two groups have continued to use separate nomenclature. The mathematical articles strove to treat very general situations; the chemistry articles concentrated on specific situations.

A related story illustrates a cultural difference between chemistry and mathematics. The main point of this example is that while mathematicians hold proofs in the highest esteem, chemists are often more impressed by a numerical computation than a proof. Suppose one considers the ground state of an atom or ion with nuclear charge $Z$ and two electrons (for $Z = 1$ this is $H^+$, for $Z = 2$ it is He, for $Z = 3$ it is Li+, etc.). The energy of this ground state is given by a convergent power series in $\lambda = 1/Z$ if $|\lambda|$ is less than the radius of convergence $\lambda^*$. At some critical value $\lambda^{*\text{crit}}$, the ground state energy coincides with the bottom of the continuous spectrum of the system. In 1966 a chemist, Frank Stillinger, made a conjecture [9] that $\lambda^{*\text{crit}} < \lambda^*$, based on a few assumptions and the behavior of the first 21 coefficients in the power series. This led him to make the physically interesting conjecture
that for $\lambda \in (\lambda^{\text{crit}}, \lambda^*)$, the system might have a bound state embedded in its continuous spectrum. In 1977 another chemist, William Reinhardt, used a dilation analyticity argument to prove [7] that the precise behavior of an embedded bound state conjectured by Stillinger could not occur. Although this mathematical proof completely answered the physically interesting question, it did not terminate interest in the problem among chemists, partially because Reinhardt's proof did not provide specific information about the value of $\lambda^*$. The problem was laid to rest to the satisfaction of the chemists among chemists, partially by proof completely answered the physically in- ternal numerical computation by Jonathan Baker, David Freund, Robert Hill, and John Morgan [1] in 1990. They numerically computed the first 401 coefficients in the power series and used them to estimate the values of $\lambda^{\text{crit}}$ and $\lambda^*$. They concluded that $\lambda^{\text{crit}} = \lambda^* = 1.09766...$

There are several other cultural and institutional barriers that inhibit collaboration between chemists and mathematicians. A researcher in one field who publishes papers in the journals of another field risks being unappreciated in either field or denied tenure or a promotion as a result. Furthermore, there are few people who know both subjects well, and there are relatively few review articles that deal with subjects on the boundary between the two disciplines. If these barriers can be overcome, there are many challenging opportunities at the interface between these two disciplines.

Many chemical questions lead to extremely difficult mathematical problems. For example, suppose one wants to know some detail about the dynamics of a water molecule. The Schrödinger equation that describes this molecule can be written down immediately. Unfortunately, it is a partial differential equation in 40 independent variables (3 for each of 13 particles, and 1 for time). By using conservation of total momentum and total angular momentum, one can separate a few of the variables, but one still faces a PDE in high dimension with singular coefficients. A direct attack on the problem is essentially hopeless, but chemists generate useful information by using a variety of approximations and numerical techniques they have developed. There are plenty of mathematical opportunities here. Are the approximations valid? Are there useful rigorous error bounds? Are the numerical algorithms converging to the correct results? Can one develop better numerical techniques? Water, of course, is a simple molecule. One would like to be able to study much more complicated molecules, such as polymers or biological molecules. The study of chemical reactions is even more challenging, since the number of independent spatial variables is the sum of those for the individual reactant molecules.

Many chemical questions bear a similarity to this example. One can model the problem at a very basic level, but there is no hope of finding a solution at that fundamental level. The chemists frequently replace the basic model with some approximate model, and they usually resort to computer calculations before reaching any conclusions. Along the way, they leave plenty of opportunities for mathematicians.

Mathematicians who pursue these opportunities will be tackling difficult problems, but they face the prospect of rich rewards. The main messages in Mathematical Challenges from Theoretical/Computational Chemistry are that chemistry could provide a source of excellent problems in many areas of mathematics and that increased interaction would benefit both disciplines.

References


On November 16, 1995, the mathematics faculty at the University of Rochester got what was probably the biggest shock of their professional lives. An hour before the university administration was to unveil a major restructuring plan, they learned their Ph.D. program would disappear, the department faculty would be reduced by half, and adjuncts and faculty from other departments would be called in to teach lower-level mathematics courses.

The whole university faculty knew that the institution faced serious financial problems and that the restructuring would entail cuts in graduate programs. But no one in the Mathematics Department was prepared for such a severe blow. "It was a great surprise, it came as a shock to learn, one hour before it was announced, that this was happening," says Samuel Gitler. Ironically, just eight years before, Gitler had been hired expressly to build up the department.

The plight of the Mathematics Department at the University of Rochester has been discussed avidly since the announcement of the cuts. The university administration and trustees have received over one hundred letters from mathematicians and scientists urging them to reconsider their decision. In December the AMS sent a fact-finding committee to the Rochester campus, and the committee has produced a report.

The AMS Council has passed a resolution, initially drafted after copious discussions within the Committee on the Profession, strongly urging the university to reconsider its decision. AMS President Cathleen S. Morawetz has appointed a task force, chaired by President-elect Arthur Jaffe, to work further on the issue. Despite all the pressure, the university administration has held its ground and shows no sign of changing its decision.

Today's tight job market together with shrinkage in university budgets have led some in the mathematical community to suggest scaling back on doctoral programs. So why the outcry when a Ph.D. program goes under? First of all, Rochester's Mathematics Department is quite

1 The report is available on e-MATH, at the URL http://www.ams.org/committee/profession/rochester.html.
Jackson worked for a year and a half developing its engineering school. In the end they becoming an undergraduate institution or closing its engineering school. In the end they devised the Rochester Renaissance Plan, which aims to improve undergraduate education and uphold Rochester's reputation as a research university with strength in science and engineering.

The centerpiece of the plan is a strategy to raise student quality and increase tuition revenue. The university aims to raise student quality by reducing future admissions by 20 percent; this should work at least in the short term, because the top 80 percent of the current class have higher SAT scores than the remaining 20 percent. But how can reducing the student body raise tuition revenue? At present much of the tuition money collected is redirected in the form of scholarships to students who pay only partial or no tuition. The university is gambling that, by emphasizing undergraduate education, it will heighten its image as an "elite" school and improve its ability to attract high-quality students who can pay full tuition. If this part of the plan fails, the university could be in worse shape than before. Despite the risk, many faculty, tired of years of financial uncertainty, are relieved to have someone firmly take the reins. "Their plan entails some risks, but boy, having somebody with a plan who understands the problem is such a huge step," says Thomas LeBlanc, chair of the Computer Science Department. "I don't know how we could have continued on the path that we were on."

The plan also calls for cuts of various sorts. Overall, the faculty will be trimmed by 10 percent. The administration opted for selective rather than across-the-board cuts. Four graduate programs—chemical engineering, comparative literature, linguistics, and mathematics—will be eliminated. In at least one way, mathematics suffers the most of the four: There are interdepartmental Ph.D. programs in which faculty from the first three areas can continue to participate, but there is nothing comparable for mathematics. In four other departments—earth and environmental science, history, mechanical engineering, and philosophy—the graduate programs will shrink, with reductions in faculty ranging from 12 percent to 33 percent.

Mathematics also sustains the deepest cut in faculty size: the reduction from 21 to 10 is the largest in terms both of number and percentage. All but one person in the Mathematics Department have tenure, and the university has pledged not to fire any tenured faculty. Given the present age distribution of the department, it could take twenty years to achieve the reduction. The administration has said that would be fine with them. "On the other hand, this is a five-year plan they've sold to the board of trustees," notes Mathematics Department member Douglas C. Ravenel. "And surely after five years there's going to be some kind of reckoning with the board." So it is clear that the administration is
Resolution Passed by the Council of the American Mathematical Society, January 9, 1996

The Council of the American Mathematical Society is deeply concerned over the University of Rochester's announced intention to severely downgrade its strong mathematics program by eliminating Ph.D studies, shrinking the mathematics faculty "over time" by more than one half, and assigning the teaching of calculus to faculty in other departments and to non-tenured adjuncts.

This plan displays a lack of understanding of the nature of mathematics, its role as a core discipline among the sciences, and its place in a well-rounded education.

The entire Rochester academic community is ill-served by such a strategy. Calculus students will be taught by instructors much less likely to have either the wide-ranging overview of mathematics or the involvement with the subject necessary for truly effective teaching. Nor will these instructors be likely to stay abreast of current evolution in the pedagogy and content of calculus.

The hiring of low-paid adjuncts with no long-term commitment to or from the institution will undermine educational quality. It could lead to an egregious violation of principles of non-exploitation enunciated in the January 1994 resolution adopted by the Council in the name of the Society, on "Supportive Practices and Ethics in the Employment of Young Mathematicians." Advanced undergraduates in mathematics and graduate students in other scientific disciplines will be deprived of the support that a mathematics graduate program provides to their studies. Faculty in quantitative disciplines will miss opportunities to consult and collaborate with their colleagues in mathematics. In the absence of excellence in mathematics, the attractiveness of Rochester as a first-rate research center in physical science, engineering, and economics will diminish.

On intellectual, educational, and practical grounds, Rochester's intended treatment of mathematics is incompatible with its aspirations to national distinction as a research university emphasizing quality graduate education.

The Council strongly urges the University of Rochester's administration to reconsider its proposed course of action with regard to mathematics.

Many of the letters protesting the cuts in the Mathematics Department reinforce this point. One of the most powerful letters came from physicist Nobel Laureate Steven Weinberg."I would not advise any prospective undergraduate or graduate student who wishes to concentrate on the physical sciences to go to a university that did not have a graduate program in mathematics," Weinberg writes to Jackson. "It seems to me extremely unwise to eliminate your program in an area like mathematics that stands at the intellectual center of a large part of modern science."

Paul Slattery, chair of the Department of Physics and Astronomy at Rochester, says he "very strongly supports" the Renaissance Plan, even though he is not comfortable with the cuts in the Mathematics Department. He points out that there is a Ph.D. program in mathematics at every university where the physics or chemistry program is ranked in the top half of the recent National Research Council (NRC) ranking of graduate programs. "That gives you a feeling that we would be strange outliers in the community of universities that have a strong focus in the physical sciences," he says. He notes that the lack of a doctoral program in mathematics could hinder his ability to hire good people in physics, particularly in theoretical areas.

The Rochester administration realizes that the lack of a graduate program in mathematics will make Rochester an anomaly among research universities, but they do not seem worried. Jackson points out that, unlike in the laboratory sciences, graduate students are not imperative to doing research in mathematics. "The research tends to be fairly lonely work by a faculty member, maybe with colleagues who are at the same speed," he says. "Our sense was, you can do a lot of distinguished research without the Ph.D. program. But without one, will Rochester be able to attract good mathematical researchers? "My own belief is that the market is thick enough that we can, in fact, get and keep people who have substantial research agendas," Jackson says. He notes that the university can provide incentives other than a Ph.D. program, such as research time and support for postdocs, although there is nothing written about this in the Renaissance Plan.

Linkages to Other Departments

While the Mathematics Department has garnered considerable support outside Rochester, support on campus is less definite. Slattery sees the cuts in the Mathematics Department as a weakness in an otherwise strong plan, and he says he and others on campus are quietly discussing possibilities for "evolutionary changes" to address this weakness. He feels he must take

A Research University without a Math Ph.D. Program?

The Mathematics Department was just as aware as any other of the seriousness of Rochester's financial problems and of the inevitability of painful cuts. And the department generally does not disagree with the major outlines of the Rochester Renaissance Plan. But it does disagree vehemently with the idea that Rochester can continue to be a research university with emphasis in science and engineering when it no longer has a Ph.D. program in mathematics. "I really think that this administration has no sense of what higher education and research are," says Gitler. "They are going to make Rochester a trade school, not a university." Says mathematics graduate student Nora Franzova, "This university cannot be called a research university anymore if it doesn't offer basic research in the purest field of research there is—mathematics."

counting on people taking other positions or early retirement incentives.
this kind of discreet, nonconfrontational approach. "One of the reasons why there hasn't been a lot of public outcry [on the campus]," he explains, "is the feeling that we should support the president, because if this thing doesn't work in the aggregate, then we're really in trouble."

In addition, the administration has made it clear that the departments that support the plan will benefit. A letter from the administration to faculty explaining the plan put it this way: "We wish to make clear that in the new college environment, resources will flow more generously to those departments which succeed best in supporting the overall goals of the Renaissance Plan." Such statements could discourage supporters of the Mathematics Department from speaking out. But could it also be that the Mathematics Department has few supporters on campus? To hear the administration tell it, intellectual linkages with other departments were scarce. "As much as we tried to explore, we actually found very few present interactions that were taking place," says Jackson. "That is, it might be good in theory, but it wasn't taking place in reality."

The administration has said that one of its reasons for choosing to cut the Mathematics Department was that it had very few interactions with other departments. The question of how much interaction there has been is a matter of some dispute. The Mathematics Department has collected a number of examples of joint research between its faculty and faculty in other departments. The topics range from ultrasonic medical imaging to cryptography. In addition, students and faculty from other departments regularly attend graduate classes in the Mathematics Department.

By contrast, the picture painted by the administration is one of an isolated Mathematics Department. As part of the formulation of the Renaissance Plan, Aslin and Phelps conducted interviews with seventy-five faculty—three members from each of the twenty-seven departments on campus (in a couple of departments, fewer than three faculty were interviewed—one of these was the Mathematics Department). Aslin says they asked science and engineering faculty specifically about linkages to the Mathematics Department. "To be quite frank, we found very few," says Aslin. The issue seems to be that the interactions were ad-hoc—a single research project or a specific course rather than an institutionalized program with high visibility. The interactions "were faculty A with faculty B because they had taken the initiative to form some sort of intellectual link," he explains. "But they were not nearly as robust as the kinds of interactions we saw between other departments outside of mathematics." And, Aslin claims, this was not be-

cause other departments have no interest in mathematics. "It turns out that they have sought those linkages external to the University of Rochester."

Others reinforce this view and take it one step further. "There is a large mathematical intellectual community on campus, and it goes well beyond the Mathematics Department," says computer science chair LeBlanc. He says there are a number of faculty in the engineering school who could "double as applied mathematicians" and some people in his department and in the Physics Department who are interested in certain areas of mathematics. Centrality of the discipline was one of the things the administration looked at in deciding which graduate programs to cut. "One can make the abstract argument that mathematics is central," he says. "But if you go to twenty-seven departments and every one of them tells you, 'The math department is not central to our program,' then although the abstract argument of centrality of mathematics is a good argument intellectually, if the reality is different, it makes perfect sense to view that as the basis for a decision."

**Contention over Calculus Teaching**

Another element that entered into the administration's decision to center cuts in the Mathematics Department was their perception that in mathematics "undergraduate instruction is less than optimal." Aslin says his interviews with faculty revealed that some departments were dissatisfied with mathematics instruction, particularly in calculus. In addition, there were anecdotal reports from the Center for Academic Support, which provides tutoring and other services, that students were having trouble with mathematics. Although he admits that some of the students' difficulties stem from underpreparation, Aslin believes that the Mathematics Department has not stepped up to address the problems. "What you look for is initiative on the part of the department...to begin to address what are in some sense nationwide educational concerns that go beyond the problems that are local at our particular institution," he says. "And I think we have not seen [that] kind of interest on the part of the faculty here in our Mathematics Department."

For its part, the department contends it has heard few specific complaints about its teaching. A report prepared by the department presents data from student evaluations showing that students are just as satisfied, and in some cases more satisfied, with courses in their department as they are with courses in other departments. And mathematics has made some attempts to reach out to other departments on the issue of calculus teaching. For example, two
years after he was appointed chair, Gitler conducted meetings with all the science departments to talk about what their students needed from mathematics courses. Recalls Gitler, "We talked and talked...and then when I said, 'okay, now it's time for you to put it in writing,' nobody sent anything in writing.'

Three years ago, before Jackson came to Rochester, a task force on calculus was formed. The task force brought together representatives from different departments to discuss what they needed from calculus courses and what changes could be made. "My understanding is that the meetings were not successful," says Jackson. "I'm not going to blame anybody on this, but they were ships passing in the night. The math department's view of what the science departments should want, and the science departments' view of what they wanted—they weren't talking the same language."

The Mathematics Department does not disagree that little came out of the task force. According to Mathematics Department chair Joseph Neisendorfer, "The people in the biology and chemistry departments didn't think it was worth their while to participate; they were content with the situation as it was." At that time, the undergraduate degree in computer science was housed in the Mathematics Department (in 1994 it was moved to the Computer Science Department), so computer science did not express much interest in calculus. "The only complaints that I have ever heard came from mechanical engineering, and at one time from some people in physics," Neisendorfer says. And the complaints from physics have now disappeared: in cooperation with the physics faculty, Neisendorfer helped to structure a pair of courses in calculus and introductory physics that would run in close coordination. The arrangement seems to be working well. Some departments also complained that mathematical homework was not graded. The Mathematics Department does not have sufficient staff to grade all homework, but two mathematics faculty are now developing a computer program that will provide students with feedback on their homework.

The problems with mechanical engineering were not so easy to resolve. Five years ago, the Mechanical Engineering Department, dissatisfied with the instruction its students were getting in mathematics, began teaching second-year calculus courses of its own. Clearly this has led to some friction between the two departments. Some on the mathematics faculty believe that declining enrollments in mechanical engineering prompted that department to add more courses to keep their faculty busy. But mechanical engineering chair John C. Lambropoulos says his department began the courses because the preparation their students were getting in the Mathematics Department was "not adequate", and they wanted to introduce more engineering applications and material specific to later courses. There has also been talk of establishing an applied mathematics department on campus, although under the current budget constraints it seems unlikely this would happen anytime soon.

The criticism the Rochester Mathematics Department has taken about its undergraduate instruction seems to be pretty similar to that endured by many other mathematics departments. But far from proving that there was no problem with mathematics instruction at Rochester, some observers say, this simply shows that many mathematics departments have not been responsive to problems (or at least perceived problems) with the instruction they provide. Nevertheless, many believe the Rochester administration dealt with this the wrong way. Salah Baouendi of the University of California, San Diego, who chaired the AMS fact-finding committee that visited Rochester, puts it this way. "Even if there are problems between departments—and it is not unusual to have different points of view—it is certainly wrong for the administration to take a core discipline such as mathematics...and eliminate its graduate program," he declares. "There are other ways to solve these problems."

In fact, the central question many have been asking is: Will the measures taken by the administration improve undergraduate teaching of mathematics? Many think not. In just a few minutes' conversation, Franzova and her fellow mathematics graduate student Lisa Christman exhibited a great deal of dedication to and enthusiasm for teaching. The department will soon lose such students. Christman, a second-year student, is not sure she'll be back in the fall, and she reports that twelve to fifteen of the department's thirty-four students will be gone by the end of the academic year. Most of the first-year students are leaving. This means that already this fall the university will have to arrange new ways to staff its lower-level mathematics courses.

The administration's plan to hire adjuncts to cover lower-level teaching in the Mathematics Department has elicited wincings from the mathematics community. In a letter to the Rochester administration, Alan Schoenfeld of the University of California, Berkeley, wrote, "I'll be blunt in summary: such instruction is typically cheap, and you get what you pay for." A major commitment is needed to make appropriate use of such staff, he argues. In addition, the best faculty will leave, and those that remain will have second-class status because of the lack of a graduate program and because their teaching will be
farmed out to adjuncts. "[T]he changes you propose are almost certain to produce a significant lowering of the quality of instruction in mathematics courses—no matter how you staff these courses," he writes. "This is the direct opposite of what you intend."

Decision Process Criticized
Throughout the formulation of the Rochester Renaissance Plan, the administration held its cards close to its chest. While they could not very well call a faculty vote on which graduate programs to cut, some say the administration could have been more open. Neisendorfer says that two weeks before the announcement of the plan, he spoke with the dean of graduate studies, who said there would be some cuts, but nothing drastic. It appears that only Aslin, Jackson, and Phelps knew anything about the details of the plan.

There have been complaints about the criteria the administration used to decide which programs to cut. The "internal" information they used came primarily from the seventy-five interviews with faculty. For "external" information, they relied on the NRC rankings of graduate programs and, to a lesser extent, the rankings published yearly in U.S. News and World Report. The administration has been heavily criticized for using these rankings as the basis for such decisions. In fact, one of the people who wrote to the administration to protest the cuts in the Mathematics Department was Marvin L. Goldberger, dean of the Division of Natural Sciences at the University of San Diego and cochair of the NRC committee that produced the rankings.

Many universities obtain external information about their departments through outside visit teams. Asked about this suggestion, Aslin contends that it would have taken three to five years to conduct such evaluations of all twenty-seven departments at Rochester. Couldn't one bring in an outside team to evaluate just those departments that appeared questionable? "The problem is," says Jackson, "that if you ask a discipline to come in and evaluate a program that's already been identified as targeted, the response you're almost certainly going to get from the people in the discipline is a case as to why you shouldn't touch the program."

Morton Lowengrub is not convinced. A member of the AMS fact-finding committee, Lowengrub is dean of arts and sciences at Indiana University. "How do they know they couldn't trust the information" from an outside committee? he asks. As a university administrator who has had to deal with downsizing on his own campus, Lowengrub has used outside evaluations a great deal. "If you set the parameters correctly and you get respectable people, you get very good in-
formation that puts into perspective the department's role in the discipline," he argues. In fact, Lowengrub expresses great dismay at the entire process the university used to arrive at its decision. "They did not carry on a dialogue with the Mathematics Department; they never gave them a chance to respond," he says. "This is one of the saddest parts of the whole process."

Politics Comes to the Fore
As protests against the cuts in the Mathematics Department have mounted, the Rochester administration has endlessly explained and justified its decision. But some, far from being reassured that the basis for the decision was reasonable, have concluded that politics was at work. "My impression, the more and more I look at it, is that they felt mathematics as a group would not be able to respond to this," says Gitler. "More and more I am convinced that it was a political decision and definitely not an academic solution." Many in the Mathematics Department share his view.

According to Ronald Douglas the fact that the cuts in the graduate programs were spread around—some in the social sciences, some in the humanities, some in the sciences, and some in engineering—points to a political decision. Furthermore, "some of the rhetoric was clearly such that they knew what they wanted to prove and then went back and got the information they needed to support it." After visiting the campus as a member of the fact-finding committee and reading the various documents associated with the plan, Douglas has come up with a theory of what happened that is roughly the following.

The administration had to cut a department in the sciences, so the question was which one. It made no sense to cut biology and chemistry, because the faculty numbers are critical to staff the laboratory-based courses taken by the many pre-med students. The Physics and Astronomy Department was already facing a cut in its faculty related to the shutdown of one of its facilities funded by the National Science Foundation. Moreover, substantial outside support in biology, chemistry, and physics depended on maintaining faculty size in these disciplines. (The Mathematics Department has done very well in attracting outside support: nearly two thirds of its members have grants. However, the total dollar amount is much smaller than in other disciplines.) Earth and environmental science is such a small department that even wiping it out would not save enough money. This meant that a cut to the Mathematics Department was inescapable. Once the administration concluded this, Douglas suggests, they felt they could solve two problems at once. They could produce the necessary dollar amount of sav-
ings, and they could take steps that they felt would address the instruction problems in mathematics.

Douglas believes that the only way the administration would reverse its decision is if they were somehow convinced that the cuts in the Mathematics Department might threaten the centerpiece of the Rochester Renaissance Plan: raising student quality and increasing tuition revenue. He is not sure that part of the plan will work in any case, because in the Northeast competition for high-quality students has been "heating up immensely." "They are banking on making Rochester a hot place for undergraduates, but I'm skeptical they will succeed," he says.

Some in the Mathematics Department believe that the termination of the graduate program could harm the university's attractiveness to undergraduates. "Rochester's main selling point for attracting students is that it has a small student body and small classes, so you can get a good undergraduate education," says Ravenel. "At the same time, it is a research university, so as an undergraduate you have the opportunity to get some taste of what research is like... In the long run, the absence of a mathematics graduate program will, I believe, affect the intellectual tone of the university, and it will affect the university's ability to attract and recruit faculty and students in related areas."

For now, the Mathematics Department at Rochester has to live with the administration's decision. The AMS is doing what it can to help. The AMS task force on Rochester will continue to monitor the situation and provide assistance where possible. In addition, the AMS Task Force on Excellence in Mathematical Scholarship has already been looking at these kinds of issues for about a year now, and their report could help other departments avoid a fate like Rochester's. Perhaps all of the attention will help the department, but for now it seems still to be reeling from the blow.

—Allyn Jackson
Demotion of Mathematics Meets Groundswell of Protest

Arthur Jaffe, Salah Baouendi, and Joseph Lipman

The University of Rochester's plan to downgrade its mathematics program has called forth an extraordinary surge of protest not only from mathematicians but also from well-known scientists both in universities and in business. Statements have been made by at least six Nobel laureates, by dozens of members of the National Academy of Sciences, as well as by other leaders in science and industry. The outpouring comes from many fields, including biology, chemistry, computer science, economics, geology, mathematics, philosophy, physics, and sociology.

The uproar from the scientific community arose for at least two reasons. First, the Rochester plan has become a symbolic attack at the core of the American research university. Secondly, the decision was reached in an apparently arrogant manner: the president and a few intimate advisors made broad judgments in areas far from their own expertise, without the benefit of careful external review. Both these reasons mean events in Rochester are being watched carefully across the country by other universities who might follow this bad model, and by scientists who are appalled both with the methodology and with the results.

Norman Ramsey, Nobel laureate in physics, remarked on being told of the Rochester plan, "Surely you must be joking. If you had only one science department at a university, it would be mathematics, and you build from there."

In scientific circles the Rochester plan has become a symbol of the wrong way to downsize.

The Rochester administration announced their controversial "Renaissance Plan", with the stated aim of improving the quality and the attractiveness of the university through downsizing (20 percent students, 10 percent faculty). Faculty cuts are to occur through encouraged attrition in selected departments. The faculty reduction for mathematics, from twenty-one to ten, is the most severe. Four graduate programs will be terminated: mathematics, chemical engineering, comparative literature, and linguistics. It is clear that the number of graduate students

1A detailed discussion of these events is available on the Internet at http://www.ams.org/committee/profession/rochester.html.
in mathematics should be reduced nationally. However, the total elimination of a graduate program in a leading department, within a university that claims to remain at the forefront of science and technology, makes no sense.

Addressing the resulting teaching shortfall (over 70 percent of Rochester's undergraduates enroll in calculus courses), President Thomas H. Jackson states, "We do reject the notion that tenure-track mathematicians and mathematics Ph.D. students are the only potential groups capable of offering high-quality mathematics instruction." Vice provost and dean Richard Aslin states, "We can significantly decrease the faculty size in mathematics who are primarily devoted to delivering quality undergraduate instruction to math majors and other sophisticated science majors while seeking other avenues (technology and nonresearch faculty) to deliver instruction in basic calculus (typically for nonmajors)." In fact, President Jackson has acknowledged the likelihood that the best mathematics faculty will leave.

Renowned economist Lionel McKenzie, professor emeritus at Rochester, just returned from Japan, where he received the Order of the Rising Sun. He feels strongly that his university has made a major mistake with respect to mathematics and that his own work would have been impossible without a lot of cross-fertilization from Rochester mathematicians. McKenzie is working within the university to have the administration take a different path.

The collection of protest letters already received by the Rochester administration constitutes a remarkable testimonial to the place of mathematics in research and in education. Many letter writers assert that Rochester cannot maintain its research excellence in the physical sciences and in other quantitative areas—as it aspires to do—without a strong program in mathematics, which it now has. Others state that ending the graduate program in mathematics and consigning the bulk of calculus teaching to adjuncts and faculty in other departments will markedly degrade the quality of education Rochester offers to undergraduates. Hence Rochester will become less attractive both to prospective students and to prospective faculty.

Several writers criticize the reliance by the Rochester administration on rankings of their mathematics graduate program in the U.S. News & World Report and in the 1995 National Research Council polls rather than on careful external evaluation of each department. Not only can polls be "based largely on knowledge by hearsay and intuition rather than hard study of programs," but, as explained by Fields Medal winner Michael Freedman, "...departments with specialized strength will be underrated."

Thirty-one professors in the Harvard Physics Department (including three Nobel laureates, thirteen members of the National Academy of Sciences, and the dean of the Division of Applied Science) signed the following statement:

The Department of Physics at Harvard University is dismayed to learn of the decision by the University of Rochester administration to cut in half the size of their mathematics faculty and to discontinue their graduate program in mathematics. Rochester has a tradition of being one of the leading American universities in science and in technology. Recent history confirms the interaction between fundamental mathematical concepts and advances in science and technology. We believe that it is impossible to have a leading university in science and technology without a leading department of mathematics. We hope that Rochester will reconsider its decision.

Members of the Harvard Chemistry Department, including a Nobel laureate and eight members of the National Academy of Sciences, expressed similar sentiments:

Our department is dismayed. For centuries, mathematics has rightly been termed "the queen of the sciences", and this is just as apt today. In particular, chemistry has benefited more and more from mathematical developments and concepts. A university that aims to have a worthy program in science and technology simply must have a genuine department of mathematics pursuing original research. We urge the administration of the University of Rochester to reconsider.

Steven Weinberg, University of Texas, Nobel laureate in physics, wrote:

I was proud to receive an honorary doctoral degree from the University of Rochester in 1979, for I knew Rochester as a distinguished center of research in physics, my own field. But recent news from your university makes me fear that it will not be able to continue to maintain this high reputation.
I am not a mathematician, but I regard mathematics as the core of any research program in the physical sciences. If you do not have a graduate program in mathematics then, eventually you will have no research mathematicians, which will make Rochester far less attractive to theoretical physicists. Experimental physicists may not feel the loss of the mathematics program directly, but with fewer first-rate theoretical physicists you will begin to lose your best experimentalists as well. You will also be weakened in your ability to compete for good students; both graduate and advanced undergraduate physics students need to take advanced courses in mathematics, which can only be taught well by active research mathematicians. I imagine that similar effects will eventually be felt in your chemistry and optics departments. I would not advise any prospective undergraduate or graduate student who wishes to concentrate on the physical sciences to go to a university that did not have a graduate program in mathematics.

Co-Nobelist Sheldon Glashow adds:

The study of mathematics (including graduate education, undergraduate concentration, and research) has always been and will always remain an essential component to any entity purporting to be a university.

Joel Moses, a computer scientist and provost at MIT, wrote:

I for one cannot imagine operating a school of engineering in the absence of a strong and research-oriented mathematics department. The same can be said for a school of science. I am also dismayed at the prospect of covering a substantial portion of the teaching load in mathematics with adjunct faculty. If you carry through with it, I predict that your programs in sciences and engineering will suffer a marked decline.

The University of Rochester has a well-known program in optics. In reply to a recent solicitation for graduate applications for an optics fellowship at Rochester, Professor Peter Pershan of Harvard wrote, "I will be happy to advise prospective students about the optics program at Rochester; however, the recent budget problems that have induced the University of Rochester to propose closing their mathematics graduate program will certainly be noticed by our students. It has already been widely discussed within our physics department."

George Backus, research professor of geophysics at the University of California at San Diego and a member of the National Academy of Sciences, wrote:

At UCSD, the Institute of Geophysics and the Scripps Institute of Oceanography often recommend that our Ph.D. students take graduate courses in the UCSD Department of Mathematics. Modern theoretical geophysics and physical oceanography simply cannot be done without sophisticated modern mathematics. To teach these advanced mathematical subjects with sophistication and insight requires people for whom they are the primary research interest.

Expressing an industrial point of view, Neil A. Frankel, manager, Advanced Components Laboratory at the Xerox Corporation, wrote in the December 7 issue of the Rochester Democrat and Chronicle:

It is evident that neither [Kodak nor Xerox] is well served by the elimination of two technology-related [graduate] departments [chemical engineering and mathematics]. To stay ahead of the very significant competition from Japan and elsewhere, [Kodak] will need all the quality engineering talent it can find. The availability of a quality university in Rochester enhances our ability to attract the very best people to our company. If graduate mathematics is eliminated, I really don't see how UR can support first-rate programs in the sciences and in engineering, and I fear that all of these will decline.

Professor Sir Michael Atiyah is director of the Newton Institute in Cambridge, England; he is master of Trinity College (Newton's own college), and he is also the past president of the Royal Society. Sir Michael emphasized the unity of pure and applied mathematics, writing:

Increasingly the complex problems that scientists now face require more sophisticated mathematical understanding. The advent of more powerful computers has in no way decreased the fundamental relevance of mathematics. I can illustrate the
scope of mathematical interaction with other fields by listing just a few of the interdisciplinary programmes that we have run at the Newton Institute in the past few years: computer vision, epidemics, geometry and physics, cryptology, financial mathematics, and meteorology.

Edward Dougherty, editor of the *Journal of Electronic Imaging*, wrote in the January 1996 issue:

While at first this might appear to most people as simply one major research university deciding to restructure itself into a not-so-major university, for those of us in the imaging community there is much more at stake. Because it is home to both Kodak and Xerox, Rochester is one of the major imaging centers in the world, and therefore the future of imaging is closely tied to significant imaging events in Rochester. Suspension of graduate research and teaching in two key foundational imaging disciplines is not insignificant.

Chemical engineering plays a role in imaging materials, toners, and numerous other staples of digital imaging. The case for mathematics is even more compelling when it comes to digital imaging.

Simply put, there is no scientific phenomenology without mathematics. The kind of mathematics graduate courses necessary for contemporary research in image processing might simply cease to exist in the city of Kodak and Xerox.

One justification given by Rochester's administration for eliminating the mathematics graduate program is its perceived weakness in comparison with other programs. While acknowledging the presence of several world-class mathematicians on their faculty, the administration has been significantly influenced by rankings by *U. S. News & World Report* and by the National Research Council. However, many letter writers have defended the quality of the department, pointing out that its strengths are specialized. But in several subfields Rochester is extraordinarily strong, and in algebraic topology the department is among the very best in the country. Ironically, the areas of strength are subfields which have had a major impact on related disciplines (physics, economics, or engineering).

Marvin L. Goldberger, dean of the Division of Natural Sciences in the University of California at San Diego, was cochair of the recent NRC study of graduate departments. He is also president emeritus of the California Institute of Technology, former director of the Institute for Advanced Study in Princeton, and a member of the National Academy of Sciences. He wrote:

I was absolutely appalled and dumbfounded to learn... of the University of Rochester's intention to do away with its graduate program in mathematics and to have only a service program in the field. It is hard to imagine that a first-rate university with an outstanding mathematics faculty (The National Research Council survey notwithstanding, and as cochair of that study I speak with some authority on the significance of those rankings) would take such an action, no matter how dire financial circumstances might be.

Not only is mathematics an exciting and vital intellectual endeavor, but from a number of standpoints [it] plays an exceptional educational role at both the undergraduate and graduate levels. Advanced mathematics is essential in all areas of applied science; economics; technological risk analysis; to an increasing extent in fundamental and applied biology (e.g., drug design); in national security issues involving communication, cryptanalysis, satellite reconnaissance—the list is endless, but one more example is particularly relevant: in recent years topology has played a central role in elementary particle physics where string theory is a candidate for "Theory of Everything". This is another case of the remarkable and mysterious relationship between mathematics and the physical world. Topology is one of the strengths of the Rochester Mathematics Department.

Saunders Mac Lane, Max Mason Distinguished Professor Emeritus of Mathematics, University of Chicago, and former vice president of the National Academy of Sciences, wrote:

I am surprised and shocked to see the extent to which NRC "ratings" have figured in the decision... I am famil-
iar with the work of the NRC. (I was chairman of the "Report Review Committee" of the NRC for eight years.) I simply do not think that these NRC ratings are serious enough to be used for administrative decisions at universities. ... I do not think that the U.S. News & World Report has any standing whatever as a serious source of information. In particular the device of listing the "top 15" or the "top 30" seems to me almost meaningless. The use of U.S. News (page 2 of your "Rationale for restructuring" memo) to calculate the number of Ph.D. programs needed ["to attain a national ranking higher than Rochester's as an institution attractive to undergraduates"] seems to me barren and superficial ... As you know, the Rochester Mathematics Department has chosen to specialize in analysis and in homotopy theory (I know the latter field; Rochester is eminent there). This choice seems to me reasonable for a smaller university. However, it may have a strong effect on ratings, as, for example, for raters not familiar with homotopy there.

Barry Mazur, William Petschek Professor of Mathematics at Harvard University and a member of the National Academy of Sciences, wrote:

The University [of Rochester] is one of the not-very-numerous places in the country where active research in number theory is undertaken. But this is not the only field of mathematics in which the current program at Rochester is important. In the hard classical problems in algebraic topology, for example, Rochester is very strong. Individually (and perhaps collectively) the algebraic topologists at Rochester are responsible for some of the most productive new turns in that field, and I guarantee you that few universities (Harvard included) could boast as distinguished a faculty in this area.

Richard Kane of the University of Western Ontario wrote:

It is my strong belief that many of the students produced [there in topology] are outstanding—as good as topology students produced ANYWHERE. These students have created a very positive image of Rochester.

Dean Aslin explains what the university intends to offer its undergraduates in mathematics. "There are other ways to service our need for calculus instruction, including the hiring of nonresearch adjunct faculty and/or the redirection of other qualified faculty from other disciplines. ... The refocused department that emphasizes quality calculus instruction ... and individual research excellence will best serve the needs of the college. A reduction in steady-state faculty size over time from twenty-one to ten FTEs, with additional non-tenure-track teaching faculty who staff much of the elementary calculus sequences, can achieve these goals."

Kenneth A. Ross, president of the Mathematical Association of America (MAA), a professional organization with about 30,000 members concerned primarily with collegiate mathematics instruction, wrote on behalf of the Executive Committee:

Mathematics and mathematics instruction are constantly changing. Recent initiatives by the National Science Foundation have, for example, resulted in major changes in the way that calculus is taught. Advances in technology have affected not only mathematics pedagogy but also the curriculum. To attract and retain the brightest undergraduates requires that those who are responsible for instruction be active mathematicians and be aware of the ways that both the subject and its instruction are changing.

In view of this the Board of Governors of the MAA at its annual meeting in January 1995 passed a resolution that makes it clear that it is a disservice to students and to the profession to relegate the teaching of mathematics to adjuncts and faculty from other disciplines.

Alan H. Schoenfeld, professor of education and mathematics at the University of California, Berkeley, wrote:

My considered judgment is that, despite your best intentions, your plan for restructuring will inevitably worsen the quality of undergraduate mathematics instruction at Rochester. [It] is a recipe for disaster. Here are the two main reasons why. First, such a plan is likely to result in the complete demoralization of the department's faculty. The best researchers will leave because they can
and because the environment is clearly not hospitable to a major aspect of their professional lives. There is no way that you can hope to maintain a dedicated mathematics teaching faculty under those conditions. High-quality teaching takes place only where it is a widely shared priority and people are respected for it.

Second, there are very serious dangers in placing calculus instruction in the hands of others. After many years of stagnation the undergraduate mathematics curriculum, stimulated by "calculus reform", is undergoing a significant transformation. That reform has come from within the mathematical community and is rapidly taking hold within it. Keeping abreast of such change—in particular, major pedagogical and content changes in calculus—requires being connected to the mathematical community. Creating and delivering instruction consonant with reform requires both knowledge and commitment. The odds that faculty from other departments would (a) know about such reforms and (b) be willing to make the effort required to implement such changes in service courses outside their home departments are virtually nil. One of my responsibilities as chair of the Mathematical Association of America's Committee on the Teaching of Undergraduate Mathematics was gathering data on and trying to fix the "adjunct/temporary instruction problem" in mathematics. I'll be blunt in summary: such instruction is typically cheap, and you get what you pay for. A major instructional and administrative commitment is required to make appropriate use of such staff under the best of circumstances... I conclude that the changes you propose are almost certain to produce a significant lowering of the quality of instruction in mathematics courses—no matter how you staff those courses. This is the direct opposite of what you intend.

David Hoffman, head, Scientific Graphics Research Initiative, Mathematical Sciences Research Institute, Berkeley, recalled his undergraduate experience at Rochester:

As an honors-program history major [at Rochester] with a strong interest in the sciences, I took graduate courses in mathematics, hung around the math department, and got to discuss math with graduate students and young faculty. I also attended many literature courses. I was exposed to a great deal of science firsthand in an atmosphere that highly valued the humanities and the arts. It is evident to me, and I hope it is clear to you, that this has been a strong influence on my career. For me, all these things came together around mathematics. Without a strong graduate program in mathematics, I could not possibly have had this formative undergraduate experience. Such an experience will be impossible after the "Rochester Retrenchment". Replacing mathematics professors by part-time and temporary workers will lower the quality of instruction at the entry level. A "teaching specialist" in calculus could never have given me the insight, challenges, and encouragement I got from professional research mathematicians at the U. of R., even those who were not great classroom instructors...

Tom Davis, principal scientist at Silicon Graphics, wrote:

No matter how much time you spend trying to convince yourselves otherwise, this will certainly hurt the quality of your undergraduates' mathematics education (and hence their education in all the engineering and scientific fields).

In the thirteen years since I helped to found the company Silicon Graphics, I've noticed that it is becoming more and more difficult for us to hire students with a sufficient background in mathematics. Every year we require more, and the students seem to have less. So if you're interested in producing students who can compete in these rapidly growing job markets, you should be thinking about how to increase the amount and quality of mathematics they learn.

Richard Ernst, Nobel laureate in chemistry, wrote:

The natural scientists and engineers at the ETH [Swiss Federal Institute of Technology] would very violently re-
ject a proposal that the courses in mathematics should be given by members of their own applied departments or by mathematics teachers who are not at the same time active at the research front.

I expect that universities with a weak or nonexisting mathematics department will be the first ones to disappear. I am sure that you do not want the University of Rochester to belong to those institutions.

Summing up, Herman Feshbach, the former chair of the M.I.T. Physics Department and past president of the American Physical Society, remarked, "With one action, Mr. Jackson has reduced Rochester to a second-rate university."

On December 6, 1995, the American Mathematical Society sent a fact-finding delegation to Rochester. On December 12, President Cathleen Morawetz sent the report of that committee to President Jackson, along with a letter stating in part: "Let me state firmly that in tough times tough decisions must be made and everything is on the table. I have learned this as director of the Courant Institute of Mathematical Sciences (NYU) (1984-1988), trustee of Princeton University (1972-77), director of NCR (1978-1990), and trustee of the Sloan Foundation (1980-1995). This has also given me insight into how decisions are made and ought to and can be changed before they do irreversible damage."

She also offered the assistance of the Society in finding a way to preserve the integrity of the mathematics program consistent with the overall goals of the university.

In the absence of any change in the Rochester administration’s position, the Society has appointed a task force, chaired by the president-elect. The task force, while still being formed, consists of mathematicians and prominent scientists as well as persons from the world of business. It is a testimony to the central role of mathematics that Marvin Goldberger and Alexander Rich have agreed to serve along with others on the task force, as have Nobel laureates Walter Gilbert (biology), Dudley Herschbach (chemistry), Robert Solow (economics), and Steven Weinberg (physics). The charge of this group is to follow developments, to inform the community, to facilitate assistance to Rochester, and to solicit support.

Every two years the American Mathematical Society invites a well-known scientist from outside mathematics to address the Society. This Gibbs Lecture is a major event, generally attracting several thousand listeners. In January 1996 Steven Weinberg ended his Gibbs Lecture with a description of the central role of mathematics in all of science and a forceful statement that the closing of the graduate program in mathematics at Rochester is a symptom of general malaise in our universities. Weinberg concluded, "I am proud to be a member of this task force."

This groundswell of protest from the scientific community demonstrates that the Rochester plan is not only bad for mathematics, but it is also bad for the University of Rochester, it is bad for American science, and it is bad for the country.
A Mathematician Reads the Newspaper

John Allen Paulos
212 pages
Basic Books
$18.00 Hardcover

John Allen Paulos, who sprang to fame with Innumeracy, has written another book meant to open the eyes of the mathematically curious. A Mathematician Reads the Newspaper is his attempt to educate the public about the uses—and misuses—of mathematics in newspaper articles.

It is a laudable aim. As a science and medical reporter for the New York Times, I have done my own share of privately railing against press releases that mislead by misusing mathematics and statistics and bemoaning reporters who might benefit from a bit more numeracy. And I have often said that the main advantage to me of having studied mathematics is that it taught me to think.

But I am not sure that Paulos succeeds with his book. It is hard to know how illuminating his exegesis will be for the mathematically naive, but I suspect that few will come away with the sort of insight that might enable them to read news stories more critically. What may happen is that readers will become more skeptical of newspaper articles, especially those that go against their own prejudices or preconceptions, without having the tools to analyze the articles.

I can, however, say with some confidence that readers of the Notices will already know all of the mathematics that Paulos presents and will learn little about newspapers and reporting from his book.

I had very mixed reactions to A Mathematician Reads the Newspaper. Although it is a short book with a spryly air that makes it seem inviting, I felt as though I was slogging through it. It never came alive because Paulos rarely gave fresh examples of newspaper stories that might have benefited from mathematical insights.

On the other hand, I enjoyed getting to know Paulos through this book. He seems to be a likable academic with an infectious enthusiasm for his subject. He loves newspapers and mathematics, he seems to be earnest and well meaning, and he loves corny jokes, even going so far as to repeat the joke about the drunk looking for keys underneath the streetlight (p. 26). Ever the professor, he cannot resist sprinkling his text with little questions for those earnest students who want to challenge themselves. In a section on reporting risks, he throws in an anecdote about an advertisement he remembers reading when he was a child, offering land in Colorado.
for 25 cents a square inch. "What would an acre of this undoubtedly desolate land cost? A square mile?" he asks. The answers are in a footnote (p. 142).

But, as an inveterate reader of book reviews, I also know the frustration of being misled by a review that is too forgiving. The question I always want answered is, Should I read this book, or should I recommend it to a friend? To be honest, in the case of Paulos's book, I have to say that the answer to both questions is no.

It is, to begin with, an unusual book. It might have been more appropriately titled A Mathematician Writes a Newspaper—and a newspaper in which, oddly enough, every article, even the recipes, is an editorial. "The format of this book will be loosely modeled after that of a standard newspaper," Paulos writes in his introduction (p. 4). And, sure enough, he starts with a section called "Politics, Economics and the Nation", moves on to "Local Business and Social Issues", and eventually ends up with "Food, Book Reviews, Sports, Obituaries". Each section is made up of very short—two- to three-page—commentaries with titles written to sound like headlines of news stories. Thus we have, in section one, a chapter called "Recession Forecast If Steps Not Taken. Unpredictability, Chaos, and Pooh-Poohing the Pooh-Bahs". In a section on "Science, Medicine, and the Environment", we have "More Dismal Math Scores for U.S. Students. X, Y, and U".

But these are not news stories or anything like them. The only resemblance is the headlines. What they are are excuses for Paulos to expound upon subjects that seem dear to his heart. For example, the chapter "DNA Fingers Murderer. Life, Death, and Conditional Probability" has nothing to do with any actual murder and precious little to do with DNA. Instead it is a 1 1/2-page discussion of conditional probability. For mathematicians, the discussion is unlikely to be of interest because they will already know everything that Paulos says. For nonmathematicians, Paulos frequently is understandable, but at times he jumps too quickly into technicalities.

A prime example comes in one of the first chapters, called "Recession Forecast If Steps Not Taken". It is a chapter on nonlinear dynamical systems. But how many general readers will be comfortable with Paulos's explanation of nonlinear dynamical systems as "mathematical spaces on which vector fields are defined"? He follows this by an explanation: "A vector field may be thought of as a rule f saying, in effect, that if an object is currently at point x, it moves to the next point, f(x), then to point f(f(x)), and so on. The rule f is nonlinear if, for example, the variables involved are squared or multiplied together and the sequence of the object's posi-

tions is its trajectory. A mathematical subterfuge allows us to consider the movement of a fictitious object around a very high-dimensional space instead of the movement of many objects around a lower-dimensional space" (p. 23).

To illustrate nonlinear dynamical systems, Paulos chooses to use the Laffer curve of the Reagan era. But he gives no insight into why one would expect chaotic behavior in this economic model. A more pertinent example might have been climate models predicting global warming. Paulos, however, never mentions that topic, even though he uses Lorentz's butterfly effect to illustrate the sensitivity of nonlinear systems to initial conditions.

Paulos's occasional lapses into dense, jargon-laden technical prose might have been unimportant if he had given his readers some insight into actual news stories. So I looked eagerly in the section on "Science, Medicine, and the Environment" for such illuminating details. These are subjects that I know well, that I write about every day, and I can easily think of examples of stories that were missed, misunderstood, exaggerated, or underplayed because reporters did not always appreciate the subtleties of mathematics.

But I was disappointed. For example, the chapter called "More Dismal Math Scores for U.S. Students" could have discussed the difficulties of comparing test scores of American students to those of students in other countries. Paulos could have looked up a slew of newspaper articles over the years bemoaning the poor performance of Americans and the few articles explaining why it is essentially impossible to compare scores when the student populations are so different. But instead the chapter is Paulos's plea for Americans to care more about mathematics and to recognize its importance in their everyday lives. It is a chapter decrying innumeracy.

In fact, one of the striking features of A Mathematician Reads the Newspaper is that almost never is a single newspaper article referenced, no newspaper article is discussed in any detail or quoted from, and even when a paper is mentioned, Paulos almost never gives the date of an article. Instead, he will say such things as, "Recently, although their stories reported on the same events and the same day, the New York Times and the Wall Street Journal headlined them, respectively, as..." (p. 29). But what day is he talking about? And, of course, most readers might want to know whether the two papers that had different headlines nonetheless had similar stories.

The book's index cites the New York Times more than any other newspaper, with fourteen references to it. But only six of those refer to spe-
pecific articles, and those references are as fleeting as the one about the headlines in the *Times* and the *Journal*. Paulos says that the *New York Times*, the *Washington Post*, and the *Los Angeles Times* are the most influential papers, but he mentions the *Post* just four times: once to say he reads it, once to say that it was cited in an analysis of op-ed columns, once to say it is one of the three most important papers, and once to say that it and the *Times* published profiles of John Mack, the Harvard psychiatrist who wrote of people being abducted by aliens. The *Los Angeles Times* gets similar short shrift with just three mentions, one of which is being the note saying that it is one of the top three papers.

Sometimes Paulos seems trapped by his format, seemingly at a loss for something to say about his newspaper sections on such things as obituaries or society pages. I have to sympathize. Where, after all, is the mathematics in obits? But Paulos somehow pulls through. In a chapter on obituaries, he writes: "I wonder about the relationships among the obituary's length, \( L \); the deceased's achievements, \( A \); his or her fame, \( F \) (which is largely independent of achievement); and the interval between these and death, \( I \); and the number of other 'important' deaths that day, \( D \). Maybe it's something roughly like \( L = (A \times F^2) / \sqrt{I \times D} \)" (p. 199). This, of course, tells us nothing about obituaries and nothing about the power of mathematical reasoning. Paulos could have spoken to an obituary writer or an editor if he really wanted to understand how newspapers decide whose obituaries to write and how long they should be. But then he would have been hard pressed to find any mathematics to discuss.

And that is the crux of my quarrel with this book. It seems to be a series of observations, written to conform to the artificial structure of what Paulos conceives as a newspaper-like book. Paulos shows little sign of having undertaken even the most minimal search through Nexis or some other data base to find newspaper articles that might illustrate his points. He does not seem to understand much about newspaper writing, and he does not seem to have taken care to make his mathematics comprehensible to the general public.

The book ends with advice to reporters and to newspaper readers. As Paulos says, this "concerns issues of journalistic hygiene and what we can do to improve ours"—a particularly distasteful way of putting it, I think (p. 202).

He suggests a series of questions that reporters should ask, some of which are useful. I wish more reporters would ask, as he suggests, whether conclusions were drawn from a valid study or a collection of anecdotes.

Others, however, struck me as off base. In particular, I question his suggestion that reporters ask, "What is known about the dynamics of the whole system? Are they stable or do they seem sensitive to tiny perturbations?" (p. 202). The job of a reporter is to discern in interviews whether experts in a field think that a finding is solid. We are not referees, and there is no way on earth that we or readers concerned with "journalistic hygiene" are going to be able to judge a result independently. Our job is to do a thorough job of reporting and then to tell a story in plain English, to explain why the story is important and why people are reading it now—in other words, why it is newsworthy. Mathematicians' jobs are to tell us if a result is less than it might seem or if it is better than we might realize.

Unfortunately, I do not think that *A Mathematician Reads the Newspaper* will help either those of us who are reporters or those of you who read the *Notices* to do a better job.
New Titles in Differential Equations

Pattern Formation: Symmetry Methods and Applications

—John Chadam, Fields Institute, Waterloo, ON, Canada, Martin Golubitsky, University of Houston, TX, William Langford, University of Guelph, ON, Canada, and Brian Wetton, University of British Columbia, Vancouver, Editors

This volume contains the proceedings of two related workshops held at The Fields Institute in February and March 1993. The workshops were an integral part of the thematic year in Dynamical Systems and Bifurcation Theory held during the 1992–1993 academic year.

Fields Institute Communications, Volume 5; November 1995; 358 pp.; Hardcover; ISBN 0-8218-0256-9; List $99; Individual member $59; Order code FIC/SNA

Discretization of Homoclinic Orbits, Rapid Forcing and “Invisible” Chaos

—Bernold Fiedler, University of Stuttgart, Germany, and Jürgen Scheurle, University of Hamburg, Germany

The results in this book are illustrated by high precision numerical experiments. The experiments show that, due to exponential smallness, homoclinic transversality is already practically invisible under normal circumstances for only moderately small discretization steps.


Inverse Nodal Problems: Finding the Potential from Nodal Lines

—Ole H. Hald, University of California, Berkeley, and Joyce R. McLaughlin, Rensselaer Polytechnic Institute, Troy, NY

Can you hear the shape of a drum? No. In this book, the authors ask Can you see the force on a drum? Hald and McLaughlin prove that for almost all rectangles, the potential in a Schrödinger equation is uniquely determined (up to an additive constant) by a subset of the nodal lines.


All prices subject to change. Charges for delivery are $3.00 per order, or for air delivery outside of the continental U.S., please include $6.50 per item. Prepayment required. Order from: American Mathematical Society, P. O. Box 5904, Boston, MA 02205-5904. Or for credit card orders, fax (401) 331-3842 or call toll free 800-321-4AMS (4267) in the U.S. and Canada. Residents of Canada, please include 7% GST.
Lectures on Quantum Groups

Jens Carsten Jantzen, Aarhus Universitet, Denmark

This book is an introduction to the theory of quantum groups. The main topic is the quantized enveloping algebras introduced independently by Drinfeld and Jimbo.

Graduate Studies in Mathematics; Volume 6, 1995; 266 pages; ISBN 0-8218-0478-2; Hardcover; All AMS members $35; List $44; Order code GSM/6NA

Algebraic Number Fields
Second Edition

Gerald J. Janusz, University of Illinois, Urbana

In this volume, the important theorems regarding the units of the ring of integers and the class group are proved and illustrated. Many examples are given in detail.

Graduate Studies in Mathematics; Volume 7, 1995; 271 pages; ISBN 0-8218-0429-4; Hardcover; All AMS members $35; List $44; Order code GSM/7NA

Proceedings of the Hirzebruch 65 Conference on Algebraic Geometry

Mina Teicher, Bar-Ilan University, Ramat Gan, Israel, Editor

Attended by 60 participants from Israel and abroad, the conference in May of 1993 focused on four topics: topology of algebraic varieties, classification of surfaces, vector bundles, and 3-folds.

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

Israel Mathematical Conference Proceedings; Volume 9, 1995; 462 pages; Softcover; Individual member $39; List $65; Order code IMCP/9NA

Seminar on Fermat's Last Theorem

V. Kumar Murty, University of Toronto, ON, Canada, Editor

Based on a seminar held during 1993–1994 at the Fields Institute for Research in Mathematical Sciences, this book contains articles on elliptic curves, modular forms and modular curves, Serre’s conjectures, Ribet’s theorem, deformations of Galois representations, Euler systems, and annihilators of Selmer groups.

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

Conference Proceedings, Canadian Mathematical Society; Volume 17, 1995; 265 pages; ISBN 0-8218-0313-1; Softcover; Individual member $39; List $49; Order code CMSAMS/17NA

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"The mystery of brilliant productivity will always be the posing of new questions, the anticipation of new theorems that make accessible valuable results and connections. Without the creation of new viewpoints, without the statement of new aims, mathematics would soon exhaust itself in the rigor of logical proofs and begin to stagnate as its substance vanishes. Thus, mathematics has been most advanced by those who distinguished themselves by intuition rather than by rigorous proofs.\footnote{Hermann Weyl reproduces this quote from Felix Klein's lectures on the history of mathematics in his Unterrichtsblatter für Mathematik und Naturwissenschaften 38 (1932), 177-188.}

Fischer Black fits this description well. He was an idea man given to lively debates and to unusual and often unpopular scientific views, whose curiosity led him to create new theoretical connections and to pursue their practical applications in the business world. Born in Washington in 1938, he graduated from Harvard College in physics in 1959 and obtained a Ph.D. in applied mathematics at Harvard in 1964. Thereafter Fischer Black followed his own star. In a rather unconventional way he mixed academia with business, seeking to understand the problems which interested him most, typically in financial markets. His colleagues at Goldman Sachs, the firm where he worked from 1984 until his untimely death,\footnote{Fischer Black died of cancer August 30, 1995, at his home in New Canaan, Connecticut, at the age of 57.} recall "his sense of what's important". This, at the end of the day, is what defines good science. Solving yesterday's famous open theorems is useful and well rewarded. But finding the new paths that matter is essential. Fischer Black had the skill and the judgement to do the latter.

A somewhat aloof and quiet man, he was nevertheless given to strong opinions and frank critical evaluations. His death led to an outpouring of interest from a variety of sources, a testimony of the many different paths that he traveled during his life. In the winter of 1995 several financial journals published articles following his death. Popular publications in economics, such as The Economist, wrote also about his contributions to everyday business practice. Black kept working virtually until the last day of his life. His book Exploring General Equilibrium, published a few months ago, grapples with issues that involve a mathematical formulation of market behavior and is at the frontier of economics.

Fischer Black married three times and was the father of five children and two stepchildren. He changed jobs several times. Starting as a management consultant in computer science at Bolt, Beranek and Newman for a year, where he worked on information for libraries and hospitals, he then moved to the consulting firm Arthur D. Little (ADL), where he was influenced by colleagues working on institutional and theoretical problems in finance. He left to found his own

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Fischer Black

consulting firm, Associates in Finance, in 1969. In 1971-72 he became a Ford Visiting Professor at the University of Chicago, joining the faculty as a professor in the Graduate School of Business thereafter. In 1975 he joined the faculty of the Sloan School of Management at MIT. He remained at MIT until 1984, when he shifted jobs once again, this time out of academia and back into the business world, to join Goldman Sachs & Company, where he became a partner and worked until his death. Fischer Black was president of the American Finance Association in 1985, was selected Financial Engineer of the Year in 1994, and received the Graham and Dodd Award for the best published paper in The Financial Analysts Journal four times. Fischer Black is perhaps best known for his work with Myron Scholes in developing a mathematical model for pricing securities called options. He met Scholes through Michael Jensen, with whom he worked on a consulting project to evaluate mutual funds. Scholes introduced Black to Robert Merton, and the three worked closely on the problem of valuing financial instruments.

Fischer Black's most quoted paper is on the Black-Scholes option pricing model. This paper, "The Pricing of Options and Corporate Liabilities", finds a formula for pricing an option. An option is a security giving the right, but not the obligation, to buy or sell an asset, subject to certain conditions, within a specified period of time. This paper is much quoted and used by theorists and businesspeople alike. Yet, as is the case with many other classic papers in economics, Black had much difficulty in getting his paper accepted for publication. The paper was rejected by several leading journals, appearing finally in 1973 in the Journal of Political Economy. A recent piece by Merton and Scholes in The Journal of Finance reports that the difficulties of publication were such that the empirical tests of their model appeared in print a full year earlier in the un refereed annual sessions volume of The Journal of Finance.

Black's 1973 paper provides a pricing formula for options which is based on a classic economic principle, no-arbitrage. This principle establishes that as long as advantageous trading opportunities exist, the trading activity will not be extinguished. An arbitrage opportunity exists, for example, if a security can be bought in New York at one price and sold at a slightly higher price in London. This price difference creates a riskless opportunity for profits, and trading will not cease until the two prices in New York and in London are brought into line. There is also an arbitrage opportunity if two portfolios that are equivalent to each other, in the sense that they help hedge risks in the same way, can be bought at different prices. Everyone will sell the more expensive portfolio to buy the cheaper one. Trading activity should wipe out such opportunities. At a rest point of the trading activity, called a market "equilibrium", there must be no such arbitrage opportunities. The equilibrium of the trading system leads to the determination of prices, formally through the use of diffusion processes and simple stochastic calculus. This in a nutshell is the concept behind the Black-Scholes formula.

The concept of no-arbitrage pricing is not new, but Black and Scholes gave it a new use. There is a long and distinguished tradition of using no-arbitrage techniques to price assets. In 1931 Harold Hotelling, a highly original mathematical economist at Columbia University, used this method to explain why the prices of exhaustible resources, such as petroleum, must increase at the same rate as the rate of interest. Hotelling's finding was controversial but rests on a sound and now well-accepted fact: that natural resources are assets as much as any other financial assets. People will trade them until their value and their returns match those of other available opportunities.

3 A complete list of Fischer Black's publications is provided in an article by Robert Merton and Myron Scholes in the December 1995 issue of The Journal of Finance.

The connection between the pricing of options and natural resources was also made clear by several other prominent economists—Kenneth Arrow, Anthony Fischer, and Claude Henry—in papers published in 1968 and 1974. Options are valuable, they said, because they allow us to wait until more information is revealed before making a decision. The option gives one the opportunity to buy an asset later at an agreed price and thus postpones the decision to buy until one has more information. In summary, the option allows one to postpone potentially irreversible decisions until more information becomes available. Thus the pricing of an option encodes the value of information.

This issue has become germane in recent years because of concern over possible irreversible long-term environmental changes such as ozone depletion and global warming. We do not know for sure the effects of global emissions of carbon dioxide and ozone, but they could be irreversible: for example, damage such as global climate change—global warming or, at the other extreme, even a new Ice Age. Uncertainty arises due to our inability to predict the effects of emissions accurately. If future damages are uncertain and irreversible, there is value in keeping our options open. It is worth undertaking certain costs in order to keep the current climate pattern when the alternative could be a once-and-for-all irreversible global climate change. The option value is the value of forestalling the point of no return. A formula computing this value tells us how much it is worth to invest in decreasing ozone and carbon emissions today—in other words, the value of keeping our options open.

Hotelling’s no-arbitrage pricing of exhaustible resources does not, however, concentrate on uncertainty, while Black and Scholes focus precisely on that. Hotelling’s formula is based on the ability to compare the value of oil in the ground with that of a bond paying a fixed rate of return. A formula computing this value tells us how much it is worth to invest in decreasing ozone and carbon emissions today—in other words, the value of keeping our options open.

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He was an idea man given to lively debates

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7 A detailed story of how the formula for valuing options was created is presented in “The Universal Financial Device”, a chapter in Capital Ideas, P. Bernstein, Free Press, New York, 1992.

8 G. Chichilnisky, Global environmental risks, op. cit., and Catastrophe futures, Best Review, February 1996. Correlated risks are, by definition, risks which affect most of the population at once. The law of large numbers works by allowing a relatively safe prediction of the proportion of the population that will be affected. Knowing this relatively safe proportion, insurance schemes derive actuarial tables to determine the incidence of risks and to cost the price of selling insurance to different parts of the population. Insurance redistributes the costs between those who suffer the damage and those who do not. When everyone is affected at once, this scheme cannot work.

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6 This can be called scientific uncertainty and can be hedged under certain conditions by financial instruments whose payoffs are contingent on the frequency of unfavourable events, G. Chichilnisky and G. Heal, Global environmental risks, Journal of Economics Perspectives (1983).
Financial innovation, namely, the creation of new ways to hedge uncertainty, is often a socially valuable activity. For example, one of the main sources of uncertainty today is the global environment. This is driven by the environmental changes that humans are causing to the atmosphere of the planet and to its climate. Climate change is a new aspect of one of the oldest risks known to humans: weather risks. Today financial markets are developing new ways of coping with climate risks to hedge the human costs of catastrophes such as hurricanes, floods, and earthquakes, which have led to record losses in recent years. The Chicago Board of Trade introduced in 1992 financial instruments called “catastrophe futures”. These can be used to complement reinsurance when the risks are heavily correlated, as catastrophic risks often are, and therefore the law of large numbers does not work properly. The mathematics of uncertainty is as fascinating and useful as Fischer Black knew it to be. New issues have arisen which open up new avenues of thought and require the development of new mathematical tools. Risks that are endogenously determined by human activity, which I call endogenous uncertainty, open up new and challenging problems in mathematics, economics, and finance. Endogenous risks are those which are caused not solely by nature’s moves but also by human actions. Endogenous risks require a different treatment. The pricing of new financial instruments that induce changes in the risk profile of existing instruments, such as derivatives can do, is still an open area. Such instruments define endogenous risks. The formula proposed by Black and Scholes does not cover those instruments because arbitrage cannot be used to deduce prices of instruments that are not fully comparable with others. These new problems are practical in nature, and their solutions demand imagination and new mathematical tools. They require the unusual mix of skills and curiosity that was Fischer Black’s trademark.

10Earthquakes are exogenous risks. But the risk of global warming, if this is caused in part by humans’ emission of carbon dioxide into the atmosphere of the planet, is an endogenous risk: it is a risk caused by the functioning of the economy. So is the risk of a stock market crash.
AMS-MAA-SIAM Frank
and Brennie Morgan Prize
for Outstanding Research
in Mathematics by an
Undergraduate Student

The new Frank and Brennie Morgan Prize stands
to recognize and encourage outstanding mathe-
матical research by undergraduate students.
Undergraduates are working on problems of
current research interest, proving theorems,
writing up results for publication, and giving
talks on their work. There is undergraduate re-
search today at the highest standards of pro-
fessional excellence. The prize was endowed by
Mrs. Frank Morgan and also carries the name of
her late husband. (Their son, Frank Morgan of
Williams College, is on the prize selection com-
mittee.)

The first Frank and Brennie Morgan Prize was
awarded at the Joint Meetings in Orlando in Jan-
uary 1996 to KANNAN SOUNDARARAJAN of
Princeton University. An Honorable Mention was
awarded to KIRAN KEDLAYA of Harvard Univer-
sity. The prize selection committee consisted of
Kelly J. Black, Gulbank D. Chakerian, Frank
Morgan, Robert Robson, John Ryff, Martha Siegel
(chair), Gilbert Strang, and Lee Zia.

Kannan Soundararajan

Citation
Kannan Soundararajan (Sound) has presented
a body of truly exceptional research. As an un-
dergraduate at the University of Michi-
gan, he had been pursuing a program
of research in analy-
tic number theory
and has made out-
standing contribu-
tions to that field.
A year ago he
solved a long-stand-
ing and much stud-
ied conjecture of
Ron Graham, jointly
with R. Balasubra-
manian. When at Bell Labs two years ago, he es-

tablished asymptotic formulae for the distribu-
tion of “smooth polynomials”. Especially in the
last two undergraduate years he has had great
success in establishing properties of the Rie-

mann zeta function on the line \( \Re s = 1/2 \). His
work has brought him acclaim from accom-
plished researchers in the field, who have cited
him as a superb analytic number theorist. His
work involves estimates of \( |\zeta(1/2 + it)| \) and es-
timates for the gaps between the zeros of the
zeta functional. The work that the committee
found most compelling was the sophisticated

Kannan Soundararajan
approach to the spacing of the ordinates of the zeros of the zeta function. Scholars in the field claim that his results have completely rewritten the subject. He has already had four papers appear in outstanding research journals, has had two other papers accepted, and has submitted three others.

Response
I take great pleasure in accepting this award. Over the last few years I have had the pleasant and rewarding experience of interacting with many notable mathematicians. For sharing their mathematical wisdom, their infectious enthusiasm for the subject, and their patient indulgence, I gladly thank them all. In particular I am grateful to Professors R. Balasubramanian, A. Granville, H. L. Montgomery, K. Ramchandra, and T. D. Wooley, who remain constant sources of encouragement.

Biographical Sketch
Sound was born in Madras and spent most of his high school years there. He studied at the Padma Seshadri High School, whose teachers, he claims, were responsible for stimulating his interest in mathematics. They suggested that he visit the Institute for Mathematical Sciences, which is one of the centers for mathematical research in Madras. There he came in contact with Professor R. Balasubramanian, to whom Sound owes his interest in number theory. Faculty members at the University of Michigan, where Sound was an undergraduate and a member of the 1993 fifth-ranked Putnam team, recommended him to the Morgan Prize Committee. Sound placed seventh in the Putnam Competition in 1994. He is now a graduate student in mathematics at Princeton University. Apart from mathematics he is quite fond of literature, music, and chess. He says that he hopes that someday he will play Go without blushing.

Honorable Mention
Kiran Kedlaya

Citation
Much of Kiran's research has been carried out in connection with summer research or internship programs for undergraduates. He has an impressive portfolio of four professional-level research papers that demonstrate sophistication, depth, and versatility far beyond what might be expected of a student due to graduate in June 1996. He has substantially improved on results of Babai and Sós (1985) on the size of the largest product-free subset of a finite group of order n. The referee's report on the paper calls it "lovely" and continues with, "The elementary combinatorial idea is quite ingenious." Kiran's progress on a tough problem involving outer-planar partitions of planar graphs has brought acclaim from experts, who emphasize that he has made more progress than many professionals who have tackled it. Although only a few infinite families of vertex-transitive non-Cayley graphs are known, Kiran has added another. He also has obtained several new results and new proofs of known results in the area of solving constrained Pell equations.

Biographical Sketch
Kiran Kedlaya hails from Silver Spring, MD, and is currently a senior at Harvard University studying mathematics and physics. He plans to get a Ph.D. and probably enter academia. His interest in mathematics was piqued in high school by such activities as the American Regions Math League (ARML) competition and the American Mathematical Competitions (AMC). He was a three-time winner of the USA Math Olympiad and attended the International Math Olympiad three times (winning two gold medals and one silver medal). Since graduating from high school, he has continued his involvement with the AMC, writing questions for the USAMO and assisting in the Math Olympiad Summer Program. He is also a two-time Putnam Fellow.

Kiran was recommended to the Morgan Prize Committee by Joe Gallian, who knew his work from his participation in the REU at the University of Minnesota, Duluth. Kiran's mathematical interests include algebraic number theory, algebraic geometry, and combinatorics. His non-mathematical interests include volunteering with the American Red Cross; singing in the Harvard Glee Club; playing chess, bridge, and ultimate frisbee; and learning foreign languages.
The 1996 Oswald Veblen Prize in Geometry was awarded at the Joint Mathematics Meetings in Orlando in January 1996 to Richard Hamilton of the University of California, San Diego, and to Gang Tian of the Massachusetts Institute of Technology.

Oswald Veblen (1880-1960), who served as president of the Society in 1923 and 1924, was well known for his mathematical work in geometry and topology. In 1961, the trustees of the Society established a fund in memory of Professor Veblen, contributed originally by former students and colleagues and later doubled by his widow. Since 1964 the fund has been used for the award of the Oswald Veblen Prize in Geometry. Subsequent awards were made at five-year intervals. A total of ten awards have been made: Christos D. Papakyriakopolous (1964), Raoul H. Bott (1964), Stephen Smale (1966), Morton Brown and Barry Mazur (1966), Robion C. Kirby (1971), Dennis P. Sullivan (1971), William P. Thurston (1976), James Simons (1976), Mikhail Gromov (1981), Shing-Tung Yau (1981), Michael H. Freedman (1986), and Andrew Casson and Clifford H. Taubes (1991). At present, the award is supplemented from the Steele Prize Fund, bringing the value of the Veblen Prize to $4,000, divided equally between this year's recipients.

The 1996 Veblen Prize was awarded by the AMS Council on the basis of a recommendation by a selection committee consisting of Jeff Cheeger, Peter Li, and Clifford Taubes (chair).

The text that follows contains the committee's citation for each award, the recipients' responses upon receiving the prizes, and a brief biographical sketch of each recipient.

Richard Hamilton

Citation

Richard Hamilton is cited for his continuing study of the Ricci flow and related parabolic equations for a Riemannian metric and he is cited in particular for his analysis of the singularities which develop along these flows.

The Ricci flow equations were introduced to geometers by Hamilton in 1982 ("Three manifolds with positive Ricci curvature", J. Differential Geometry 17 (1982), 255-306). These equations form a very nonlinear system of differential equations (of essentially parabolic type) for the time evolution of a Riemannian metric on a smooth manifold. The equations assert simply that the time derivative of the metric is equal to minus twice the Ricci curvature tensor. (The Ricci curvature tensor is a symmetric, rank two tensor which is obtained by a natural average of the sectional curvatures.) This flow equation can be thought of as a nonlinear heat equation for the Riemannian metric. After an appropriate, time-dependent rescaling, the static solutions are simply the Einstein metrics. In introducing the Ricci flow equations, Hamilton proved that compact, three-dimensional manifolds with positive definite Ricci curvature are diffeomorphic to spherical space forms. (These are quotients of the three-dimensional sphere by free, finite group actions.)
Over the subsequent years, Hamilton has continued his study of the Ricci flow equations and related equations, delving ever deeper to understand the nature of the singularities which arise under the flow. Hamilton proved that singularities do not arise in three dimensions when the Ricci curvature starts out positive. Hamilton has come to understand the geometric constraints on the singularities which arise under the Ricci flow on a compact, three-dimensional Riemannian manifold and under a related flow equation (for the “isotropic curvature tensor”) on a compact, four-dimensional manifold. This understanding has allowed him, in many cases, to classify all possible singularities of the flow.

In the four-dimensional case, Hamilton was recently able to give a topological characterization of the possible singularities which arise from the isotropic curvature tensor flow if the starting metric has positive isotropic curvature tensor. The conclusion is as follows: If a singularity arises, then it can be described as a lengthening neck in the manifold whose cross-section is an embedded spherical space form with injective fundamental group. Hamilton deduced from this fact that simply connected manifolds with positive isotropic curvature are diffeomorphic to the four-dimensional sphere.

For the compact 3-manifold case, Hamilton, in a recent paper, analyzed the development of singularities in the Ricci flow by studying the evolution of stable, closed geodesics and stable, minimal surfaces under their own, compatible, geometric flows. This analysis of the flows of stable geodesics and minimal surfaces leads to a characterization of the developing singularities in terms of Ricci soliton solutions to the flow equations along degenerating, geometric subsets of the original manifold. (A Ricci soliton is a solution whose motion in time is generated by a 1-parameter group of diffeomorphisms of the underlying manifold.)

The Oswald Veblen Prize in Geometry is awarded to Richard Hamilton in recognition of his recent and continuing work to uncover the geometric and analytic properties of singularities of the Ricci flow equation and related systems of differential equations.

Response
It is a great honor to receive the Oswald Veblen Prize from the AMS. This award recognizes the tremendous growth of the whole field of nonlinear parabolic partial differential equations in geometry, of which my own work is but a small part. Special thanks are due to my parents, Dr. and Mrs. Selden Hamilton, who provided me with every conceivable head start in education; my high school geometry teacher, Mrs. Becker, for an enduring love of three-dimensional geometry; my mentor, James Eells, Jr., whose work with Joseph Sampson on the Harmonic Map Heat Flow originated and inspired the field; and my colleagues S.-T. Yau and Richard Schoen, who suggested the neck-pinching phenomenon and encouraged me to study the formation of singularities.

It is a pleasure to share the prize with Gang Tian, whose work on Kähler manifolds is outstanding.

Biographical Sketch
Professor Hamilton was born in Cincinnati, Ohio, in 1943. He received his B.A. from Yale University in 1963 and his Ph.D. from Princeton University in 1966 under the direction of Robert Gunning. He has held professorships at Cornell University and the University of California at Berkeley and visiting positions at the University of Warwick, the Courant Institute, the Institute for Advanced Study in Princeton, and the University of Hawaii. He is currently professor of mathematics at the University of California, San Diego.

Gang Tian
Citation
Gang Tian is cited for his contributions to geometric analysis and, in particular, for his work on the question of existence and obstructions for Kähler-Einstein metrics on complex manifolds with positive first Chern class.

The basic Kähler-Einstein problem is to find necessary and sufficient conditions for the existence of a Kähler metric on a given complex manifold whose Ricci curvature is a constant multiple of the metric itself. The sign of the constant is determined by the degree of the manifold's first Chern class. The case where the sign is negative was solved independently by Aubin and Yau, while the sign zero case (where the first Chern class vanishes) was solved by Yau in his celebrated solution to the Calabi Conjecture. Applications of the zero (and non-posi-
tive) first Chern class results have been legion, and so progress on the positive first Chern class cases has been eagerly sought after. However, the case of positive first Chern class has remained mostly mysterious until the recent work of Tian (and others).

In particular, Tian completely settled the existence question for Kähler-Einstein metrics on complex surfaces, showing that they exist if and only if the group of holomorphic transformations is reductive. Later, Tian (generalizing work with W. Y. Ding) found the first obstructions to the existence of Kähler-Einstein metrics which do not require the existence of holomorphic vector fields. Subsequently, he was able to show that for hypersurfaces, the existence of a Kähler-Einstein metric implies that the hypersurface is stable in the geometric invariant theory sense. (This constitutes a first big step in Yau’s program to characterize manifolds with Kähler-Einstein metrics in geometric invariant theory terms.) Tian had previously developed some general criteria for the existence of Kähler-Einstein metrics, which he applied to complex hypersurfaces in complex projective spaces.

Tian has also proved various theorems which control the limiting behavior of sequences of Kähler-Einstein metrics with bounded $L^n$-norm on a complex $n$-dimensional manifold. And, he has classified the asymptotically locally Euclidean Kähler-Einstein manifolds which result as limits of such sequences.

On a different subject, Tian (with Y. Ruan) also published a sequence of fundamental papers on the new subject of quantum cohomology which prove, in particular, that the quantum cohomology ring is associative. (Quantum cohomology refers to a family of deformations of the cohomology ring of a symplectic manifold which is defined by an appropriate count of intersection numbers of cohomology classes with certain symplectic curves.)

For these contributions and others unnamed, Gang Tian is awarded the Oswald Veblen Prize in Geometry.

**Response**

I am highly honored to be one of the recipients of the Veblen Prize of the American Mathematical Society. First, I would like to express my gratitude to my thesis advisor, S.-T. Yau, for having initially suggested this problem to me: finding Kähler-Einstein metrics on manifolds with the first Chern class positive. Ten years ago he also shared with me his belief that the problem would be related to certain stability properties of the underlying manifolds. I would also like to thank my colleagues at the Courant Institute of Mathematical Sciences for providing me with an excellent environment for my research. It is surely one of the most stimulating places for mathematical research. Finally, I am very happy to share this prize with R. Hamilton.

**Biographical Sketch**

Gang Tian was born on November 24, 1958, in the People's Republic of China. He received his B.S from Nanking University (1982), his M.S. from Peking University (1984), and his Ph.D. from Harvard University (1988). After positions at Princeton University and the State University of New York at Stony Brook, he went to the Courant Institute of Mathematical Sciences at New York University in 1991. In 1995 he moved to the Massachusetts Institute of Technology. He also holds professorships at the Mathematics Institute of the Academia Sinica and at Peking University. He has held visiting positions at the Institute for Advanced Study in Princeton, the Institut des Hautes Etudes Scientifiques, and Stanford University. Tian received a doctoral dissertation fellowship (1987) and a research fellowship (1991-1993) from the Alfred P. Sloan Foundation. In 1990 he presented a 45-minute invited address at the International Congress of Mathematicians in Kyoto. He presented the Bergmann Memorial Lecture at Stanford University in 1994. That same year, he received the 19th Alan Waterman Award from the National Science Foundation.
Meeting of the Advisory Committee of the NSF's Mathematical and Physical Sciences Directorate

Sitting in on a meeting of the Advisory Committee for the Mathematical and Physical Sciences (MPS) Directorate of the National Science Foundation (NSF), one finds it hard to avoid the conclusion that the Division of Mathematical Sciences (DMS) is small potatoes. The MPS directorate is home to five divisions: Astronomical Sciences, Physics, Chemistry, Mathematical Sciences, and Materials Research. The fact that the DMS is lumped in with "big science" was abundantly clear during this meeting, which had large facilities as a special focus. Of the five MPS divisions, the DMS and the Division of Chemistry have the least emphasis on facilities. The Division of Materials Research has 26 centers which are not as large as those in astronomy and physics but collectively add up to a large amount.

Overhead transparencies illustrated a healthy crop of major research facilities—LIGO, the Gemini telescope project, a new array of forty telescopes for millimeter-wavelength astronomy, the Large Hadron Collider that is proposed as an add-on to CERN and as an alternative to the now-dead Superconducting Supercollider. All are multimillion-dollar projects that would take several years to build and millions of dollars more to maintain. One NSF executive actually brought up the Mathematical Sciences Research Institute to make a point about the range of facilities the MPS funds: MSRI's $3.1 million yearly budget was contrasted with an upgrade for the Cornell Electron Storage Ring, a tool for research in high energy physics with annual funding of $17.4 million.

The discussion of the Advisory Committee only danced around some of the most explosive issues facing the MPS directorate—such as how, in a time of declining budgets, to balance the support of individual investigators with large, highly visible facilities. Some members of the Committee—notably Margaret Wright, a mathematician at AT&T Bell Laboratories, and Susan Graham, a computer scientist at UC Berkeley—tried a few times to broach this topic. Wright pointed out that once a decision has been made to fund a new facility, it's not possible to "shave off" funds to fit a declining budget. But it is possible to "shave off" funds from divisions like the DMS, which has very few large commitments. Indeed, in such a scenario, support for individual investigators and small groups all across the MPS becomes vulnerable. The fact that the discussion fizzled might indicate a desire to avoid open warfare within the committee. With representation from all of the MPS disciplines, its members have widely ranging priorities.

Nevertheless, these kinds of hard choices will become increasingly common in the future. MPS Director William C. Harris pointed out that the NSF will not have the comfortable 5-10% increases it has seen in recent years. In fact, he suggested that his directorate needs to plan for a 25% decrease over the next few years. Traditionally, the way in which NSF money has been divided among the divisions is dictated in part by history, so radical changes in division budgets from year to year are generally unheard of. But, Harris predicted, this will have to change. He said the MPS directorate would not be "locked
into previous history” and that he wanted to start out “with a clean sheet of paper” for making decisions about funding priorities across the MPS divisions.

Some of this seems to be happening already. For example, the MPS established a couple of new programs recently by taking a small slice out of each division’s budget. The division contributions were put into a central pot, for which researchers from any MPS area could compete. The DMS made its contributions, which put a small dent in the DMS budget, and is now hoping that mathematicians will be able to compete effectively for the funds. This trend, if continued, could dramatically change the funding profile of the MPS.

Another dramatic change could come if the MPS takes seriously an idea that has been around for a while now: eliminating summer salaries. Donald J. Lewis, DMS Director, brought up the idea, asking whether summer salaries constitute the best way to spend MPS funds. In 1995, salaries for principal investigators (PIs) comprise 12% of the MPS budget and 26% of the DMS budget. For the past seven or eight years, the DMS has found it increasingly difficult to provide the usual two months of summer salary support, and many PIs funded by the DMS today receive only one month of summer support. Now this same pressure is being felt in the other MPS divisions, particularly in the astronomy division, which has made facilities a high priority and is currently funding very few PIs. Physics has also been discussing a move to only one month of summer salary on their grants.

The committee discussed only briefly the idea of eliminating summer salaries, and they made no recommendations. One committee member pointed out that the elimination of summer salaries wouldn’t be so bad for senior investigators. But he predicted that it would be tough on younger researchers, who are likely to be at a stage in life where they are putting their kids through college.

Were they to hear this comment, Congress and taxpayers would no doubt notice he said nothing about summer salaries buying research to benefit the nation. And therein lies the rub: in the end, it is Congress and taxpayers who need to be convinced that organizations like the NSF are worth funding, and funding well. Committee member Joseph Johnson, a physicist at Florida A&M University, urged the committee and the NSF to better communicate with the public. As he put it, today “the corner groceryman is asking, ‘Why should I spend money on research?’”

—Allyn Jackson
Mathematics Opportunities

Tentative REU Sites for Summer 1996

The Division of Mathematical Sciences (DMS) of the National Science Foundation provides support each summer for a number of Research Experiences for Undergraduates (REU) programs. These programs provide undergraduate students with enriching, hands-on research experiences in the mathematical sciences.

What follows is a list of REU programs planned for the summer of 1996. Please note that this list is tentative. An updated list may be obtained by sending e-mail to reu@dms@nsf.gov.

Mathematical Analysis and Analysis of Nonlinear Phenomena, 12 students, 7 weeks. Contact Steven E. Shreve, Department of Mathematics, Carnegie Mellon University, Pittsburgh, PA 15213; telephone 412-268-8484; fax 412-268-6380; e-mail cn0s@andrew.cmu.edu.

Fractals and Harmonic Analysis, Geometric Convexity, Circle Packings, Tensegrities, 8 students, 8 weeks. Contact Robert S. Strichartz, Department of Mathematics, Cornell University, Ithaca, NY 14853; telephone 607-255-3509; fax 607-255-7149; e-mail reu@math.cornell.edu.

Algebra, Topology, Applied Mathematics, and Analysis, 6 students, 8 weeks. Contact David C. Carothers, Department of Mathematics, Hope College, Holland, MI 49423; telephone 616-394-7530; fax 616-394-7123; e-mail reu@hope.bitnet.

Algebra, Topology, Analysis, Probability, and Applied Mathematics, 10 students, 8 weeks. Contact Daniel Maki, Department of Mathematics, Indiana University, Bloomington, IN 47405; telephone 812-855-0745; fax 812-855-0046; e-mail reu@indiana.edu; World Wide Web http://www.math.indiana.edu/reu/home.html.

Inverse Problems in Mathematics and Engineering (joint program between mathematics and engineering), 6 students, 8 weeks. Contact Suzanne Weaver Smith, Department of Engineering Mechanics, University of Kentucky, Lexington, KY 40506; telephone 606-257-4584; fax 606-257-8057; e-mail reu@ms.uky.edu; World Wide Web http://www.ms.uky.edu/~reu/.

Graph Theory, Group Theory, and Number Theory, 10 students, 2 months. Contact Clifford A. Reiter, Department of Mathematics, Lafayette College, Easton, PA 18042; telephone 610-250-5277; fax 610-250-9850; e-mail reiterc@lafcol.lafayette.edu.

Probabilistic Methods in Graph Theory Combinatorics and Number Theory, 6 students, 9 weeks. Contact Anant P. Godbole, Department of Mathematics, Michigan Technological University, Houghton, MI 49931; telephone 906-487-2884, ext. 2068; fax 906-487-2357; e-mail anant@math.mtu.edu.

Geometry and Topology, 3 students, 8 weeks. Contact Morris Kalka, Department of Mathematics, Tulane University, New Orleans, LA 70118; telephone 504-865-5274; e-mail reu@math.tulane.edu.

Analysis, Probability and Finite Mathematics, 6 students, 10 weeks. Contact Cleon Yohe, Department of Mathematics, Washington University, St. Louis, MO 63130; telephone 314-225-1725; fax 314-935-5799; e-mail cy@math.wustl.edu.

Matrix Analysis and Its Applications, 8 students, 8 weeks. Contact David P. Stanford, Department of Mathematics, College of William and Mary, Williamsburg, VA 23187; tel...
Mathematics Opportunities

phone 804-221-2002; fax 804-221-2988; e-mail dpstan@facstaff.wm.edu.

Discrete Mathematics, Combinatorics and Graph Theory, 6 students, 10 weeks. Contact Joseph A. Gallian, Department of Mathematics and Statistics, University of Minnesota, Duluth, Duluth, MN 55812-2496; telephone 218-726-7576; fax 218-726-8300; e-mail jgallian@d.umn.edu; World Wide Web http://www.d.umn.edu/~jgallian/.

Number Theory, Algebraic Geometry and Applied Analysis, 10 students, 8 weeks. Contact Alan H. Durfee, Department of Mathematics, Mount Holyoke College, South Hadley, MA 01075; telephone 413-538-2162; fax 413-538-2327; e-mail reu@math.holyoke.edu.

Combinatorics, Dynamical Systems and Stochastic Processes, 8 students, 8 weeks. Contact Terence R. Blows, Department of Mathematics, Northern Arizona University, Flagstaff, AZ 86011; telephone 602-523-6863; fax 602-523-5847; e-mail bblows@ nauvax. unc. nau. edu.

Computational and Combinatorial Group Theory, 10 students, 8 weeks. Contact Andy Miller, Department of Mathematics, University of Oklahoma, Norman, OK 73019; telephone 405-325-6711; fax 405-325-7484; e-mail amiller@ nsuvax. math. wou nor. edu.

Analysis of Algorithms, Geometry, Population Dynamics, and Topology, 8 students, 8 weeks. Contact Dennis J. Garity, Department of Mathematics, Oregon State University, Corvallis, OR 97331; telephone 503-737-5138; fax 503-737-0517; e-mail reu@math. orst.edu; World Wide Web http://www. orst. edu/~garityd/reuhome. html.

Computational Group Theory, 6 students, 7 weeks. Contact Gary J. Sherman, Department of Mathematics, Rose-Hulman Institute of Technology, Terre Haute, IN 47803; telephone 812-877-8445; fax 812-877-3198; e-mail sherman@rose-hulman.edu.

Theory and Application of Statistical Methods, 10 students, 8 weeks. Contact Madhuri S. Mulekar, Department of Mathematics and Statistics, University of South Alabama, Mobile, AL 36688; telephone 334-460-6264; fax 334-460-7969; e-mail mmulekar@ jaguar1. usouthal. edu; World Wide Web http://www. mathstat. usouthal. edu/~mmulekar/research. html.

Computational Group Theory, 6 students, 8 weeks. Contact Rhonda L. Hatcher, Department of Mathematics, Texas Christian University, Fort Worth, TX 76129; telephone 817-921-7335; fax 817-921-7333; e-mail hatcher@ gamma. is. tcu. edu.

Inverse Problems, 8 students, 8 weeks. Contact James A. Morrow, Department of Mathematics, University of Washington, Seattle, WA 98195; telephone 206-543-1161; fax 206-543-0397; e-mail morrow@m ath. washington. edu.

Geometry, 8 students, 9 weeks. Contact Colin Adams, Department of Mathematics, Williams College, Williamstown, MA 01267; telephone 413-597-3300; fax 413-597-4116; e-mail colin.adams@ williams. edu.

— DMS
For Your Information

NRC Science Education Standards Released

A national committee of school teachers, university and college faculty, scientists, and state and local school administrators released its final version of the nation's first comprehensive standards to improve science education in grades K-12.

During the past year, the National Research Council (NRC), which coordinated the development of the Standards, distributed for public comment 40,000 copies of a draft to thousands of individuals and hundreds of groups. The resulting document—the National Science Education Standards—represents wide agreement about what is important in science education. It offers clear guidance and insightful examples in a format that is easy to use.

The Standards provide specific guidelines for science content, science teaching, professional development of teachers, assessment, science education programs, and the science education system. The project was funded by the National Science Foundation, the National Aeronautics and Space Administration, and the National Institutes of Health.

Further information about the Science Standards is available at the NRC World Wide Web site, http://www.nas.edu/. Copies of the Standards can be ordered online from the National Academy Press at the same Web address. To order by phone, call 1-800-624-6242 or 202-334-3313 in the Washington, DC, area. The mailing address is National Academy Press, 2101 Constitution Avenue, NW, Washington, DC 20418. Single copies of the report are $19.95 plus $4.00 shipping and handling.

—from NRC News Release
Committee on the Profession (CoProf)  
1995 Annual Report  

Salah Baouendi, Chair  

1. Organization  
- CoProf held face-to-face meetings on April 22–23, 1995, and September 30–October 1, 1995. Also, much business was conducted by e-mail.  

2. Employment  
- From its inception, this committee has considered the employment situation to be its highest priority (as well as a high priority for the Society as a whole). CoProf's standing subcommittee on employment has been one of its most active.  
- CoProf conducted a "Review of AMS Employment Activities". This review may be found on e-MATH (URL: http://www.ams.org/committee/profession/review-employ.html).  
- CoProf has been involved with the AMS-SIAM project, funded by the Sloan Foundation, on nonacademic employment opportunities for mathematicians. This project is now under way, with Project Director Linda Thiel.  
- CoProf sponsored a talk by Stanley Benkoski, "Preparing for a Job outside Academia", at the 1995 Annual Meeting in San Francisco. It is sponsoring a talk by Linda Thiel, "Nonacademic Career Opportunities in Mathematics", at the 1996 Annual Meeting in Orlando, and it is also sponsoring a session, "Preparing Ourselves and Our Students for Careers in Mathematics", at the 1996 Mathfest in Seattle.  
- At its January 1995 meeting, the Council of the AMS approved the resolution "On Graduate Programs in Mathematics". The text of this resolution appears in the June 1995 Notices and is available on e-MATH. At CoProf's suggestion, a copy of this resolution was mailed to all graduate departments.  
- AMS staff reported to CoProf that copies of the statement "Supportive Practices and Ethics in the Employment of Young Mathematicians", drafted by CoProf and passed by the Council in January 1994, would be mailed to all advertisers of academic position and would be reprinted in the Notices. (It appears in the December 1995 Notices.)  
- We discussed the report of the Data Committee, "Employment Experiences of 1990-1991 U.S. Institution Doctoral Recipients in the Mathematical Sciences"; commended the Data Committee on this excellent report, which can be found in the July 1995 Notices; and encouraged the Data Committee to continue this and similar studies; and further, supported the recommendation of CoMC to hold career-oriented Short Courses.  
- CoProf has recommended that the AMS publicize and describe mathematics graduate programs which appear to be effective in preparing their students for nonacademic employment, as these may serve as models for other departments that may wish to modify their programs.  

3. Participation  
- At its January 1995 meeting, the Council approved a resolution by CoProf that the AMS establish a Task Force on Participation for Underrepresented Minorities in Mathematics. We heard from the chair of this task force, Prof. James Turner, in April as it was getting under way and dis-
discussed a preliminary version of its report in September. (This report is scheduled to be presented to the January 1996 Council.)

4. Membership

CoProf has discussed possible modification of the AMS dues structure. This matter is still under consideration; it is intended that a survey of the membership will be held before any action is taken. CoProf has been considering changes in the format of the AMS ballot, with an eye to improving the response rate (which in the 1994 election was under 10 percent). We also discussed the question of contested elections and questions of institutional membership and provision of services to institutional members.

5. Fellowships and Prizes

CoProf recommended to the Council a redirection of the AMS Centennial Fellowship program from "mid-career mathematicians" to "recent Ph.D.s". This change, the details of which can be found in the October 1995 Notices, was approved by the Council, and it is taking effect with the current round of fellowships (i.e., those with tenure beginning in the fall of 1996). CoProf reviewed and forwarded to the Council for approval 1) a proposed charge for the Menger Prize Committee, 2) a proposed change to the eligibility criteria for the Fulkerson Prize.

6. Other

- The January 1995 Council approved a resolution regarding future meeting sites that had been submitted to it by CoMC and CoProf.
- CoProf recommended that copies of the AMS statement on ethical guidelines, which appears in the June 1995 Notices, be mailed to members and that this statement be periodically reprinted in the Notices.
- CoProf recommended that the CoMC proposal for graduate student sessions at national meetings be tried once and then evaluated.
- CoProf reviewed the portion of the 1996 AMS Operating Plan which deals with professional programs and services.
- The executive director gave CoProf a report on e-MATH. In particular, he noted that under the reorganization of e-MATH now in place, CoProf will serve as the editorial committee for the Professional Programs and Services section of e-MATH.
- CoProf discussed AMS public awareness activities and has begun a formal review of these, to be completed in 1996.
- CoProf endorsed the view of its chair that the policy committee chairs should be ex officio members of the Council. This question is now under review.
- CoProf and CoE have been concerned with the termination of the graduate program in mathematics at the U. of Rochester. At the recommendation of CoProf, the chairs of CoE and CoProf have been appointed by the president as an ad hoc committee to visit the U. of Rochester and to report back to the Society.
The selection committees for these prizes request nominations for consideration for the 1996 awards. Information about these prizes may be found in the November 1995 Notices, pp. 1323-1332.

Three Leroy P. Steele Prizes are awarded each year in the following categories: (1) the Steele Prize for Lifetime Achievement: for the cumulative influence of the total mathematical work of the recipient, high level of research over a period of time, particular influence on the development of a field, and influence on mathematics through Ph.D. students; (2) the Steele Prize for Mathematical Exposition: for a book or substantial survey or expository-research paper; and (3) the Steele Prize for Seminal Contributions to Research: for a paper, whether recent or not, that has proved to be of fundamental or lasting importance in its field, or a model of important research.

The Award for Distinguished Public Service is presented every two years to a research mathematician who has made a distinguished contribution to the mathematics profession during the preceding five years.

The Frank Nelson Cole Prizes are awarded at five-year intervals for contributions to algebra and number theory, respectively.

The Ruth Lyttle Satter Prize is awarded every two years to recognize an outstanding contribution to mathematics research by a woman in the previous five years.

Nominations with supporting information should be submitted to the Secretary, Robert M. Fossum, Department of Mathematics, University of Illinois, 1409 West Green Street, Urbana, IL 61801. For the Steele Prizes, include a short description of the work that is the basis of the nomination, including complete bibliographic citations. For the Public Service Award, include a short description of the pertinent activities of the nominee. For the Cole and Satter Prizes, include a short description of the work that is the basis of the nomination, including complete bibliographic citations. A curriculum vitae should be included for all nominees. The nominations will be forwarded by the Secretary to the appropriate prize selection committee, which will, as in the past, make the final decisions on the awarding of the prizes.

Deadline for nominations is March 31, 1996.
Add this Cover Sheet to all of your Academic Job Applications

How to use this form

1. Using the facing page or a photocopy, (or a TeX version which can be downloaded from the e-math "Employment Information" menu), fill in the answers which apply to all of your academic applications. Make photocopies.

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

The Joint Committee on Employment Opportunities has adopted the cover sheet on the facing page as an aid to job applicants and prospective employers. The 1995-96 hiring season is the second year in which the cover form is being utilized. 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:
dmm@math.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.
Last Name
First Name
Middle Names
Social Security Number optional
Address through June 1996
Home Phone
Current Institutional Affiliation
Work Phone
Highest Degree and Source
Ph.D. Advisor
If the Ph.D. is not presently held, date on which you expect to receive
Indicate the mathematical subject area(s) in which you have done research using the 1991 Mathematics Subject Classification printed on the back of this form. If listing more than one number, list first the one number which best describes your current primary interest.
Primary Interest
Secondary Interests optional
Give a brief synopsis of your current research interests (e.g. finite group actions on four-manifolds). Avoid special mathematical symbols and please do not write outside of the boxed area.

Most recent, if any, position held post Ph.D.
University or Company
Position Title Dates
Indicate the position for which you are applying and position posting code, if applicable
If unsuccessful for this position, would you like to be considered for a temporary position?

☐ Yes    ☐ No

If yes, please check the appropriate boxes.
☐ Postdoctoral Position  ☐ 2+ Year Position  ☐ 1 Year Position
List the names, affiliations, and e-mail addresses of up to four individuals who will provide letters of recommendation if asked. Mark the box provided for each individual whom you have already asked to send a letter.

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The prize is awarded each year to an undergraduate student (or students having submitted joint work) for outstanding research in mathematics. Any student who is an undergraduate in a college or university in the United States or its possessions, or Canada or Mexico, is eligible to be considered for this prize.

The prize recipient's research need not be confined to a single paper; it may be contained in several papers. However, the paper (or papers) to be considered for the prize must be submitted while the student is an undergraduate; they cannot be submitted after the student's graduation. The research paper (or papers) may be submitted for consideration by the student or a nominator. All submissions for the prize must include at least one letter of support from a person, usually a faculty member, familiar with the student's research. Publication of research is not required.

The recipients of the prize are to be selected by a standing joint committee of the AMS, MAA, and SIAM. The decisions of this committee are final. The 1996 prize will be awarded for papers submitted for consideration no later than June 30, 1996, by (or on behalf of) students who were undergraduates in December 1995.

Nominations and submissions should be sent to:
Morgan Prize Committee
c/o Robert M. Fossum, Secretary
American Mathematical Society
University of Illinois
Department of Mathematics
1409 West Green Street
Urbana, IL 61801-2975

Questions may be directed to the chairperson of the Morgan Prize Committee:
Martha J. Siegel
Department of Mathematics
Towson State University
Towson, MD 21204-7097
telephone 410-830-2980
e-mail: siegel-m@toe.towson.edu
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

March 1, 1996: Application deadline for U.S.-fSU Cooperative Grants. Telephone 703-526-9720, fax 703-526-9721, e-mail information@crdf.org.

March 1, 1996: Application deadline for DIMACS REU program for 1996-97. REU coordinator, Deborah Frantzblau: e-mail frantzbla@dimacs.rutgers.edu, phone 908-445-4573.

April 1, 1996: Application deadline for postdoctoral fellowships at the the Mittag-Leffler Institute for the 1996-1997 academic year. Kjell-Ove Widman, Director, Mittag-Leffler Institute; e-mail widman@ml.kva.se.

April 1, 1996: Deadline for nominations for the AWM Alice T. Schafer Prize. Information: telephone 301-405-7892, e-mail awm@math.umd.edu.


April 1, 1996: Deadline for 1996-1997 IBM Postdoctoral Fellowship in Mathematical Studies, Committee on Postdoctoral Fellowships, Department of Mathematical Sciences, IBM Research Division, T. J. Watson Research Center, P. O. Box 218, Yorktown Heights, NY 10598.

April 1, 1996: Deadline for preliminary proposals for NSF Local Systemic Change through Teacher Enhancement Program. To obtain program announcement, telephone 703-306-1130, fax 703-644-4278, e-mail pubs@nsf.gov.


Where to Find It

A brief index to information which appeared in previous issues of the Notices.

Advanced Research Projects Agency, program officers October 1995, p. 1160

Air Force Office of Scientific Research, program officers October 1995, p. 1160

AMS e-mail addresses October 1995, p. 1157

AMS Ethical Guidelines June 1995, p. 694

AMS Officers and Committee Members September 1995, p. 1026


Army Research Office, program officers October 1995, p. 1161

Board on Mathematical Sciences, National Research Council February 1995, p. 277

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Department of Energy, program officers October 1995, p. 1159

Disciplinary Subcommittee for the Mathematical Sciences February 1995, p. 277

JPBM Public Information Office (new address) December 1995, p. 1563


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


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

NSF, Mathematical Scientists on the Advisory Committee for the Mathematical and Physical Sciences Directorate February 1995, p. 277

NSF, program officers in math January 1996, p. 58

NSF, program officers in math education October 1995, p. 1160

National Security Agency, program officers October 1995, p. 1161

Office of Naval Research, program officers October 1995, p. 1161
Mathematics Calendar

March 1996


Focus: The dramatic evolution of computer technology has caused a return to the biological paradigms which inspired many of the early pioneers of information science such as J. von Neumann, S. Kleene and M. Minsky. Similarly, many fields of the life and human sciences have been influenced by paradigms initiated in systems theory, computation, and control engineering. The purpose of this workshop is to pursue this fruitful interaction of engineering and the exact sciences, with the life and human sciences, by investigating the processes which can provide systems, both artificial and natural, with autonomous and adaptive behavior.

Topics: Autonomous behavior of biophysically and cognitively inspired models; autonomous agents and mobile systems; collective behavior by semi-autonomous agents; self repair and regeneration in computational and artificial structures; autonomous image understanding; brain imaging and functional MRI.


Submissions: Paper submissions, in the form of four-page extended abstracts, are solicited in areas of relevance to this workshop. They should be sent before January 15, 1996, to one of the workshop co-chairs. The Workshop Proceedings will be published in book form with full papers. Selected papers will appear in the prestigious journal Theoretical Computer Science.

Workshop Co-Chairs: E. Gelenbe, Dept. of Electrical and Computer Engineering, Duke Univ., Durham, NC 27708-0291, eoledo@duke.edu; N. Schmajuk, Dept. of Experimental Psychology, Duke Univ., Durham, NC 27708-0291, nestor@acpub.duke.edu.


4-8 IMA Workshop on Nonlinear Optical Materials, Institute for Mathematics and its Applications, Univ. of Minnesota, 206 Church St., SE, Minneapolis, MN 55455. (Apr. 1995, p. 482)

Topics: This workshop will serve to highlight the current state of mathematical models with regard to materials for nonlinear optics applications. The strength of the nonlinear interaction and the effective interaction length play a crucial role in determining whether a material may prove useful or not for a particular application. An ongoing theme of the workshop will be whether there exist scaling laws which would allow one a priori to design nonlinear optical materials which compromise between large interaction lengths and fast response times. The great technological success of optical fibers as soliton transmission systems, for example, hinges on the availability of very large interaction lengths in modern single-mode low-loss fibers, which compensate for

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 listing of meetings of the Society, and of meetings sponsored by the Society, will be found on the first page of the Meetings and Conferences section.

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@math.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.)
the very weak nonlinear refractive interaction of the glass. In contrast, many nonlinear optical applications require very short interaction lengths (microns) for ultrafast integrated optical processing of information. Low-dimensional structures obtained by molecular beam epitaxy and other interaction lengths (micros) for ultrafast telecommunications. Solitons and wave propagation in nonlinear dispersive media are of current interest in nonlinear optical communications involving both laser sources and optical processing elements; design principles are as yet poorly supported by theory. Theoretical support is needed for emerging design principles.

**Information:** For further information see the Web page: http://www.ima.umn.edu/map.html#sp.workshop9 or by e-mail to staff@ima.umn.edu, or by regular mail to the Institute for Mathematics and its Applications, Univ. of Minnesota, 514 Vincent Hall, Minneapolis, MN 55455.

*6-7* Communication Networks and Neural Networks: The Challenge of Network Intelligence, Duke University, Durham, NC. **Focus:** This workshop will focus on the use of neural network and fuzzy logic methodology to design, analyze and control computer and communication networks. **Abstract Topics:** Contributions in the form of four-page extended abstracts (including references) are solicited in, but not limited to, the following research topics: intelligent networks; communication network adaptation and control; traffic analysis and modeling using neural networks; prediction of traffic and user behavior using neural networks; neural and fuzzy logic models for telecommunication networks; neural networks, multimedia services and imaging. **Proceedings:** The workshop proceedings will be published in book form. Submissions should be sent before February 1, 1996, to one of the workshop organizers.

**Organizers:** E. Gelenbe, Dept. of Electrical and Computer Engineering, Duke Univ., Durham, NC 27708-0291, e-mail: egel@ ee.duke.edu. I. Habib, Dept. of Electrical and Computer Engineering, City College, CUNY, New York, NY 10031; e-mail: ibhacc@ cunyvm.cuny.edu.

*6-8* 20th Annual Conference of the German Society for Classification, Freiburg, Germany. (Feb. 1996, p. 240)

*7-9* Joint Spring Topology Conference and Southeast Dynamical Systems Conference, Ball State University, Muncie, Indiana. (Dec. 1995, p. 1565)


*15-16* Eleventh Auburn Miniconference on Real Analysis, Auburn University, Auburn, AL. (Feb. 1996, p. 240)

**Principal Speakers:** A. W. Miller (Univ. of Wisconsin), L. Larson (Univ. of Louisville). **Information:** NSF support provides lodging for faculty participants and travel support for student participants. No registration fee. Sessions for contributed 20-minute talks both days. Deadline for inclusion on schedule: early March. For more information: E. Brown, tel: 334-844-6595, e-mail: broon4@ mail.auuburn.edu, or G. de Souza, tel: 334-844-6565, e-mail: desouga@mail.auuburn.edu.


*17-20* IMS Eastern Regional Meeting, Richmond, VA. (Feb. 1996, p. 240)

*17-21* Prospects in Mathematics, Princeton, NJ. (July 1995, p. 794)

*21* Workshop on Arrangements of Hyperplanes, University of Iowa, Iowa City, Iowa. **Speakers:** J. Damon, R. Hain, M. Oka, L. Paris, H. Terao. **Organizers:** M. Falk and R. Randell. **Information:** This informal workshop precedes the Special Session on Arrangements of Hyperplanes to be held during the Iowa City Meeting of the AMS, March 22-23. See Meetings pages for the list of speakers in the Special Session. More information, including titles and abstracts, will be available at http://www.math.uiowa.edu/faculty/hyperplanes.html.

*21-22* Barrett Lectures, University of Tennessee, Knoxville, TN. (Jan. 1996, p. 61)

*21-24* Conference Honoring I. Babuska, University of Maryland, College Park, MD. (Feb. 1996, p. 240)

*22-23* Central Section, University of IA, Iowa City, IA. **Information:** W. Drady, AMS, P.O. Box 6887, Providence, RI 02940; e-mail: wad@math.ams.org.

*23* Second South Eastern Linear Algebra Meeting, Williamsburg, Virginia. **Purpose:** The second South Eastern Linear Algebra Conference will be held at the College of William and Mary on Saturday, March 23, 1996. The meeting will be on linear algebra and its applications - matrix theory, numerical linear algebra, linear algebra in optimization.

**Deadlines:** There will be no registration fee, and the organizers do not have funds to support participants. The deadline for titles and abstracts of talks is Feb. 15, 1996.

**Information:** Updated information of the meeting and some local information of Williamsburg can be found on the WWW site http://www.cs.wm.edu/~ckilisi/sealim.html. There will be another public announcement including the titles of the talks in late February. Please send your e-mail address to C.-K. Li, cki@cs.wm.edu or R. Mathias, mathias@es.wm.edu to be put on the list to receive further mailings.


*25-29* IMA Workshop on Topics Related to Nonlinear PDE, Univ. of Minnesota, Minneapolis, MN. **Organizers:** V. Sverak (Univ. of Minnesota), S. Müller (Universität Freiburg). **Information:** Further information: http://www.ima.umn.edu/map.html#sp.workshop10, by e-mail to staff@ima.umn.edu, or by regular mail to the Institute for Mathematics and its Applications, Univ. of Minnesota, 514 Vincent Hall, 206 Church St., Minneapolis, MN 55455.


*28-31* 27th Annual Iranian Mathematics Conference, Shiraz University, Shiraz, Iran. (Sept. 1995, p. 1070)


**April 1996**

*1-3* Data Compression Conference - DCC '96, Snowbird, Utah. (Feb. 1996, p. 241)


*1-5* Advanced 5-day Course on Partial Differential Equations, Group Theory, and Variational Calculus, INRIA, Rocquencourt, France. **Purpose:** The purpose of this course is to give a self-contained, rather complete introduction to new techniques, at a graduate level. A particular emphasis will be put on the modern development of the variational calculus by exhibiting its link with both jet theory (higher order variational calculus, variational sequence, inverse problem of the calculus of variations, etc.) and group theory (first and second Noether theorems, etc.). The course will also provide for the
first time the group theoretical unification of finite element method for engineering sciences along the lines already proposed at the beginning of the century by the brothers E. and F. Cosset for elasticity, H. von Helmholtz for heat and H. Weyl for electromagnetism.


Registration: The number of participants is limited, so early subscription is advised. Upon receipt of your registration form, confirm your attendance. Additional information, and an invoice will be sent.

Information: For more information, contact the Course Director: J. F. Pommaret, tel: +33-1-4914-3585; fax: +33-1-4914-3572; e-mail: serre@cerma.enpc.fr.


3 Dynamics and Optimal Control of Turbulence and Combustion: Basic Research and Industrial Applications, United Technologies Research Center, E. Hartford, CT. (Jan. 1996, p. 61)

9-11 Real Numbers and Computers, Marseille, France. (Feb. 1996, p. 241)

9-12 Thirteenth European Meeting on Cybernetics and Systems Research, University of Vienna. (Aug. 1995, p. 904)

9-13 1996 Copper Mountain Conference on Iterative Methods, Copper Mountain, CO. (Feb. 1996, p. 241)


12-16 Recent Developments in Number Theory, Nottingham, UK. (Feb. 1996, p. 241)


15-May 3 School on Nonlinear Functional Analysis and Applications to Differential Equations, International Center for Theoretical Physics, Trieste, Italy. (July 1995, p. 794)

17-20 European Workshop on Kinetic Equations, Granada, Spain.


Information: To receive further information by e-mail: japm@ugr.es or carrillo@lta.ugr.es, Departamento de Matematica Aplicada, Universidad de Granada, 18071-Granada, Spain.


18-21 The University of Notre Dame Symposium on Current and Future Directions in Applied Mathematics, Department of Mathematics, University of Notre Dame, Notre Dame, IN 46556-5863.

Program: Invited speakers will deliver one-hour lectures on current and future trends in their research field. The lectures will be complemented by a number of mini-sessions which will focus on specific research areas in applied mathematics. A panel discussion is planned for Saturday, April 20, about the role of applied mathematics in the next decade. Because of the special scope of this symposium, the organizers encourage the participation of graduate students.

Principal Speakers: The principal speakers are as follows: R. Brockett (Harvard Univ.), C. Byrnes (Washington Univ. St. Louis), J. Chadam (Fields Inst.), N. Ercolani (Univ. of Arizona), R. Elwing (Texas A & M Univ.), A. Friedman (IMA Univ. of Minnesota), D. McLaughlin (Courant Inst. of Mathematical Sciences), J. Marsden (Control and Dynamical Systems, Caltech), M. Todd (Cornell Univ.).

Contributed Talks: The organizers are soliciting contributed talks and small cohesive sessions focusing on new or emerging topics in applied mathematics. Prospective contributors and organizers of sessions should submit an extended abstract of approximately two pages to the organizing committee by February 15, 1996. Submissions should be sent either electronically to the mail collection: sym@kenna.math.nd.edu, or by regular mail to: Applied Mathematics Symposium, Dept. of Mathematics, Univ. of Notre Dame, Notre Dame, IN 46556-5863.


Sponsors: Dept. of Mathematics, BRMS Hewlett Packard Research Lab, Center for Applied Mathematics, College of Science.

Information: All requests about the symposium should be sent to sym@kenna.math.nd.edu. Further information can be obtained via the World Wide Web address: http://www.science.nd.edu/math/symposium.html.

19-21 Southeastern Section, Baton Rouge, LA.

Information: W. S. Drady, AMS, P.O. Box 6887, Providence, RI 02940; e-mail: wsd@math.ams.org.


May 1996


4-5 Pacific Northwest Geometry Seminar (Spring Meeting), University of Washington, Seattle, WA. (Jan. 1996, p. 62)


8-10 IMA Tutorial on Monte Carlo Methods, Univ. of Minnesota, Minneapolis, MN. (Sept. 1995, p. 1070)

9-11 International Conference on Nonlinear Problems in Aviation and Aerospace, Daytona Beach, FL. (Jan. 1995, p. 79)

12-16 Second Magma Conference on Computational Algebra, Marquette University, Milwaukee, Wisconsin.

Conference Themes: An interdisciplinary conference on computational algebra and number theory, computer algebra and their applications. The purpose of this conference is to bring together mathematicians and software developers to present recent developments in cognate areas of computational algebra and number theory, to inform theoreticians about available computational tools and provide an opportunity to become familiar with their use, to identify desirable directions for theoretical research and practical development, and to promote the use of advanced tools in applied areas.

Topics: Computational methods for, but not restricted to, the following areas: Algebraic geometry, cohomology, commutative algebra, elliptic curves, finite fields, finite geometry, group theory, knot theory, module theory, number theory, ring theory, and semigroups. Application of such techniques to problems in algebra, coding theory, combinatorics, cryptography, design theory, discrete signal processing, hardware design and physics.

Conference Structure: Invited talks, contributed talks, workshops, software demonstrations, and poster sessions.

Submissions and Timetable: Besides the invited lectures and workshops, a number of sessions for the presentation of 30-minute contributed talks are planned. Please send an extended abstract (one to three pages) for proposed contributed talks in an area relevant to the Conference to the address listed below before March 8, 1996. The program committee will make a selection before April 1 of talks to be presented in Milwaukee; speakers will be invited to submit a full paper, which will undergo the refereeing process for the Journal of Symbolic Computation. If necessary a poster session will be organized to allow additional contributions to be presented.

The organizers also welcome submissions for the demonstration of software; send a short (one-page) proposal to the address below before March 8, 1996.


13-16 IMA Workshop on Numerical Methods for Polymeric Systems, Univ. of Minnesota, Minneapolis, MN. (Sept. 1995, p. 1070)

Topics: A wide variety of different states of matter involve polymers. Some obvious examples include the arrangement of polymers in crystals and fibers, glasses, gels and the rubbery state, melts and solutions, as well as polymers at interfaces and in confined geometries. Two families of numerical techniques which are widely used in many of these areas are Monte Carlo methods and molecular dynamics. For dilute polymer solutions, Monte Carlo algorithms are becoming well understood. For more strongly interacting systems, such as dense polymer systems or isolated polymers with strong attractive forces, the situation is much less advanced: the theory of the algorithms is not fully developed.

The workshop will bring together people working on Monte Carlo methods for the simpler systems and for the more complex systems. At the same time, where dynamic information is required, the most successful approach may be molecular dynamics.

Organizer: S. Whittington.

Information: http://www ima.umn.edu/map.html or by e-mail to staff@ima.umn.edu, or by regular mail to the Institute for Mathematics and its Applications, Univ. of Minnesota, 514 Vincent Hall, Minneapolis, MN 55455.

13-17 64e Congrés de l'Association Canadienne-Française pour l'Avancement des Sciences, Montréal, Québec. (Feb. 1996, p. 241)


17-18 Mathematics for Undergraduate Life Sciences Students, Iowa State University, Ames, Iowa.

Program: The focus of the conference will be on mathematics motivated by biological experiments or data readily available to undergraduate life sciences students.

Invited Speakers: J. Cushing, Univ. of Arizona, L. Gross, Univ. of Tennessee-Knoxville, J. Jungck, Beloit College.


Deadlines: Abstracts should be submitted to J.L. Cornette (e-mail: cornette@iastate.edu) by April 1, 1996.

Information: The conference is partly funded by the Division of Undergraduate Education, National Science Foundation. Food and lodging for 50 participants will be provided, with preferences to participants contributing papers and to insure substantial groups of both life scientists and mathematicians. Current program information can be found on the World Wide Web at http://www.public.iastate.edu/~mathclasses/unconf.html.

19-23 Conference on Applied Computational Fluid Dynamics, Freiburg, Germany. (Feb. 1996, p. 242)


20-23 Parallel CFD'96, Capri, Italy. (Feb. 1996, p. 242)

21-23 2nd International Symposium on Spatial Accuracy Assessment in Natural Resources and Environmental Sciences, Fort Collins, Colorado. (Feb. 1996, p. 242)

20-24 The 6th Asian Logic Conference, Beijing, P. R. China. (Sept. 1995, p. 1070)

20-June 7 MONTREAL 96 Summer School on Nonlinear Dynamics in Physiology and Medicine, McGill University, Montreal, Quebec, Canada.

Program: At a combination of integrated lectures and computer laboratories/demonstrations, with exercises in numerical computation and data analysis. Designed for an interdisciplinary audience, with strong emphasis on examples from biological research, and on the use of traditional and newer techniques for time series analysis.

Topics: Week 1: Introduction to nonlinear dynamics. Applications: behaviour of spontaneous and forced nerve and cardiac cells, the control of respiration.

Week 2 (two parallel streams): 1) Intermediate nonlinear dynamics: systems with spatial dependence, delayed feedback and/or stochastic influences. 2) Linear and nonlinear time series analysis. Applications: excitable media, biological pattern formation, hematological cell regulation systems, analysis of data from physiological time series such as heart rate.

Week 3: Five in-depth case studies of modeling and data analysis in biology: stochastic resonance in mammalian temperature receptors; dynamics of the pupil light reflex; human tremor; firing patterns of the forced squad giant axon; traveling and spiral waves in cardiac tissue.

Presented by: Faculty of the Centre for Nonlinear Dynamics in Physiology and Medicine.

Information: Montreal96 Summer School, Centre for Nonlinear Dynamics, McGill Univ, 3655 Drummond St., Montreal, Quebec, Canada H3G 1Y6; tel: 514-398-2102; fax: 514-398-7452; e-mail: montreal96-info@nd.mcgill.ca. WWW: http://www.cnd.mcgill.ca/montreal96.

22-26 Great Plains Operator Theory Sym-
Mathematics Calendar

posium, Arizona State University, Tempe, Arizona. (Oct. 1995, p. 1164)


27-30 28e Journees de Statistique de l'Association pour la Statistique et ses Utilisations, Quebec City, Quebec. (Feb. 1996, p. 242)


29-June 1 International Conference on Dynamical Systems and Differential Equations, Southwest Missouri State University, Springfield, MO. (Feb. 1996, p. 242)

June 1996


3-6 IMA Tutorial on Topology and Statistical Mechanics of Polymers, Univ. of Minnesota, Minneapolis, MN. (Sept. 1995, p. 1070)

3-7 8th Quadrrennial International Conference on Graph Theory, Combinatorics, Algorithms and Applications, Kalamazoo, Michigan. (Feb. 1996, p. 242)


3-7 Fourth International Conference on p-Adic Functional Analysis, University of Nijmegen, Nijmegen, The Netherlands. (Sept. 1995, p. 1070)

3-7 Eighth Quadrrennial International Conference on Graph Theory, Combinatorics, Algorithms, and Applications, Western Michigan University, Kalamazoo, MI. (May 1995, p. 395)

3-8 Ninth International Conference on Domain Decomposition Methods, By the Hardanger Fjord, near Bergen, Norway. (Oct. 1995, p. 1165)

3-12 Integral Geometry, Radon Transform and Complex Analysis, Ca' Dolfin, Venezia, Italy. (Feb. 1996, p. 242)


Local Coordinator: J. Wolfe, Dept. of Math., Oklahoma State Univ., Stillwater, OK 74078-0001; tel: 405-744-5781.


10-14 IMA Workshop on Topology and Geometry in Polymer Science, Univ. of Minnesota, Minneapolis, MN. (Sept. 1995, p. 1070)

Topics: Linear polymer molecules in dilute solution are highly flexible and can be self-entangled, especially in more concentrated solutions, or in the melt. It is only recently that the powerful methods of algebraic topology have been used systematically to characterize and describe these entanglements. Starting from the simplest possible system (a ring polymer in dilute solution) one needs to ask how badly knotted the polymer will be, as a function of the degree of polymerization, the stiffness, the solvent quality, etc. When linking between rings is possible, these links (or catenanes) will influence the static and dynamic properties of the solution. At another level, one then needs to know how entanglement complexity will affect rheological properties. For instance, what is the contribution of entanglements to the elastic properties of a rubbery polymer? The workshop will bring together topologists, combinatorialists, and members of the theoretical polymer physicists and chemistry communities.

Organizers: S. Whittington (smithing@alchemistry.chem.utoronto.ca), D. W. Sumners (SUMNERS@GAUSS.MATH.FSU.EDU) and T. Lodge (lodge@chemsun.chem.umn.edu).

Information: http://www.ima.umn.edu/msp.html#msp.workshop12, by e-mail to staff@ima.umn.edu, or by regular mail to the Institute for Mathematics and its Applications, Univ. of Minnesota, 514 Vincent Hall, Minneapolis, MN 55455.

10-14 Conference in Honor of Peter D. Lax and Louis Nirenberg, Venice, Italy. (Feb. 1996, p. 243)

10-15 Conference in Mathematical Analysis and Applications, Linkoping University, Sweden.


* 12-15 ATLAST 1996 Linear Algebra Workshop, Salve Regina University, Newport, RI. Workshop Presenter: S. Leon, Univ. of Massachusetts, Dartmouth.

Program: ATLAST is an NSF Project to Augment the Teaching of Linear Algebra through the use of Software Tools. Workshop participants will learn about existing software for linear algebra and will be trained in the use of the MATLAB software package. Attendees will design classroom lessons that incorporate computer software making use of ATLAST materials that were developed in previous workshops. These materials will be included in the forthcoming "ATLAST Book of Computer Exercises" (Prentice-Hall, Fall, 1996). Participants will also learn to design computer exercises and lab projects for inclusion in the ATLAST database and possible inclusion in future editions of the ATLAST book.

Applications and Deadlines: All teachers of undergraduate linear algebra courses at colleges or universities in the USA are invited to apply for the ATLAST workshops. The deadline for applications is March 21, 1996. Late applications will be accepted on a space-available basis. Each workshop will be limited to thirty participants. A screening committee will review applications and notify applicants of its decisions by the beginning of April. For instructions on applying contact: S. J. Leon, ATLAST Project Director, Department of Mathematics, University of Massachusetts Dartmouth, North Dartmouth, MA 02747-2300; tel: 508-999-8329; fax: 508-999-8901; e-mail: ATLAST@UMASS.EDU.


13-16 1996 Joint Annual Meeting of the Classification Society of North America and the Numerical Taxonomy Group, University of Massachusetts, Amherst, MA. (Oct. 1995, p. 1163)


15-19 Sixth International Conference on Hyperbolic Problems, Theory, Numerics, Applications, Hong Kong. (Oct. 1995, p. 1165)


17-21 Householder Meeting on Numerical Algebra, Pontresina, Switzerland. (Feb. 1996, p. 243)


* 17-27 Summer School on Symmetries and Differential Equations and Workshop on Lie Symmetry Software with Applications to Nonlinear Problems, International Sophus Lie Centre (ISLC), Nordfjordeid, Norway.


22-23 University of Minnesota Conference on Inference and Applications Honoring the 25th Year of the School of Statistics, Minneapolis, Minnesota. (Feb. 1996, p. 243)

* 22-26 Art and Mathematics Conference (AM96), SUNY-Albany, Albany, New York. Theme: AM96 is the fifth annual interdisciplinary conference relating art and mathematics.

Information: N. Friedman, Dept. of Math. and Stat., SUNY, Albany, NY 12222; e-mail: artmath@math.albany.edu; fax: 518-442-4731; tel: 518-442-4621.

23-26 International Conference on Multiple Comparisons, Tel Aviv, Israel. (Feb. 1996, p. 243)

Local Coordinator: M. Scherer, Dept. of Math., Univ. of Redlands, Redlands CA 92373; tel: 909-793-2121.


24-26 IMS Western Regional Meeting and International Biometric Society/WNAR Summer Meeting, Pullman, Washington. (Feb. 1996, p. 244)

24-27 First Workshop on Numerical Analysis and Applications, Russia, Bulgaria. (Feb. 1996, p. 244)

* 24-28 A Reform Calculus Shortcourse: Calculus Enhanced With Computer-Algebra and Grading Using the TI-92, University of Massachusetts, Amherst, MA. Program: Each participant will have loan of a TI-92 for the week. Computer based laboratory instruments will also be available for data collection. Real-world applications and other calculus reform pedagogy will be featured.

Presenter: J. Fiedler, Ph.D., Visiting Professor at the Ohio State University; F. Demana, Ph.D., the Ohio State Univ., will be a guest lecturer one day.
Information: There are a limited number of spaces available. Applicants will be accepted on a first-come first-served basis upon receipt of the $150 registration fee. Conference rates are available at the Campus Center Hotel. Please make checks payable to the University of Massachusetts Amherst Mathematics Department and mail to: M. A. Connors, Dept. of Mathematics and Statistics, Lederle Graduate Research Tower, Univ. of Massachusetts, Amherst, MA 01003; tel: 413-545-0907; e-mail: mconnors@math.umass.edu.

24-28 Advances in Computational Fluid Dynamics, Louisiana Tech University, Ruston, Louisiana. (Feb. 1996, p. 244)


* 25-28 Thirteenth Dundee Conference on Ordinary and Partial Differential Equations, Dundee, Scotland.

Purpose: The purpose of the conference is to bring together research workers with a common interest in differential equations and their applications. The theme of the meeting is the study of ODEs and PDEs as models arising in physical and biological systems, including electromagnetic, acoustic, electronics, and fluids. Particular attention will be focused on recent developments in the analysis of wave propagation, inverse problems, and dynamical
systems, including nonlinear systems. The program will consist of invited and contributed lectures.


**Contributed Talks:** Contributed talks are invited on any work connected with ordinary and partial differential equations and their applications. Twenty-five minutes will be allocated to each speaker for presentation and discussion.

**Information:** Further information and application forms may be obtained from the conference WWW page: http://www.mcs.dundee.ac.uk:8080/-deconf/index.html or by contacting the conference secretary: Conference on Differential Equations, R. J. Jarvis, Dept. of Mathematics and Computer Science, Univ. of Dundee, Dundee DD1 4HN, Scotland, U.K.; e-mail: deconf@mcs.dund.ac.uk.


25-29 Summer School on Conformal Geometry and Geometric Function Theory, Segovia, Spain. (Feb. 1996, p. 244)

25-30 Second Siberian Congress On Industrial And Applied Mathematics (INPRIM-96), Novosibirsk Akademgorodok, Novosibirsk, Russia.

**Presentation:** The Sobolev Institute of Mathematics, the Institute of Informatics Systems, the Institute for Computational Technology, and the Computer Center of the Siberian Branch of the Russian Academy of Sciences, together with Novosibirsk State University, Novosibirsk State Technological University, and the Siberian Society for Promotion of Science and Education (SIBOS) conven the International Congress INPRIM-96. Dedicated to the memory of A. A. Lyapunov (1911-1973), A. P. Ershov (1931-1988), and I. A. Potalet (1915-1983).


**Information:** All questions concerning participation in the Andrei Ershov Second International Memorial Conference should be addressed to the chairman of the indicated conference, Alexandre Zamulin, Institute of Informatics Systems, 6, Lavrentjev pr., 630090 Novosibirsk, Russia; tel: +7-3832-396288; fax: +7-3832-350692; e-mail: zamulin@inprim.math.nsk.su. Please inform the organizers that your decision to participate in the congress by March 1, 1996. Forward your mail to Sergey Treskov, Institute of Mathematics, 630090 Novosibirsk, Russia, phone: +7-3832-350692; fax: +7-3832-350692; e-mail: inprinmath.math.nsk.su. Indicate in your Pre-registration form, 1. First name 2. Middle name 3. Last name 4. Position 5. Address 6. Fax 7. Phone 8. E-mail 9. Title and one page abstract of the talk 10. Date of birth 11. Citizenship 12. Passport

July 1996

1-4 Finite Element Methods: Superconvergence, Post-Processing and A Posteriori Estimates, University of Jyväskyla, Finland. (Feb. 1996, p. 244)

1-5 Grid Adaptation in Computational PDEs: Theory and Application, Edinburgh, Scotland. (Jan. 1996, p. 63)

1-5 8th International Biometric Conference, Amsterdam, The Netherlands. (Feb. 1996, p. 244)

1-5 Semigroups and Their Applications, Prague, Czech Republic. (Feb. 1996, p. 244)

1-7 Contemporary Problems in the Theory of Dynamical Systems, Nizhny Novgorod, Russia. (Nov. 1995, p. 1366)

1-12 SMS NATO ASI: Graph Symmetry: Algebraic Methods and Applications, Université de Montréal, Montréal, Canada. (Dec. 1995, p. 1567)

*2-5 International Research Conference on Mathematical Models of Nonlinear Excitation, Transport, Dynamics, Control in Condensed Systems and Other Mediums, Tver State Technical University, Tver, Russia.

Topics: The nonlinear excitation in condensed systems; numerical modeling and algorithms; the mathematical models of transport processes and external influences in nonlinear systems; dynamics and structures of the molecular and biomolecular systems; nonlinear systems evolution. It is planned to discuss both the fundamental and applied problems.

Organizers: Tver State Technical Univ., the State Higher Educational Committee of the Russian Federation, the Russian Academy of Sciences, Institute of Mathematical Problems of Biology (Puschino).

Conference Program: Plenary reports (40 minutes), sectional reports (20 minutes), stand reports, round-table talks. Official languages: English, Russian.

Publication: Conference proceedings will be published after the conference. The application form and the abstracts should be sent to the Organizing Committee by May 20, 1996, by post or e-mail. The abstracts of communications will also be published.


Information: All correspondence should be sent to L. A. Uvarova at Dept. of Information and Applied Mathematics, Tver State Technical Univ., Aphanasty Nikitin embankment, 22, 170626, Tver, Russia. Teltype: 17155; "Znanie"; e-mail: post@polish.tver.su; fax: +7-095-531-24-03 (in the left upper corner write: Box 3267).

*2-12 Advanced Courses—Geometry and Physics, Centre de Recerca Matematia, Bellaterra, Spain.

Speakers: G. Sehgal, Cambridge Univ., "Conformal Field theories"; D. Kotschick, Univ. of Basel, "Four-manifolds and Seiberg-Witten gauge theory"; L. H. Kauffman, Univ. of Illinois at Chicago, "Invariants of links and manifolds". The lectures will be held in the morning; afternoons will be devoted to complementary activities (problem sessions, expository talks, seminars).

Coordinators: S. Xambo, V. Navarro.

Grants: The CRM can offer a limited number of grants covering the registration fees. The deadline for applying is March 20, 1996.

Registration: Fee: 20,000 pta. Deadline: April 15, 1996. Payment for registration and accommodation should be made by April 15, 1996.

Accommodation: The CRM can offer accommodation from July 1 to July 12 (11 nights). (See registration form for more details.)

Information: WWW: http://crm.es or ftp crm.es or mail crm@crm.es.

*5-8 The 1996 Annual Conference of the Australasian Association for Logic, University of Queensland, Brisbane, Australia.

Organizer: This conference is being organized by the incoming AAL president, L. Hinkefuss, Philosophy Dept., Univ. of Queensland, Australia, 4072; e-mail: Hinkefuss@lingua.citrus.uq.oz.au; fax: +61-0-7-33651968; tel: +61-0-7-33652578.

Information: For more information about accommodations, please contact: J. Sipek, Operations Manager, The Women's College, Univ. of Queensland, Australia, 4072; tel: +61-0-7-38701171; fax: +61-0-7-38709511.

7-11 Symposium on Finite Element Applications in Fluid Dynamics, San Diego, California. (Feb. 1996, p. 244)

7-11 Symposium on Numerical Developments in Computational Fluid Dynamics, San Diego, California. (Feb. 1996, p. 245)

7-12 40th Annual Meeting of the Australian Mathematical Society, Flinders University, Adelaide, South Australia. (Feb. 1996, p. 245)

7-14 Financial Mathematics, Accademia Cusano, Bressanone (BZ), Italy. (Feb. 1996, p. 245)


8-10 Heat Transfer 96 (Fourth International Conference on Advanced Computational Methods in Heat Transfer), Udine, Italy. (June 1995, p. 704)

8-12 Prague Mathematical Conference 1996, Prague, Czech Republic. (Apr. 1995, p. 482)

8-12 Sydney International Statistical Congress, Sheraton-Wentworth Hotel, Sydney, Australia. (Nov. 1995, p. 1366)


8-19 Composition Operators on Spaces of Analytic Functions, University of Wyoming, Laramie, Wyoming. (Jan. 1996, p. 64)


10-17 The Second World Congress of Nonlinear Analysis, Athens, Greece, or Istanbul or Ankara, Turkey. (Feb. 1993, p. 281)

13-18 Algebra and Discrete Mathematics: Group Theory: Finite to Infinite, Cagliari. (May 1997, p. 64)

14-19 The Seventh International Conference on Fibonacci Numbers and Their Applications, Technische Universität Graz, Austria. (Apr. 1995, p. 482)


15-19 International Summer School on Evolution Equations, Prague, Czech Republic. (Jan. 1996, p. 64)

15-19 Numerical Methods and Computational Mechanics in Science and Engineering; Second Announcement and Call for Papers, Miskolc, Hungary. (Jan. 1996, p. 64)

15-19 Universal Algebra and Lattice Theory, Szeged, Hungary. (Feb. 1996, p. 245)


15-26 IMA Summer Program on Emerging Applications of Number Theory, Univ. of Minnesota, Minneapolis, MN. (Sept. 1995, p. 1071)

*16-26 Summer School—Commutative Algebra, Centre de Recerca Matematia, Bellaterra, Spain.


Second week, July 22-26: M. Green, Univ. of California, Los Angeles, "Some interactions between commutative algebra and algebraic geometry"; C. Hunek, Purdue Univ., "The theory of tight closure"; W. Vasconcelos, Rutgers Univ., "Rees algebras, Noether normalizations and complexity theory". The course will mainly consist of 6 series of 5 lectures surveying and highlighting recent developments in commutative algebra in a broad sense, including areas shared with other fields in mathematics. There will also be addressed talks and complementary activities: problem sessions, expository talks, seminars, computer demos. Participants interested in giving a short talk (30 min.) should submit an abstract by the end of February 1996. Depending on the numbers, the coordinators
24-26 ISSAC'96 International Symposium on Symbolic and Algebraic Computation, Zürich, Switzerland. (Jan. 1996, p. 64)

24-27 1996 Linear Algebra Workshop: University of California San Diego, La Jolla, CA.
Workshop Presenter: L. Roberts, Georgia Southern University.
Program: ATLANT is an NSF Project to Augment the Teaching of Linear Algebra through the use of Software Tools. Workshop participants will learn about existing software for linear algebra and will be trained in the use of the MATLAB software package. Attendees will design classroom lessons that incorporate computer software making use of ATLANT materials that were developed in previous workshops. These materials will be included in the forthcoming "ATLAST Book of Computer Exercises" (Prentice-Hall, Fall, 1996). Participants will also learn to design computer exercises and lab projects for inclusion in the ATLANT database and possible inclusion in future editions of the ATLANT book.

Applications and Deadlines: All teachers of undergraduate linear algebra courses at colleges or universities in the USA are invited to apply for the ATLANT workshops. The deadline for applications is March 21, 1996. Late applications will be accepted on a space available basis. Each workshop will be limited to thirty participants. A screening committee will review applications and notify applicants of its decisions by the beginning of April. For instructions on applying contact: S. J. Leon, ATLANT Project Director, Department of Mathematics, University of Massachusetts Dartmouth, North Dartmouth, MA 02747-2300; tel: 508-999-8320; fax: 508-999-8901; e-mail: ATLAST@UMASS.EDU.


27-August 3 1996 Federated Logic Conference, Rutgers University, New Jersey. (Jan. 1996, p. 64)

Instructors: F. Wattenberg, M. Mankus (Weber St. Univ.), L. Peterson (Bonneville H. S.).
Local Coordinator: G. Wayne, Penn. State Univ., University Park, PA 16803; tel: 814-865-3661; e-mail: wayne@math.psu.edu.


30-August 8 14th Brazilian Algebra Meeting, IMPA, Rio de Janeiro, Brazil. (Feb. 1996, p. 245)

30-August 10 Eighth International Conference on Representations of Algebras and Related Topics (ICRA VIII), Trondheim and Geiranger, Norway. (Feb. 1996, p. 245)

August 1996


6-9 Workshop on Numerical Ranges and Numerical Radii, Sapporo, Japan. (Feb. 1996, p. 246)


12-16 2nd China Matrix Theory Conference, Jilin, Taiwan. (Feb. 1996, p. 246)


12-13 School on Algebraic Groups & Arithmetic Groups, International Centre for Theoretical Physics. (July 1995, p. 795)

13-17 Fifth International Colloquium on Numerical Analysis, Plovdiv, Bulgaria. (Apr. 1995, p. 482)

14-17 International Linear Algebra Society Meeting, Chemnitz, Germany. (Jul./Aug. 1994, p. 679)


17-22 Fifth Conference of the Canadian Number Theory Association, Carleton University, Ottawa, Ontario, Canada. (Feb. 1996, p. 246)
18-23 Seventh International Colloquium on Differential Equations, Plovdiv, Bulgaria. (Apr. 1995, p. 482)

18-24 8th Prague Topological Symposium on General Topology and its Relations to Modern Analysis and Algebra, Prague, Czech Republic. (Sept. 1995, p. 1071)


26-29 3rd Gauss Symposium, Beijing, China. (Feb. 1996, p. 247)


26-31 4th World Congress, Vienna, Austria. (Feb. 1996, p. 247)

*31-September 4International Conference Generalized Functions-Lineal and Non-linear Problems (GF-96), Novi Sad, Yugoslavia.

Organized By: Institute of Mathematics, Novi Sad, Yugoslavia.

Chairmen: B. Stankovic, S. Pilipovic.

Call for Papers: Abstracts of the lectures will be published before the Proceedings after the Conference.

Deadline: The registration form should be sent to the organizers by March 1, 1996.

Information: S. Pilipovic, Institute of Mathematics (GF-96), Faculty of Science, University of Novi Sad, Trg D. Obradovica 4, 21000 Novi Sad, Yugoslavia; tel./fax: +381-21-350-458; e-mail: gf96@unsin.ns.ac.yu.

September 1996

2-5 International Conference on Non-linear Programming, Beijing, China. (Feb. 1996, p. 247)

3-14 Advanced Courses-Homotopy Theory, Localization and Periodicity, Centre de Recerca Matematica, Bellaterra, Spain.

Speakers: E. D. Farjoun, Hebrew Univ. of Jerusalem, "Null spaces and periodicity in unstable homotopy"; D. C. Ravenel, Univ. of Rochester, "Localization and periodicity in stable homotopy". The lectures will be held in the morning; afternoons will be devoted to complementary activities (problem sessions, expository talks, seminars).

Coordinator: C. Broto.

Grants: The CRM can offer a limited number of grants covering the registration fee. The deadline for applying is May 31, 1996.

Registration: Fee: 20,000 pta. Payment for registration and accommodation should be made by June 20, 1996.

Accommodation: The CRM can offer accommodation from September 2 to September 14 (12 nights). (See registration form for more details.)

Information: WWW: http://czc.es or ftp crm.es or mail crm@czc.es.

8-14 Combinatorics 96, Centro Congressi La Cittadella, Assisi (Perugia), Italy. (Feb. 1996, p. 247)

9-13 2nd European Nonlinear Oscillations Conference, Prague, Czech Republic. (Oct. 1995, p. 1166)


9-14 International Conference on Inverse and Ill-Posed Problems, Moscow, Russia. (Feb. 1996, p. 246)


23-27 First Conference of Balkan Society of Geometers, University Politehnica, Bucharest, Romania.

Invited Speakers: P. Antonelli (Canada), N. Blazic (Yugoslavia), R. Gardner (USA), Th. Hang (France), S. Marchiafava (Italy), S. Robertson (England), R. Santilli (USA-Italy), G. Tsagas (Greece), L. Vanhecke (Belgium).

Scientific Committee: R. Miron (Romania), G. Tsagas (Greece), C. Udriste (Romania), G. Staniol (Bulgaria), S. Janus (Romania), S. Marchiafava (Italy), N. Bokan (Yugoslavia), L. Vanhecke (Belgium).

Information: Deadline September 1, 1996. For more information, please contact the organizers: C. Udriste, Univ. Politehnica of Bucharest, Dept. of Mathematics, Bd. Independentei 313, 75950 Bucharest, Romania; fax: 401-312-53-65; e-mail: udriste@math.pub.ro.


24-26 BEM 18 18th International Conference on Boundary Element Methods, Braga, Portugal. (Dec. 1995, p. 1569)

24-26 ESF Workshop on Computation of Free Boundaries and Optimal Shapes (Journees Numeriques de Besancon '96), Lamoura (Jura), France.

Sponsors: European Science Foundation, C. N. R. S.

Organizers: A. Henrot (chairman, Besancon), J.-M. Crolet (Besancon), G. Dziuk (Freiberg), J. Rappaz (Lausanne), C. Verdi (Milano).

Key Words: Numerical analysis, free boundaries, shape optimization.

Deadline: For submission of abstracts: March 1, 1996.

Theme: Free boundary problems and shape optimization are two very active fields of research today, as much in problems from industry as in deep theoretical and numerical mathematics research. The aim of this meeting is to take stock of these subjects and to develop more particularly the numerical aspects (methods and algorithms).


30-October 2 November 1996


October 1996

9-12 Conference on Automorphic Forms, Geometry and Analysis, Institute for Advanced Study. (Jan. 1996, p. 65)

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 1997**

*13-19* XIXth International Congress of Mathematical Physics, Brisbane, Australia. Program: The congress will be held on the beautiful campus of The University of Queensland. It is expected to take a broadly similar form to the Paris Congress of 1994, with plenary lectures, invited talks, and some contributed talks. Shorter satellite meetings on specialized topics will be run either side of the congress, at other locations in Australia and Southeast Asia. A joint meeting of the Australian and New Zealand Mathematical Societies is planned for Auckland in the preceding week.
New Publications Offered by the AMS

American Mathematical Society Translations—Series 2

Topography of Real Algebraic Varieties and Related Topics
V. Kharlamov, A. Korchagin, G. Polotovskii, and O. Viro, Editors
Volume 173

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

Contents
G. M. Polotovskii, Dmitry Andreevich Gudkov; E. I. Gordon, Recollection of D. A. Gudkov; V. I. Arnold, Remarks on the enumeration of plane curves; A. Borobia and V. F. Mazurovski, On diagrams of configurations of 7 skew lines of $\mathbb{R}^2$; B. Chevallier, Smoothing isolated singularities on real algebraic surfaces; A. Degtyarev, Quadratic transformations $\mathbb{R}P^2 \to \mathbb{R}P^2$; P. Gilmer, Real algebraic curves and link cobordism, II; V. V. Goryunov, Morsifications of rational functions; I. Itenberg and E. Shustin, Real algebraic curves with real cusps; V. Kharlamov and I. Itenberg, Towards the maximal number of components of a non singular surface of degree 5 in $\mathbb{R}P^3$; S. I. Khashin and V. F. Mazurovski, Stable equivalence of real projective configurations; A. B. Korchagin, Smoothing of 6-fold singular points and constructions of 9th degree $M$-curves; M. Kushelman, Automaton model of relations between two countries; T. V. Kuzmenko and G. M. Polotovskii, Classification of curves of degree 6 decomposing into a product of $M$-curves in general position; S. M. Natanzon, Spinors and differentials of real algebraic curves; V. V. Nikulin, On the topological classification of real Enriques surfaces. I; E. Shustin, Critical points of real polynomials, subdivisions of Newton polyhedra and topology of real algebraic hypersurfaces; G. A. Utkin, On a nonlinear boundary value problem of mathematical physics; O. Viro, Generic immersions of the circle to surfaces and the complex topology of real algebraic curves; V. I. Zvonilov, Stratified spaces of real algebraic curves of bidegree $(m, 1)$ and $(m, 2)$ on a hyperboloid.

April 1996, approximately 260 pages (hardcover), ISBN 0-8218-0555-X, LC 91-640741, ISSN 0065-9290
1991 Mathematics Subject Classification: 14Hxx, 14Pxx, 57Mxx, 57R45, 05A15
Individual member $59, List $99, Institutional member $79
To order, please specify TRANS2/173N

CBMS Regional Conference Series in Mathematics

Tight Closure and Its Applications
Craig Huneke
Volume 88

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

Tight closure is a method to study rings of equicharacteristic by using reduction to positive characteristic. In this book, the basic properties of tight closure are covered, including various types of singularities, e.g. F-regular and F-rational singularities. Basic theorems in the theory are presented including versions of the Briançon-Skoda theorem, various homological conjectures, and the Hochster-Roberts/Boutot theorems on invariants of reductive groups.

Several applications of the theory are given. These include the existence of big Cohen-Macaulay algebras and various uniform Artin-Rees theorems.

Features:
• The existence of test elements.
• A study of F-rational rings and rational singularities.
• Basic information concerning the Hilbert-Kunz function, phantom homology, and regular base change for tight closure.
• Numerous exercises with solutions.
Conference Proceedings, Canadian Mathematical Society

Representation Theory of Algebras
Raymundo Bautista, Roberto Martinez-Villa, José Antonio de la Peña, Editors
Volume 18

The ICRA VII was held at Cocoyoc, Mexico, in August 1994. This was the second time that the ICRA was held in Mexico; ICRA III took place in Puebla in 1980.

The 1994 conference included 62 lectures, all listed in these Proceedings. Not all contributions presented, however, appear in this book. Most papers in this volume are in final form with complete proofs, with the only exception being the paper of Leszczyński and Skowroński, Auslander algebras of tame representation type; the editors thought useful to include.

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

Contents
Dedication; I. Agoston, E. Lukács and C. M. Ringel, 
Representation theory of translation quivers; M. Auslander and I. Reiten, 
DTR-periodic modules and functors; R. Bautista and R. Zuazua, 
Morita equivalence and reduction algorithms for representations of coalgebras; V. Bawula, 
Global dimension of generalized Weyl algebras; V. Bokhert, 
A characterization of a class of scharian vector space categories of polynomial growth; F. Coelho, E. Marcos, 
H. Minkel and A. Skowroński, 
Domestic semisimple branch enlargements of tame concealed algebras; W. Crawley-Boevey, 
Rigidity integral representations of quivers; A. Cyklic, 
Representations of modular lattices generated by quasi-oriented graphs; P. Dräxler and Ch. Geiss, 
On the tameness of certain 2-point algebras; K. Erdmann, 
The Auslander-Reiten quiver of restricted enveloping algebras; G. D'Este, 
Examples of torsion theories without nice symmetries; R. Gentle and G. Todorov, 
Extensions, kernels and co kernels of homologically finite subcategories; E. L. Green, 
E. N. Marcos and O. Solberg, 
Representations and almost split sequences for Hopf algebras; E. L. Green and R. Martinez-Villa, 
Koszul and Yoneda algebras; J. Y. Guo and S. A. Sikko, 
Relative global dimension and extension subcategories; D. Happel and J. A. de la Peña, 
Quadratic forms with a maximal sincere root; J. Hille, 
Examples of distinguished tilting sequences on homogeneous varieties; Sh. Jagadeeshan and M. Kleiner, 
Stable Artin algebras of the transpose and the global dimension; B. Keller, 
Invariance of cyclic homology under derived equivalence; O. Kerner and A. Kubitze, 
On three invariants of path-algebras of wild quivers; O. Kerner and M. Takane, 
The complement of the preprojective almost complete partial tilting modules; W. Kimmerle, 
Automorphisms of ZG and the Zassenhaus conjectures; S. König, 
Strong exact Borel subalgebras and global dimensions of quasi-hereditary algebras; H. Krause, 
The endomorphism of a module; H. Lenzing, 
A K-theoretic study of canonical algebras; H. Lenzing and H. Melzer, 
Tilting sheaves and concealed-canonical algebras; Z. Leszczyński and A. Skowroński, 
Auslander algebras of tame representation type; R. Martinez-Villa, 
Applications of Koszul algebras; the preprojective algebra; Ch. Mejers and M. Schaps, 
Separable deformations of blocks with abelian normal defect group and the derived equivalent global blocks; R. Nörenberg and A. Skowroński, 
Tame minimal non-polynomial growth strongly simply connected algebras; L. Peng and J. Xiao, 
A realization of affine algebras of type An−1 via the derived categories of cyclic quivers; J. A. de la Peña and B. Tomé, 
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On stable equivalence induced by isomorphisms of factor algebras; C. M. Ringel, 
Cones; C. M. Ringel, 
The Luf-Schulz example; D. Sinzon, 
Representation embedding problems, categories of extensions and preprojective modules; A. Skowroński, 
On omnipresent tubular families of modules; G. Todorov and R. Yang, 
Locally finitely presented bifunctors; U. Unger, 
The partial order of tilting modules for three-point-quiver algebras; D. Zacheria, 
The Hochschild homology of quasi-hereditary algebras; A. G. Zavadskij, 
On tame vectorspace categories I; A. Zimmermann, 
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Representation Theory of Algebras and Related Topics
Raymundo Bautista, Roberto Martinez-Villa, José Antonio de la Peña, Editors
Volume 19

These proceedings report a number of lecture series delivered during the Workshop of Representation Theory of Algebras and Related Topics held at Universidad Nacional Autónoma de México (UNAM) in August 1994.

The workshop was dedicated to recent advances in the field and its interaction with other areas of mathematics, such as algebraic geometry, ring theory, and representation of groups. The program of the Workshop consisted of 9 lecture series. In addition there was a Tame Day consisting of 6 lectures reporting...
on the recent advances in the study of tame algebras and their module categories.

During the Workshop there was a session devoted to the exhibition of computer programs developed by participants. These programs are implementations of algorithms related to the calculation of important aspects of algebras and their module categories.

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March 1996, approximately 404 pages (softcover), ISBN 0-8218-0396-4, LC 96-2455, ISSN 0731-1036

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History of Mathematics

Sources of Hyperbolic Geometry
John Stillwell
Volume 10

This book presents, for the first time in English, the papers of Beltrami, Klein, and Poincaré that brought hyperbolic geometry into the mainstream of mathematics. A recognition of Beltrami comparable to that given the pioneering works of Bolyai and Lobachevsky seems long overdue—not only because Beltrami rescued hyperbolic geometry from oblivion by proving it to be logically consistent, but because he gave it a concrete meaning (a model) that made hyperbolic geometry part of ordinary mathematics.

The models subsequently discovered by Klein and Poincaré brought hyperbolic geometry even further down to earth and paved the way for the current explosion of activity in low-dimensional geometry and topology.

By placing the works of these three mathematicians side by side and providing commentaries, this book gives the student, historian, or professional geometer a bird’s-eye view of one of the great episodes in mathematics. The unified setting and historical context reveal the insights of Beltrami, Klein, and Poincaré in their full brilliance.

Beginning with volume 4, History of Mathematics is jointly published with the London Mathematical Society. The LMS is incorporated under Royal Charter and is registered by the Charity Commissioners. Members of the LMS may order at AMS member prices.

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Mathematical Surveys and Monographs

Fundamental Groups of Compact Kähler Manifolds
J. Amorós, M. Burger, K. Corlette, D. Kotschick, and D. Toledo
Volume 44

This book is an exposition of what is currently known about the fundamental groups of compact Kähler manifolds.

Contents
Introduction; Fibering Kähler manifolds and Kähler groups; The de Rham fundamental group; L2-cohomology of Kähler groups; Existence theorems for harmonic maps; Applications of harmonic maps; Non-Abelian Hodge theory; Positive results for infinite groups; Pro group theory (Appendix A); A glossary of Hodge theory (Appendix B); Bibliography; Index.

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Cогroups and Co-rings in Categories of Associative Rings
George M. Bergman and Adam O. Hausknecht
Volume 45

This book studies representable functors among well-known varieties of algebras. All such functors from associative rings over a fixed ring R to each of the categories of abelian groups, associative rings, Lie rings, and to several others are determined. Results are also obtained on representable functors on varieties of groups, semigroups, commutative rings, and Lie algebras.

Contents
Introduction; Review of coalgebras and representable functors; Representable functors from rings to abelian groups; Digressions on semigroups, etc.; Representable functors from algebras over a field to rings; Representable functors from k-rings to rings; Representable functors from rings to general groups and semigroups; Representable functors on categories of commutative associative algebras; Representable functors on categories of Lie algebras; Multilinear algebra of representable functors on k-Ring; Directions for further investigation; References; Word and phrase index; Symbol index.

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Shortest Paths for Sub-Riemannian Metrics on Rank-Two Distributions
Wensheng Liu and Hector J. Sussmann
Volume 118, Number 564

This work studies length-minimizing arcs in sub-Riemannian manifolds \((M, E, G)\) where the metric \(G\) is defined on a rank-two bracket-generating distribution \(E\). The authors define a large class of abnormal extremals—the "regular" abnormal extremals—and present an analytic technique for proving their local optimality. If \(E\) satisfies a mild additional restriction-valid in particular for all regular two-dimensional distributions and for generic two-dimensional distributions—then regular abnormal extremals are "typical," in a sense made precise in the text. So the optimality result implies that the abnormal minimizers are ubiquitous rather than exceptional.

Contents
Introduction; Three examples; Notational conventions and definitions; Abnormal extremals; Sub-Riemannian manifolds, length
minimizers and extremals; Regular abnormal extremals for rank-two distributions; Local optimality of regular abnormal extremals; Strict abnormality; Some special cases; Appendix A: The Gaveau-Brockett problem; Appendix B: Proof of Theorem 1; Appendix C: Local optimality of normal extremals; Appendix D: Rigidity sub-Riemannian arcs and local optimality; Appendix E: A nonoptimality proof; References.

November 1995, 104 pages (softcover), ISBN 0-8218-0404-9, LC 95-34455, ISSN 0065-9266
1991 Mathematics Subject Classification: 53C22, 53A40, 49K15
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An Arithmetic Riemann-Roch Theorem for Singular Arithmetic Surfaces
Wayne Aitken
Volume 120, Number 573

The first half of this work gives a treatment of Deligne's functorial intersection theory tailored to the needs of this paper. This treatment is intended to satisfy three requirements: 1) that it be general enough to handle families of singular curves, 2) that it be reasonably self-contained, and 3) that the constructions given be readily adaptable to the process of adding norms and metrics such as is done in the second half of the paper.

The second half of the work is devoted to developing a class of intersection functions for singular curves that behaves analogously to the canonical Green's functions introduced by Arakelov for smooth curves. These functions are called intersection functions since they give a measure of intersection over the infinite places of a number field. The intersection over finite places can be defined in terms of the standard apparatus of algebraic geometry.

Finally, the author defines an intersection theory for arithmetic surfaces that includes a large class of singular arithmetic surfaces. This culminates in a proof of the arithmetic Riemann-Roch theorem.

Contents
Introduction; The intersection pairing for one-dimensional schemes; The intersection pairing for families of one-dimensional schemes; The Riemann-Roch isomorphism; Intersection functions on complex curves; The arithmetic Riemann-Roch isomorphism; Bibliography.

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Symmetry Breaking for Compact Lie Groups
Michael Field
Volume 120, Number 574

This work comprises a general study of symmetry breaking for compact Lie groups in the context of equivariant bifurcation theory. The author starts by extending the theory developed by Field and Richardson for absolutely irreducible representations of finite groups to general irreducible representations of compact Lie groups. In particular, the author allows for branches of relative equilibria and phenomena such as the Hopf bifurcation.

The author also presents a general theory of determinacy for irreducible Lie group actions along the lines previously described by Field in Equivariant Bifurcation Theory and Symmetry Breaking. In the main result of this work, it is shown that branching patterns for generic equivariant bifurcation problems defined on irreducible representations persist under perturbations by sufficiently high order non-equivariant terms.

The author gives applications of this result to normal form computations yielding, for example, equivariant Hopf bifurcations and shows how normal form computations of branching and stabilities are valid when taking account of the non-normalized tail.

Contents
Introduction; Technical preliminaries and basic notations; Branching and invariant group orbits; Genericity theorems; Finitely determined bifurcation problems I; Finitely-determined bifurcation problems II; Strong determinacy: Technical preliminaries; Strong determinacy: Finite; Strong determinacy: F compact; Non-finite; Proofs of the parametrization theorems; An application to the equivariant Hopf bifurcation; Branches of relative equilibria; References.

March 1996, 170 pages (softcover), ISBN 0-8218-0435-9, LC 95-52305, ISSN 0065-9266
1991 Mathematics Subject Classification: 58F14, 14£15, 14P05, 32S15, 57S15, 58F36
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Tilting in Abelian Categories and Quasitilted Algebras
Dieter Happel, Idun Reiten, and Sverre O. Smalø
Volume 120, Number 575

In this book, the authors generalize with respect to a tilting module of projective dimension at most one for an artin algebra to tilting with respect to a torsion pair in an abelian category. A general theory is developed for such tilting and the reader is led to a generalization for tilted algebras which the authors call "quasitilted algebras". This class also contains the canonical algebras, and the authors show that the quasitilted algebras are characterized by having global dimension at most two and each indecomposable module having projective dimension at most one or injective dimension at most one.
The authors also give other characterizations of quasitilted algebras and give methods for constructing such algebras. In particular, they investigate when one-point extensions of hereditary algebras are quasitilted.

Contents

Introduction; Tilting in abelian categories; Almost hereditary algebras; One point extensions of quasitilted algebras; Bibliography; Index.

March 1996, 88 pages (softcover), ISBN 0-8218-0444-8, LC 95-52306, ISSN 0065-9266

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Srishti D. Chatterji, Editor

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Closing date for applications is March 15, 1996. The University of Alberta is committed to the principle of equity in employment. As an employer we welcome diversity in the workplace and encourage applications from all qualified women and men, including Aboriginal peoples, persons with disabilities, and members of visible minorities.

LEBANON

AMERICAN UNIVERSITY OF BEIRUT
Teaching Overseas

The Department of Mathematics at the American University of Beirut in Beirut, Lebanon (aub), invites applications for a faculty position in the fields of pure and applied mathematics, computer science, and statistics, starting October 1, 1996. The completed doctorate is required, with postdoctoral teaching and/or research experience preferred. Rank will normally be assistant professor; usual contract is for three years. The department offers both bachelor’s and master’s degrees (except for the Computer Science Program, for which the master’s degree is planned), with a research thesis required for the master’s degree. Candidates will be expected to engage in research, to be qualified to teach on the undergraduate and graduate levels, and to be qualified to supervise student research and thesis writing. The language of instruction is English.

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

AUB is an Equal Opportunity/Affirmative Action Employer.

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

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BIRZEIT UNIVERSITY
Math. & Comp. Science Departments

Applications are invited for two faculty positions in mathematics and one faculty position in computer science beginning Sept. 1, 1996. Requirements: Ph.D. degree for three positions:

- Preferred field of specialization in mathematics is analysis.
- Preference will be given to candidates with teaching experience and strong research.
- Deadline for receiving applications is April 15, 1996.

Please e-mail your resume to Hasan@math.birzeit.edu, and send your C.V., transcripts, and three letters of recommendation to:

Dr. Abdul-Latif Abu Hijleh
Dean, Faculty of Science
Birzeit University
P.O. Box 14 Birzeit
West Bank, Israel

SULTANATE OF OMAN

SULTAN QABOOS UNIVERSITY
Department of Mathematics and Statistics
College of Science

Sultan Qaboos University, the national university of the Sultanate of Oman, invites applications for the Department of Mathematics and Statistics in the fields of mathematics (applied and pure) and statistics. Appointments are expected to start in September 1996. At present vacancies exist for lecturers (with Ph.D. a minimum requirement) and assistant professor (with a minimum of four years post-Ph.D. teaching experience).

The Department of Mathematics and Statistics has well-established degree programmes in mathematics and statistics and is responsible for providing service courses to the various colleges of the university. The department has established research groups in (i) geophysical and environmental fluid dynamics, (ii) analysis, (iii) mathematical logic, (iv) design and analysis of experiments, (v) time series, stochastic processes and reliability, and (vi) probability and statistical theory. The department has a large commitment of teaching calculus to other departments. These areas are preferred.

Apart from a very attractive tax-free base salary, the university offers free furnished accommodations, two years renewable employment contract with end-of-service gratuity, annual leave with return air tickets, free medical treatment in government hospitals. There is no tax in the Sultanate.

Interested candidates are requested to submit their full C.V., along with copies of academic and experience certificates, quoting our Ref: ADV/SCI/08/95, to:

The Director, Personnel Affairs
Sultan Qaboos University
P.O. Box 50, Al-Khod-123
Sultanate of Oman

The deadline for receiving applications is April 30, 1996.
WHAT ARE NUMBERS AND WHAT SHOULD THEY BE?
R. Dedekind

(In Modern Notation & Terminology). Profit from the sale of this monograph will be used to support research further publication of the RIM Monographs in Mathematics. US $49.99, 98 pp. (hardcover). May be ordered post-free from: Research Institute for Mathematics, 383 College Avenue, Orono, Maine 04473. Tel: 207-866-7712; Fax: 207-866-0331.

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• References

Memoirs of the AMS, Volume 119, Number 571; January 1996; 184 pp.; Softcover; ISBN 0-8218-0440-5; List $44; Individual member $26; Order code MEMO/119/571NA

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A. Boutet de Monvel

Top ics covered also include or d inary dif fer ential theory, s ingularities of maps and geometry of curves. The papers originate from the Third International Conference on Algebraic Geometry held in La Rábida, Spain.

1996 APPROX. 436 PP. HARDCOVER $99.50
ISBN 3-7643-5334-1
Progress in Mathematics, Volume 134

ALGEBRAIC TOPOLOGY: NEW TRENDS IN LOCALIZATION AND PERIODICITY

Barcelona Conference on Algebraic Topology, Sant Feliu de Guíxols, June 1-7, 1994

C. Broto, C. Casacuberta, both at Universitat Autònoma de Barcelona, Spain & G. Mislin, ETH Zentrum, Zürich, Switzerland (Eds.)

Central to this collection of papers are new developments in the general theory of localization of spaces. This field has undergone tremendous change of late and is yielding new insight into the mysteries of classical homotopy theory. Several comprehensive articles included here on general localization clarify the basic tools and give a report on the state of the art in this subject matter.

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Progress in Mathematics, Volume 136

NEW TEXTBOOKS FOR 1996

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B. Fristedt & L. Gray, both at University of Minnesota, Minneapolis

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1996 APPROX. 238 PP., 126 ILLUS. HARDCOVER $44.50 ISBN 0-8176-3900-4

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A.G. López, Universidad de Valladolid, Spain & L.N. Macarro, Universidad de Sevilla, Spain (Eds.)

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A FIRST COURSE IN GEOMETRIC TOPOLOGY AND DIFFERENTIAL GEOMETRY

E. Bloch, Bard College, New York

This text should be accessible to mathematics majors at the junior/senior level in an American university or college. The minimal prerequisites are a standard Calculus sequence (including multivariable Calculus and an acquaintance with differential equations), linear algebra (including inner products) and familiarity with proofs and the basics of sets and functions. Abstract algebra and real analysis are not required.

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World Congress of Nonlinear Analysts ’92

Proceedings of the First World Congress of Nonlinear Analysts, Tampa, Florida, August 19 - 26, 1992 (4 Volumes)

Editor: V. Lakshmikantham

Cloth $798.95 (Volumes not available separately)
ISBN 3-11-013215-X

These four volumes comprise about 350 selected contributions presented to the First World Congress of Nonlinear Analysts which was held under the auspices of the International Federation of Nonlinear Analysts (IFNA).

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Volume I consists of various aspects of partial differential equations including problems in physics, fluid mechanics, combustion theory, structural mechanics, hysteresis, and atmospheric and marine sciences.

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Volume III is devoted to the theoretical aspects of nonlinear analysis such as nonlinear operators, nonconvex analysis, control theory and optimization, fixed point theory and evolution equations. Moreover, this volume also contains models in economic theory, manufacturing systems, engineering applications, chaos, bifurcation and artificial intelligence in nonlinear electronics.

Volume IV deals with several aspects of biomathematics and ecology including biochemical systems, environmental problems, bursting rhythms and biomedicine.

These volumes are rounded out by the papers presented at “Lyapunov’s and Poincaré’s Centenary sessions” as well as “Round Table meetings” in which experts from industry and academic institutions participated.
The Centre de recherches mathématiques is hosting a year-long program in combinatorics and group theory in 1996-1997. The year will be organized around a certain number of workshops spread throughout the year. The CRM Summer School, which will again be held in Banff, Alberta during the month of August, is part of the theme year. Following is a schedule of events:

**WORKSHOP ON PSEUDORANDOM NUMBER GENERATION**  
June 3-28, 1996  
Organizers: G. Brassard (Montréal), C. Crépeau (Montréal), R. Couture (Montréal), P. L'Ecuyer (Montréal), H. Niederreiter (Austrian Academy of Sciences)  
(*) To be confirmed

**CRM SUMMER SCHOOL ON GROUP THEORY**  
August 11-23, 1996  
The summer school will be primarily aimed at PhD students in their final years and recent PhDs. Applications should be sent by **March 31, 1996** along with a curriculum vitae and a list of some recent publications.  
Organizers: G. Baumslag (CUNY), D. Gildenhuys (McGill), O. Kharlampovich (McGill), E. Zelmanov (Yale)  

**WORKSHOP ON CAYLEY GRAPHS**  
September 16-21, 1996  
Organizers: G. Hahn (Montréal), G. Sabidussi (Montréal)  

**WORKSHOP ON HYPERBOLIC AND AUTOMATIC GROUPS; GROUPS ACTING ON R-TREES**  
October 13 - 24, 1996  
Organizers: G. Baumslag (CUNY), D. Gildenhuys (McGill), O. Kharlampovich (McGill), E. Zelmanov (Yale)  

**WORKSHOP ON DISTANCE-REGULAR GRAPHS**  
November 18-23, 1996  
Organizers: G. Hahn (Montréal), G. Sabidussi (Montréal)

Those wishing to participate in the above activities are invited to write to Louis Pelletier,  
CRM, Université de Montréal, C.P. 6128, succ. Centre-ville, Montréal (Québec) CANADA H3C 3J7  
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Commencing salary will be established within the range NZ$42,500 - NZ$51,500 per annum.

Further information, Conditions of Appointment and Method of Application should be obtained from the Academic Appointments Office, The University of Auckland, Private Bag 92019, Auckland, New Zealand, phone 64-9-373 7999 ext 5097, fax 64-9-373 7023. Three copies of applications should be forwarded to reach the Registrar by the 13 May 1996.

Please quote Vacancy Number UAC.695 in all correspondence.

W B NICOLL, REGISTRAR

American Mathematical Society

Sinai's Moscow Seminar on Dynamical Systems

Editors: L. A. Bunimovich, Georgia Institute of Technology, Atlanta, B. M. Gurevich, Moscow State University, Russia, and Yakov B. Pesin, Pennsylvania State University, University Park

These papers, written by internationally known mathematicians, represent the major part of the enormous variety of Sinai's scientific interests. The book reflects the unique style of Sinai's school and its interest in various interconnections between ergodic theory and various other branches of mathematics and physics.

American Mathematical Society Translations-- Series 2; Volume 171; 1995; 247 pages; ISBN 0-8218-0456-1; Hardcover; Individual member $57; List $95; Order code TRANS2/171NA

Classification of Direct Limits of Even Cuntz-Circle Algebras

Huaxin Lin and N. Christopher Phillips, University of Oregon, Eugene

In this book, the authors prove a classification theorem for purely infinite simple C*-algebras that is strong enough to show that the tensor products of two different irrational rotation algebras with the same even Cuntz algebra are isomorphic.

Memoirs of the AMS; Volume 118, Number 565; 116 pages; ISBN 0-8218-0403-0; Softcover; Individual member $21; List $35; Order code MEMO/118/565NA

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American Mathematical Society

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This book contains the proceedings of two workshops on computational aspects of geometric group theory. The workshops were held in the winter of 1994 at DIMACS and at the Geometry Center. They covered practical group theoretic computation and theoretical problems.


Representations of Finite and Compact Groups
—Barry Simon, California Institute of Technology, Pasadena

This relatively elementary and self-contained book is a comprehensive pedagogical presentation of the theory of representation of finite and compact Lie groups. Simon approaches the subject from the viewpoint of analysis and considers both the general theory and representation of specific groups.

Graduate Studies in Mathematics, Volume 10; December 1995; 266 pp.; Hardcover; ISBN 0-8218-0453-7; List $34; All AMS members $27; Order code GSM/10NA

Groups and Symmetry: A Guide to Discovering Mathematics
—David W. Farmer, Rutgers University, New Brunswick, NJ

By means of a series of carefully selected tasks, this book leads you to discover some real mathematics. There are no formulas to memorize; no procedures to follow. Groups and Symmetry is a guide—it's job is to start you in the right direction and to bring you back if you stray too far. Discovery is left to you.

Mathematical World, Volume 5; November 1995; 102 pp.; Softcover; ISBN 0-8218-0450-2; List $19; All AMS members $15; Order code MAWRD/5NA

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Riemannian Geometry
—Gérard Besson, Université de Grenoble I, France, Joachim Lohkamp, Institut des Hautes Études Scientifiques, France, Pierre Pansu, Université de Paris-Sud, France, and Peter Peterson, University of California, Los Angeles

This book is a compendium of survey lectures presented by a select group of internationally established researchers at a conference on Riemannian Geometry sponsored by The Fields Institute for Research in Mathematical Sciences (Waterloo, Canada) in August 1993.

Fields Institute Monographs, Volume 4; January 1996; 115 pp.; Hardcover; ISBN 0-8218-0263-1; List $46; All AMS members $37; Order code FIM/4NA

Dynamical Systems and Probabilistic Methods in Partial Differential Equations
—Percy Deift, New York University-Courant Institute, NYC, C. David Levermore, University of Arizona, Tucson, and C. Eugene Wayne, Pennsylvania State University, University Park, Editors

This volume contains some of the lectures presented in June 1994 during the AMS-SIAM Summer Seminar at the Mathematical Sciences Research Institute in Berkeley. The book serves as an ideal introduction to the varied and interesting topics covered.

Lectures in Applied Mathematics, Volume 31; November 1995; 268 pp.; Softcover; ISBN 0-8218-0368-9; List $29; All AMS members $23; Order code LAM/31NA

Knots and Surfaces: A Guide to Discovering Mathematics
—David W. Farmer, Rutgers University, New Brunswick, NJ, and Theodore B. Stanford, University of California, Berkeley

This book leads readers to discover some real mathematics by means of a series of carefully selected tasks. There are no formulas to memorize; no procedures to follow. The book is a guide: It’s job is to start you in the right direction and to bring you back if you stray too far. Discovery is left to you.

Mathematical World, Volume 6; November 1995; 101 pp.; Softcover; ISBN 0-8218-0451-0; List $19; All AMS members $15; Order code MAWRLD/6NA

All prices subject to change. Charges for delivery are $3.00 per order, or for air delivery outside of the continental U.S., please include $8.50 per item. Prepayment required. Order from: American Mathematical Society, P. O. Box 5004, Boston, MA 02205-5004. Or for credit card orders, fax (401) 331-3842 or call toll free 800-321-4AMS (4267) in the U.S. and Canada. Residents of Canada, please include 7% GST.
Meetings & Conferences of the AMS

The following pages give 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. For some meetings the list may be incomplete. Up-to-date meeting information is available on the World Wide Web via the Internet at URL http://e-math.ams.org/.

Meetings:

1996
March 22-23 Iowa City, Iowa p. 374
April 13-14 New York, New York p. 374
April 19-21 Baton Rouge, Louisiana p. 375
May 22-24 Antwerp, Belgium p. 376
August 10-12 Seattle, Washington p. 376
October 5-6 Lawrenceville, New Jersey p. 377
October 11-12 Chattanooga, Tennessee p. 378
November 1-3 Columbia, Missouri p. 378
November 16-17 Pasadena, California p. 379

1997
January 8-11 San Diego, California p. 379
Annual Meeting
March 21-22 Memphis, Tennessee p. 379
April 12-13 College Park, Maryland p. 379
May 2-4 Detroit, Michigan p. 380
October 10-12 Atlanta, Georgia p. 380
September 26-28 Montreal, Canada p. 380
October 24-26 Milwaukee, Wisconsin p. 380

1998
January 7-10 Baltimore, Maryland p. 380
Annual Meeting
March 27-28 Manhattan, Kansas p. 381

Conferences:

1996

Important Information Regarding AMS Meetings
Potential organizers and speakers should refer to the January issue of the Notices for guidelines on participation and abstract submission. Close attention should be paid to specified deadlines in this issue. Unfortunately, late abstracts cannot be accommodated.

Beginning with the fall 1996 meetings, an enhanced system for submitting your abstract will be in place. See the April issue for details.

Requests for general information concerning abstracts may be sent to abs-info@ams.org. Completed electronic abstracts should be submitted to abs-submit@ams.org; paper abstracts should be sent to the Abstracts Coordinator, AMS Meetings and Conferences Department, P. O. Box 6887, Providence, RI 02940; telephone: 401-455-4182. Any other inquiries about AMS meetings may be sent to meet@ams.org.

Should your university be interested in hosting an AMS meeting, see the January issue for details.
Meetings and Conferences

Refunds for Orlando Meeting

Individuals who registered in advance for the January 1996 Joint Mathematics Meetings in Orlando, Florida, but who were prevented from attending the meeting because of severe weather along the eastern seaboard which closed airports over several days, may request a refund of 50 percent of the meeting advance registration fee by writing to the Mathematics Meetings Housing Bureau, P.O. Box 6887, Providence, RI 02940, or by sending e-mail to pop@ams.org. The Joint Meetings Committee is granting this exception to the usual refund policy because of the unusual weather circumstances, but this will in no way prejudice the application of the usual policy for future meetings. (For information, the usual policy is that a 50 percent refund can be made if notice of cancellation is received before the start of the meeting. After the start of the meeting, no refunds can be made.)

Iowa City, Iowa

University of Iowa

March 22-23, 1996

Meeting #909

Central Section

Associate secretary: Andy R. Magid

Announcement issue of Notices: January 1996, p. 117

Program issue of Notices: March 1996, p. 382

Issue of Abstracts: Vol. 17, Issue 2

Registration

Third floor of the Iowa Memorial Union: Friday, 8:00 a.m. to 5:00 p.m.; Saturday, 8:00 a.m. to 1:00 p.m.

Invited Addresses

Franc Forstneric, University of Wisconsin, Madison, Holomorphic automorphisms of C^n.

Ruth J. Lawrence, University of Michigan, Ann Arbor, Geometry and algebra: A unified voice.

Michal Misiurewicz, Indiana University-Purdue University, Indianapolis, Rotation sets in dynamical systems.

Daniel I. Tataru, Northwestern University, Unique continuation for solutions to partial differential equations.

Special Sessions

Arrangements of Hyperplanes, Michael J. Falk, Northern Arizona University, and Richard C. Randell, University of Iowa.

Commutative Ring Theory, Daniel D. Anderson, University of Iowa.

Current Issues in Nonlinear Conservation Laws, Suncica Canic, Iowa State University.


Geometric and Analytic Methods in Several Complex Variables, Franc Forstneric, University of Wisconsin, Madison.

Geometry and Cohomology, Walter I. Seaman, University of Iowa.

Group Representations and Mathematical Physics, Tuong Ton-That, University of Iowa.

Moments and Operators, Raul E. Curto, Palle E. T. Jorgensen, and Paul S. Muhly, University of Iowa.

Mostly Finite Geometries, Norman L. Johnson, University of Iowa.

Nonlinear Partial Differential Equations, Gerhard O. Strohmer and Lihe Wang, University of Iowa.

Physical Knot Theory, Gregory Buck, Saint Anselm's College, and Jonathan K. Simon, University of Iowa.

Research in Mathematics by Undergraduates, Carl C. Cowen, Purdue University, West Lafayette.

Theta Correspondences and Automorphic Forms, David C. Manderscheid, University of Iowa.

Topological 3-manifolds, Charles Frohman and Ying-Qing Wu, University of Iowa.

New York, New York

New York University, Courant Institute

April 13-14, 1996

Meeting #910

Eastern Section

Associate secretary: Lesley M. Sibner

Announcement issue of Notices: February 1996, p. 267

Program issue of Notices: April 1996

Issue of Abstracts: Vol. 17, Issue 2

Deadlines

For organizers: Expired

For consideration of contributed papers in Special Sessions: Expired

For abstracts: Expired

Invited Addresses

Claude R. LeBrun, State University of New York, Stony Brook, On 4-dimensional Einstein manifolds.

Ze'ev Rudnick, Tel Aviv University, Israel, The Riemann zeta function and random matrix theory.

Jose Scheinkman, University of Chicago, Department of Economics, Assessing the empirical performance of continuous time methods in finance.

Michael F. Singer, North Carolina State University, The inverse problem in differential Galois theory.
Special Sessions


*Gauge Field Theory*, Janet C. Talvacchia, Swarthmore College, and Yisong Yang, Polytechnic University.


*Hyperbolic Geometry and Discrete Groups*, Jane P. Gilman, Rutgers University, Newark.

*Number Theory*, William D. Duke, Rutgers University, New Brunswick, and Ze'ev Rudnick, Tel Aviv University, Israel.

*Partial Differential Equations*, Patricia E. Bauman, Purdue University, West Lafayette, Fanghua Lin, Courant Institute of Mathematical Sciences, New York University, and Peter J. Sternberg, Indiana University, Bloomington.

*Stochastic Models in Mathematical Finance*, Thaleia Zariphopoulou, University of Wisconsin, Madison.


Program Updates

Activities of the International Mathematical Union and Plans for the International Congress of Mathematicians in 1998: Saturday, 9:00 a.m. to 10:30 a.m. Panelists include David Mumford, IMU president, Jacob Palis, IMU secretary, Phillip A. Griffiths, ICM 98 program committee chair, Martin Groetschel, ICM 98 organizing committee president, Jeremy Kilpatrick, ICMI vice president, Herbert Clemens, CDE executive committee, and other members of the IMU executive committee.

Perspectives on Doing Mathematics in the Electronic Age: Saturday, 2:30 p.m. to 4:30 p.m. This international forum includes John H. Ewing, AMS, Martin Groetschel, Konrad-Zuse-Zentrum fuer Informationstechnik; and Andrew M. Odlyzko, AT&T Bell Labs, as panelists.

Corollary Program

The second series of Magnus Lectures will be delivered by Mikhail Gromov, IHES, at 6:00 p.m. on Thursday at Polytechnic University, and at 5:00 p.m. on Friday at Courant Institute of Mathematical Sciences (NYU). The title of the talks is *Geometry of groups in finite and infinite dimensions*. Please contact Kathryn Kuiken, kkuiken@magnus.poly.edu, for further information.

Accommodations Update

The Washington Square Hotel now offers a single rate of $76.50; be sure to cite group #0412.
Antwerp, Belgium

May 22–24, 1996

Meeting #912
First joint meeting of the AMS and the mathematical societies of the BeNeLux countries (Belgium, the Netherlands, and Luxemburg).

Association secretary: Robert J. Daverman
Announcement issue of Notices: January 1996, p. 120
Program issue of Notices: May 1996
Issue of Abstracts: None

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

Invited Addresses
M. Van den Bergh, Limburgs Universitair Centrum, Belgium, Noncommutative geometry and regular algebras.
Jean Bourgain, Institute for Advanced Study, Princeton University, Title to be announced.
John Conway, Princeton University, Title to be announced (Beeger Lecture).
W. Hackbusch, Recent developments in numerical mathematics (Brouwer Lecture).
Joyce R. McLaughlin, Rensselaer Polytechnic Institute, Title to be announced.
L. Schrijver, CWI, Amsterdam, The Netherlands, Combinatorial optimization with cohomology over groups.
Stephen Smale, University of California, Berkeley, and City University of Hong Kong, Relating the Hilbert Nullstellensatz to the problem: does $P = NP$?
Elias M. Stein, Princeton University, Title to be announced.
F. Takens, Rijksuniversity Groningen, The Netherlands, Chaotic dynamics in variations of the Lenon attractor.
Clifford Taubes, Harvard University, The geometry of the Selberg-Witten Equations.

Special Sessions
Algebraic Geometry, J. de Jong, Harvard University, and M. van der Put, Rijksuniversiteit Groningen, The Netherlands.
Algebra, S. Caenepeel, Vrije Universiteit Brussels, Belgium, and S. Montgomery, University of Southern California.
Buildings, H. Van Maldeghem, Rijksuniversiteit te Gent, Belgium, and M. Ronan, University of Illinois at Chicago.
Differential Geometry, L. Van Hecke, Katholieke Universiteit Leuven, Belgium, and L. Lemaire, Universite Libre de Bruxelles, Belgium.
Dynamical Systems, F. Dumortier, LUC, Hasselt, Belgium, and S. van Strien, University of Amsterdam, The Netherlands.
Harmonic Analysis, J. Ludwig, Université de Metz, France, and J.-P. Pier, Universitaire de Luxembourg, Luxembourg.
History of Mathematics, J. Mahwin, Université Catholique de Louvain, Belgium, and J.-P. Pier.
Inverse Problems, C. De Mol, Université Libre de Bruxelles, Belgium, and F. Santosa, University of Minnesota.
Logic, M. Boffa, Université de l'État à Mons, Belgium, and C. Michaux, Université de Mons-Hainaut.
Mathematical Physics, J. Bricmont, Université de Liège, Belgium, and B. Nachtergaele, Princeton University.
Motivic Cohomology and Algebraic K-Theory, E. Friedlander, Northwestern University, and J. Murre, Leiden University, The Netherlands.
Wavelets, I. Daubechies, Princeton University, and N. Temme, CWI, Amsterdam, The Netherlands.

Seattle, Washington
University of Washington

August 10–12, 1996

Meeting #913
Seattle MathFest, including the 98th Summer Meeting of the American Mathematical Society (AMS), the 74th meeting of the Mathematical Association of America (MAA), and
the summer meetings of the Association for Women in Mathematics (AWM) and Pi Mu Epsilon (PME).
Associate secretary: Susan J. Friedlander
Announcement issue of Notices: May 1996
Program issue of Notices: August 1996
Issue of Abstracts: None

Deadlines
For organizers: Expired
For consideration of contributed papers in Special Sessions: None
For abstracts: None
For summaries of papers to MAA organizers: April 22, 1996

Invited Addresses
Joel Hass, University of California, Davis (AMS-MAA Invited Address). (Code: HASS)

Lawrenceville, New Jersey
Rider University
October 5-6, 1996

Meeting #914
Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of Notices: August 1996
Program issue of Notices: October 1996
Issue of Abstracts: Vol. 17, Issue 3

Deadlines
For organizers: Expired
For consideration of contributed papers in Special Sessions: May 7, 1996
For abstracts: July 2, 1996

Invited Addresses
Louis J. Billera, Cornell University, Ithaca, Title to be announced. (Code: BILLERA)
Fred I. Diamond, University of Cambridge, United Kingdom, Title to be announced. (Code: DIAMOND)
Nicole Tomczak Jaegermann, University of Alberta, Title to be announced. (Code: TOMZCAK)
Karen E. Smith, Massachusetts Institute of Technology, Title to be announced. (Code: SMITH)

Special Sessions
Algebraic K-theory (Code: AMS SS II), Charles A. Weibel, Rutgers University, New Brunswick.
Chattanooga, Tennessee

University of Tennessee, Chattanooga

October 11-12, 1996

Meeting #915

Southeastern Section

Associate secretary: Robert J. Daverman
Announcement issue of Notices: August 1996
Program issue of Notices: October 1996
Issue of Abstracts: Vol. 17, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: May 7, 1996
For abstracts: July 12, 1996

Invited Addresses

Orlando Alvarez, University of Miami, Title to be announced. (Code: ALVAREZ)
Christopher J. Bishop, State University of New York, Stony Brook, Title to be announced. (Code: BISHOP)
David Harbater, University of Pennsylvania, Title to be announced. (Code: HARBATER)
Joyce R. McLaughlin, Rensselaer Polytechnic Institute, Title to be announced. (Code: MCLAUGHLIN)

Special Sessions

Applied Probability (Code: AMS SS J1), Thomas Kozubowski and Anna Katarzyna Panorska, University of Tennessee, Chattanooga.

Commutative Ring Theory (Code: AMS SS A1), David F. Anderson and David E. Dobbs, University of Tennessee, Knoxville.

Conformal Analysis (Code: AMS SS I1), David Howard Hamilton, University of Maryland, College Park.

Dynamical Systems and Continuum Theory (Code: AMS SS K1), John Clyde Mayer, University of Alabama, Birmingham.

Galois Theory (Code: AMS SS B1), Kevin R. Coombes, University of Maryland, College Park, and Helmut Voelklein, University of Florida.

Geometric Topology (Code: AMS SS E1), Alexander Nikolaevich Dranishnikov and James E. Keesling, University of Florida, and Jerzy Dydak, University of Tennessee, Knoxville.

Mathematical Aspects of Wave Propagation Phenomena (Code: AMS SS G1), B. Belinskiy and Steve Xu, University of Tennessee, Chattanooga.

Matrix Theory (Code: AMS SS D1), Shu-An Hu, University of Tennessee, Chattanooga, Zhongshan Li, Georgia State University, Ronald Lee Smith, University of Tennessee, Chattanooga, and Frank Uhlig, Auburn University, Auburn.


Optimization (Code: AMS SS F1), Jerald P. Dauer and Osama A. Saleh, University of Tennessee, Chattanooga.

Reform in Undergraduate Mathematics Education (Code: AMS SS H1), Betsy Darken, Aniekan Asukwo Ebiefung, Stephen W. Kuhn, and Robert Glenn Wynegar, University of Tennessee, Chattanooga.

Columbia, Missouri

University of Missouri

November 1-3, 1996

Meeting #916

Central Section

Associate secretary: Susan J. Friedlander
Announcement issue of Notices: September 1996
Program issue of Notices: November 1996
Issue of Abstracts: Vol. 17, Issue 4

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: May 15, 1996
For abstracts: July 31, 1996

Invited Addresses

Alejandro Adem, University of Wisconsin, Madison, Recent developments in the cohomology of finite groups. (Code: ADEM)

David E. Barrett, University of Michigan, Ann Arbor, Title to be announced. (Code: BARRETT)

Patricia E. Bauman, Purdue University, West Lafayette, Title to be announced. (Code: BAUMAN)

Ya S. Soibelman, Kansas State University, Title to be announced. (Code: SOIBELMAN)

Special Sessions

Algebraic Geometry (Code: AMS SS J1), Dan Eddidin and Qi Zhang, University of Missouri.

Banach Spaces and Related Topics (Code: AMS SS K1), Peter G. Casazza and N. J. Kalton, University of Missouri, Columbia.

Classifying Spaces and Cohomology of Finite Groups (Code: AMS SS H1), Alejandro Adem, University of Wisconsin, and Stewart B. Priddy, Northwestern University.

Commutative Algebra (Code: AMS SS E1), Steven Dale Cutkosky and Hema Srinivasan, University of Missouri, Columbia.
Differential Equations and Dynamical Systems (Code: AMS SS D1), Carmen C. Chicone and Yuri D. Latushkin, University of Missouri, Columbia.

Differential Geometry (Code: AMS SS C1), John Kelly Beem and Adam D. Helfer, University of Missouri, Columbia.

Gauge Theory and Its Interaction with Holomorphic and Symplectic Geometry (Code: AMS SS F1), Stamatis A. Dostoglou, University of California, Santa Barbara, and Jan Segert and Shuguang Wang, University of Missouri, Columbia.


Lie Groups and Physics (Code: AMS SS I1), Victor A. Ginzburg, University of Chicago, and Ya S. Soibelman, Kansas State University.

Partial Differential Equations and Mathematical Physics (Code: AMS SS A1), Mark S. Ashbaugh, University of Missouri, Columbia.


Pasadena, California

California Institute of Technology

November 16–17, 1996

Meeting #917

Western Section

Associate secretary: William A. Harris, Jr.

Announcement issue of Notices: September 1996

Program issue of Notices: November 1996

Issue of Abstracts: Vol. 17, Issue 4

Deadlines

For organizers: March 29, 1996

For consideration of contributed papers in Special Sessions: May 15, 1996

For abstracts: August 7, 1996

San Diego, California

San Diego Convention Center

January 8–11, 1997

Joint Mathematics Meetings, including 103rd Annual Meeting of the AMS, 80th Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM), the National Association of Mathematicians (NAM), and winter meeting of the Association for Symbolic Logic (ASL).

Associate secretary: Lesley M. Sibner

Announcement issue of Notices: October 1996

Program issue of Notices: January 1997

Issue of Abstracts: Vol. 18, Issue 1

Deadlines

For organizers: April 8, 1996

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

Memphis, Tennessee

University of Memphis

March 21–22, 1997

Southeastern Section

Associate secretary: Robert J. Daverman

Announcement issue of Notices: January 1997

Program issue of Notices: March 1997

Issue of Abstracts: To be announced

Deadlines

For organizers: June 21, 1996

For consideration of contributed papers in Special Sessions: To be announced

For abstracts: To be announced

Special Sessions

Approximation in Mathematics (Code: AMS SS A1), George A. Anastassiou, University of Memphis.

Symbolic Dynamics (Code: AMS SS B1), Paul B. Trow, University of Memphis.

College Park, Maryland

University of Maryland, College Park

April 12–13, 1997

Eastern Section

Associate secretary: Lesley M. Sibner

Announcement issue of Notices: February 1997

Program issue of Notices: To be announced

Issue of Abstracts: To be announced

Deadlines

For organizers: July 12, 1996

For consideration of contributed papers in Special Sessions: To be announced

For abstracts: To be announced
Invited Addresses

Lisa Claire Jeffrey, McGill University, *Title to be announced.* (Code: JEFFREY)

A. Kirillov, University of Pennsylvania and Moscow, *Title to be announced.* (Code: KIRILLOV)

Jian-Shu Li, University of Maryland, College Park, *Title to be announced.* (Code: LI)

Richard Pollack, Courant Institute of Mathematical Sciences, New York University, *Title to be announced.* (Code: POLLACK)

Detroit, Michigan

*Wayne State University*

**May 2–4, 1997**

Central Section

Associate secretary: Susan J. Friedlander

Announcement issue of *Notices*: March 1997

Program issue of *Notices*: May 1997

Issue of *Abstracts*: To be announced

**Deadlines**

For organizers: August 2, 1996

For consideration of contributed papers in Special Sessions: To be announced

For abstracts: To be announced

Milwaukee, Wisconsin

*University of Wisconsin*

**October 24–26, 1997**

Central Section

Associate secretary: Susan J. Friedlander

Announcement issue of *Notices*: August 1997

Program issue of *Notices*: October 1997

Issue of *Abstracts*: To be announced

**Deadlines**

For organizers: January 4, 1997

For consideration of contributed papers in Special Sessions: To be announced

For abstracts: To be announced

Montreal, Quebec, Canada

*University of Montreal*

**September 26–28, 1997**

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: December 20, 1996

For consideration of contributed papers in Special Sessions: To be announced

For abstracts: To be announced

Baltimore, Maryland

*Baltimore Convention Center*

**January 7–10, 1998**

Joint Mathematics Meetings, including the 104th Annual Meeting of the AMS, 81st Annual Meeting of the Mathematical Association of America (MAA), and annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM).

Associate secretary: Robert J. Daverman

Announcement issue of *Notices*: October 1997

Program issue of *Notices*: January 1998

Issue of *Abstracts*: Vol. 19, Issue 1

**Deadlines**

For organizers: April 10, 1997

For consideration of contributed papers in Special Sessions: To be announced
Meetings and Conferences

For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

Manhattan, Kansas
Kansas State University
March 27-28, 1998
Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of Notices: January 1998
Program issue of Notices: March 1998
Issue of Abstracts: To be announced

Deadlines
For organizers: June 26, 1997
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

American Mathematical Society

The American Mathematical Society is pleased to announce that the following distinguished mathematicians have agreed to serve as Consulting Editors to the AMS book publication program:

Elliott Lieb
Princeton University

Richard Melrose
Massachusetts Institute of Technology

Katsumi Nomizu
Brown University

Mark Pinsky
Northwestern University

Claudio Procesi
Università di Roma, I

The Consulting Editors have the authority to recommend book projects for the AMS book program.
# Presenters of Papers

**Iowa City, Iowa; March 22-23, 1996**

Numbers following the name indicate the speaker's position on the program.

- **AMS Invited Lecturer**
- **Special Session Lecturer**
- **Graduate Student**
- **Undergraduate Student**

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Representation Theory and Harmonic Analysis: A Conference in Honor of Ray A. Kunze

Tuong Ton-That, University of Iowa, Iowa City, Coordinating Editor

Kenneth I. Gross, University of Vermont, Burlington;
Donald St. P. Richards, University of Virginia, Charlottesville and
Paul J. Sally, Jr., University of Chicago, Editors

This volume is an outgrowth of the special session on
representation theory and harmonic analysis held in honor of Ray Kunze at the 889th meeting of the American Mathematical Society in January 1994.

Contemporary Mathematics, Volume 191,

Representations of Groups

Bruce N. Allison and Gerald H. Cliff,
University of Alberta, Edmonton, AB, Canada, Editors

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Program of the Sessions

Iowa City, Iowa, March 22-23, 1996

Friday, March 22

Special Session on Mostly Finite Geometries, I

8:00 AM - 10:50 AM

Organizer: Norman L. Johnson, University of Iowa

8:00 AM Remarks on linear systems with parallelism.
(1) T. G. Ostrom, Washington State University (909-51-27)

8:30 AM Regulus-free spreads of PG(3,q).
(2) Gary L. Ebert*, University of Delaware, and Ronald D. Baker, West Virginia State College (909-51-219)

9:00 AM Ovals and hyperovals in Hall planes.
(3) William E. Cherowitzo, University of Colorado, Denver (909-51-96)

9:30 AM A family of non-Buekenhout unitals in the Hall plane.
(4) Jeremy M. Dover, University of Delaware (909-22-92)

10:00 AM Semifield planes with a transitive autotopism group.
(5) Minerva Cordero-Vourtsanis*, Texas Tech University, and Raul Francisco Figueroa, University of Puerto Rico, Rio Piedras (909-51-153)

(6) M. J. De Resmini, University of Rome, Italy (909-51-155)

Special Session on Commutative Ring Theory, I

8:00 AM - 10:50 AM

Organizer: Daniel D. Anderson, University of Iowa

8:00 AM Factorization in subrings of power series rings.
(7) Preliminary report.
David F. Anderson, University of Tennessee, Knoxville (909-13-115)

8:30 AM Half-factorial domains in quadratic fields.
(8) James Barker Coykendall, IV, Lehigh University (909-13-47)

9:00 AM Generalized integral closures.
(9) Franz Halter-Koch, Karl Franzens Universität, Austria (909-13-16)

9:30 AM On generalizations of Krull domains.
(10) Alfred Geroldinger, Karl Franzens Universität, Austria (909-13-05)

10:00 AM Absolutely injective integral domains.
(11) David E. Dobbs, University of Tennessee, Knoxville (909-13-100)

10:30 AM Extensions of commutative rings with linearly ordered intermediate rings. Preliminary report.
(12) Michael S. Gilbert, University of Tennessee, Knoxville (909-13-190)

Special Session on Moments and Operators, I

8:30 AM - 10:50 AM

Organizers: Raul E. Curto, University of Iowa

Palle E. T. Jorgensen, University of Iowa

Paul S. Muhly, University of Iowa

8:30 AM Informal discussion

9:00 AM Groupoids and operators.
(13) Arlan B. Ramsay, University of Colorado, Boulder (909-47-133)

9:30 AM Hyponormal operators with finite rank self-commutator and quadrature domains. Preliminary report.
(14) Daoxing Xia, Vanderbilt University (909-47-13)

10:00 AM Spectral theory for semi-bounded Jacobi matrices.
(15) Steen Pedersen, Wright State University, Dayton (909-46-43)

10:30 AM Moment problems and positivity conditions for commuting multioperators.
(16) Florian-Horia Vasilescu, University of Lille I, France (909-47-107)

Special Session on Physical Knot Theory, I

8:30 AM - 10:50 AM

Organizers: Jonathan K. Simon, University of Iowa

Gregory Buck, Saint Anselm's College

8:30 AM Informal discussion

The time limit for each contributed paper in the sessions is ten minutes.
In the Special Sessions the time limit varies from session to session and
within sessions. To maintain the schedule, time limits will be strictly
enforced.

For papers with more than one author, an asterisk follows the name of
the author who plans to present the paper at the meeting.

Papers flagged with a solid triangle (•) have been designated by
the author as being of possible interest to undergraduate students.

Abstracts of papers presented in the sessions at this meeting will be
found in the Spring 1996 issue of Abstracts of papers presented to the
American Mathematical Society, ordered according to the numbers in
parentheses following the listings. The middle two digits, e.g., 897-20-
1136, refer to the Mathematical Reviews subject classification assigned
by the individual author. Groups of papers for each subject are listed
chronologically in the Abstracts. The last one to four digits, e.g., 897-20-
1136, refer to the receipt number of the abstract; abstracts are further
sorted by the receipt number within each classification.
Special Session on Geometry and Cohomology, I

8:30 AM - 10:20 AM
Organizer: Walter I. Seaman, University of Iowa

8:30 AM
A characterization of complex projective space.
Stephen P. Bean, University of Iowa (909-53-11)

9:00 AM
Lengths of closed geodesics in certain 2-step nilmanifolds.
Charles K. Willett, University of Iowa (909-72-19)

9:30 AM
Quasi-regular representations and the geometry of nilmanifolds.
Jeffrey D. Lewis, Texas Tech University (909-53-191)

10:00 AM
Asymptotics of heat kernels on Riemannian foliations.
Kenneth S. Richardson, Texas Christian University (909-58-66)

Special Session on Topology of 3-manifolds, I

8:30 AM - 10:50 AM
Organizers: Charles Frohman, University of Iowa
Ying-Qing Wu, University of Iowa

8:30 AM
SL(3) representations of some easy knot groups.
Hans Ulysses Boden, McMaster University (909-57-19)

9:00 AM
Perturbed flat moduli spaces for composite knots.
Christopher M. Herald, McMaster University (909-58-61)

9:30 AM
A splitting formula for spectral flow.
Mark Daniel, Indiana University, Bloomington (909-57-51)

10:00 AM
Analytic deformations of the spectrum of Dirac operators on a 3-manifold with boundary.
Paul A. Kirk, Indiana University, Bloomington, and Eric P. Klassen, Florida State University (909-57-62)

10:30 AM
The spectral flow of the odd signature operator and higher Massey products.
Paul A. Kirk, Indiana University, Bloomington, and Eric P. Klassen, Florida State University (909-58-59)

Special Session on Arrangements of Hyperplanes, I

9:00 AM - 10:20 AM
Organizers: Michael J. Falk, Northern Arizona University

9:00 AM
DNA base sequence and long-range three-dimensional structure.
Wilma Olson, Rutgers University, New Brunswick (909-57-256)

9:30 AM
Buckling transitions in superhelical DNA: Dependence on the elastic constants and DNA size. Preliminary report.
Gerard C. Randell, University of Iowa (909-52-149)

10:00 AM
Preliminary report.
Vincent J. Matsko, Quincy University (909-52-42)

Special Session on Group Representations and Mathematical Physics, I

9:00 AM - 10:50 AM
Organizer: Tuong Ton-That, University of Iowa

9:00 AM
A gravitational theory arising from 2D string symmetries.
V. G. J. Rodgers and R. P. Lano, University of Iowa (909-22-235)

9:30 AM
Orthosymplectic Lie superalgebras and Brauer algebras.
Georgia M. Benkart, University of Wisconsin, Madison (909-17-202)

10:00 AM
Invariant theory and Clebsch-Gordan-Racah coefficients of compact group.
W. H. Klink, University of Iowa (909-22-180)

10:30 AM
Ray A. Kunze, University of Georgia (909-42-204)

Special Session on Nonlinear Partial Differential Equations, I

9:00 AM - 10:50 AM
Organizers: Lihe Wang, University of Iowa
Gerhard O. Strohmer, University of Iowa

9:00 AM
Hong-Ming Yin, University of Notre Dame (909-35-14)

9:30 AM
Global entropy weak solutions of the initial-boundary-value problem for the nonlinear Euler-Poisson equations.
Gui-Qiang Chen, Northwestern University, and Dehua Wang, University of Chicago (909-35-136)

10:00 AM
Patricia E. Bauman, Daniel Phillips, Purdue University, West Lafayette, and Qi Tang, University of Sussex, United Kingdom (909-35-160)

10:30 AM
Isoperimetric and Sobolev inequalities on Carnot-Caratheodory spaces and applications.
Nicola Garofalo and Duy-Minh Nhieu, Purdue University, West Lafayette (909-35-262)

Special Session on Current Issues in Nonlinear Conservation Laws, I

9:30 AM - 10:50 AM
Organizer: Suncica Canic, Iowa State University

9:30 AM
Riemann solutions for conservation laws.
James G.limm, State University of New York, Stony Brook (909-76-98)
Program of the Sessions - Iowa City, IA, Friday, March 22 (cont’d.)

10:00 AM  Riemann problem solutions of codimensions 0 and 1. Preliminary report.
Stephen Schecter, North Carolina State University (909-35-108)

10:30 AM  Structural stability of Riemann solutions with respect to the change in viscosity.
Suncica Canic, Iowa State University (909-76-195)

Invited Address

11:00 AM – 11:50 AM
Holomorphic automorphisms of $\mathbb{C}^n$.
Franc Forstneric, University of Wisconsin, Madison (909-32-01)

Invited Address

1:30 PM – 2:20 PM
Geometry and algebra: A unified voice.
Ruth J. Lawrence, University of Michigan, Ann Arbor (909-57-04)

Special Session on Mostly Finite Geometries, II

2:30 PM – 6:20 PM
Organizer: Norman L. Johnson, University of Iowa

2:30 PM  Informal discussion

3:00 PM  A new family of extended generalized quadrangles.
Anna Kasikova and Ernest E. Shult*, Kansas State University (909-51-113)

3:30 PM  On the construction of Coulter and Matthews.
Michael J. Kallaher, Washington State University (909-51-121)

4:00 PM  Some generalized quadrangles in characteristic 2.
Geoffrey Mason, University of California, Santa Cruz (909-20-157)

4:30 PM  Recent results concerning Singer groups.
Chat Yin Ho, University of Florida (909-51-243)

5:00 PM  Coset representation of homogenous geometrical structures.
Thomas Q. Sibley, Saint John’s University (909-51-81)

5:30 PM  On the classification of 4-dimensional projective planes.
D. Betten, University of Kiel, Germany (909-51-176)

6:00 PM  Four dimensional projective planes with a solvable collineation group.
Hauke Klein, University of Kiel, Germany (909-51-177)

Special Session on Group Representations and Mathematical Physics, II

2:30 PM – 6:20 PM
Organizer: Tuong Ton-That, University of Iowa

2:30 PM  Representations of $p$-adic groups and continuum limits in physically motivated eigenvalue problems.
Yannick Meurice, University of Iowa (909-22-150)

3:00 PM  Geometric approach to representations of the Virasoro algebra. Preliminary report.
Alexandre A. Kirillov, University of Pennsylvania (909-22-17)

3:30 PM  Coherent state representations and coherent tensors.
David J. Rowe, University of Toronto (909-20-242)

4:00 PM  A BBG type resolution of produced modules.
Floyd L. Williams, University of Massachusetts, Amherst (909-22-24)

4:30 PM  Scattering equivalence and representations of the Poincaré group.
Wayne N. Polyzou, University of Iowa (909-81-162)

5:00 PM  Unitary representations of pseudounitary groups.
Raj Wilson, University of Texas, San Antonio (909-22-234)

5:30 PM  Spectrum generating operators.
Thomas Patrick Branson, University of Iowa (909-22-245)

6:00 PM  Hypergeometric functions and highest weight representations. Preliminary report.
Mark G. Davidson, Louisiana State University, Baton Rouge (909-22-182)

Special Session on Commutative Ring Theory, II

2:30 PM – 6:20 PM
Organizer: Daniel D. Anderson, University of Iowa

2:30 PM  On root closure in noetherian domains.
Moshe Roitman, University of Haifa, Israel (909-13-168)

3:00 PM  Radicals and subextensions.
Ahmed Ayache, Université de l’Ancienne Archipel, Republic of Yemen, and Paul-Jean Cahen*, Faculty de Science de St Jerome, France (909-13-164)

3:30 PM  On cross numbers of minimal zero sequences.
Scott Thomas Chapman*, Trinity University, and Alfred Geroldinger, Karl Franzens Universität, Austria (909-13-130)

4:00 PM  UMT-domains and domains with Prufer integral closure.
Marco Fontana, Terza Università Degli Studio di Roma, Italy, Stefania Gabelli, Università di Roma La Sapienza, Italy, and Evan G. Houston*, University of North Carolina, Charlotte (909-13-156)

4:30 PM  A basis for the ring of polynomials integer-valued on prime numbers. Preliminary report.
William W. Smith*, University of North Carolina, Chapel Hill, Jean-Luc Chabert, University de Picardie, France, and Scott Thomas Chapman, Trinity University (909-13-20)

5:00 PM  One-dimensional bounded factorization domains.
Jeanam Park, University of Tennessee, Knoxville (909-13-163)

5:30 PM  The u, u⁻¹ Lemma revisited.
Daniel D. Anderson, University of Iowa, and Dong Je Kwak*, Kyungpook University, Korea (909-13-45)

6:00 PM  $t$-invertibility IV. Preliminary report.
Daniel D. Anderson, University of Iowa, and M. Zafrullah*, MTA Teleport, Silver Spring, Maryland (909-13-144)

Special Session on Derivatives and Financial Mathematics, I

2:45 PM – 5:50 PM
Organizer: John F. Price, Maharishi International University

2:45 PM  Option pricing theory: From partial differential equations to fractals.
John F. Price, Maharishi International University (909-90-71)

3:30 PM  Insurance derivatives.
Thomas V. O’Brien, Bowling Green State University (909-90-70)

4:00 PM  Lattice methods for exotic options.
Robert Benhenni* and Anlong Li, First National Bank of Chicago, Chicago, Illinois (909-90-75)
Special Session on Arrangements of Hyperplanes, II

3:00 PM - 5:50 PM

Organizers: Michael J. Falk, Northern Arizona University
Richard C. Randell, University of Iowa

3:00 PM On the topology of strata in the standard discriminant.
Boris Z. Shapiro*, Stockholm University, Sweden, and Volkmar Welker, Institute for Experimental Mathematics, University of GH-Essen, Germany (909-57-268)

3:30 PM On twisted de Rham cohomology.
Alan C. Adolphson*, Oklahoma State University, Stillwater, and Steven Sperber, University of Minnesota, Minneapolis (909-14-210)

4:00 PM Signed-graphic arrangements of hyperplanes.
Guy David Bailey, University of Minnesota, Minneapolis (909-52-18)

4:30 PM Configuration spaces and subspace arrangements.
Shelia Sundaram, University of Miami (909-05-230)

Special Session on Topology of 3-manifolds, II

3:00 PM - 5:50 PM

Organizers: Charles Frohman, University of Iowa
Ying-Qing Wu, University of Iowa
3:00 PM Comparing Heegaard splittings—the bounded case.
Rubinstein, Melbourne University, Australia, and Martin G. Scharlemann*, University of California, Santa Barbara (909-57-94)

3:30 PM Quantum obstructions to embedding a manifold in $S^3$.
Charles Frohman, University of Iowa, and Joanna M. Kania-Bartoszynska*, Boise State University (909-57-56)

4:00 PM $SL(2, C)$ topological quantum field theory with corners.
Razvan Gelca, University of Iowa (909-57-30)

4:30 PM Graph manifolds and taut foliations.
(101) Mark W. Brittenham*, New Mexico State University, Las Cruces, Ramin Naimi, University of California, Davis, and Rachel Dedywydd Roberts, Washington University (909-57-52)

5:00 PM Intersecting surfaces.
(102) Rachel Dedywydd Roberts, Washington University (909-54-111)

5:30 PM Detecting the unknot in polynomial time.
(103) Preliminary report.
Charles J. Delman* and Keith D. Wolcott, Eastern Illinois University (909-57-99)

Special Session on Nonlinear Partial Differential Equations, II

3:00 PM – 5:20 PM
Organizers: Lihe Wang, University of Iowa
Gerhard O. Strohmer, University of Iowa

3:00 PM On steady two dimensional flows with concentrated vortices.
Alan R. Elcrat, Wichita State University (909-35-122)

3:30 PM Can damping inhibit blowup?
Howard A. Levine*, Iowa State University, and James B. Serrin, University of Minnesota, Minneapolis (909-35-35)

4:00 PM A new proof of boundary gradient estimates for quasilinear elliptic equations.
Gary M. Lieberman, Iowa State University (909-35-259)

4:30 PM On a connection between linearized stability and the bifurcation function.
Michael W. Smiley, Iowa State University (909-35-181)

5:00 PM Functionals with free interfaces and their flows.
(108) Preliminary report.
Qing Han, University of Notre Dame (909-35-159)

Special Session on Current Issues in Nonlinear Conservation Laws, II

3:00 PM – 4:50 PM
Organizer: Suncica Canic, Iowa State University

3:00 PM Global solutions for the Navier-Stokes equations of multidimensional, compressible, heat-conducting flow with discontinuous initial data.
David C. Hoff, Indiana University, Bloomington (909-35-38)

3:30 PM On a nonlocal dispersive equation modeling suspensions.
Kevin R. Zumbrun, Indiana University, Bloomington (909-35-134)

4:00 PM Asymptotic decay of periodic solutions of nonlinear hyperbolic systems of conservation laws.
Gui-Qiang Chen*, Northwestern University, and Hermano Frid, Northwestern University and Universidade Federal do Rio de Janeiro, Brazil (909-35-135)

4:30 PM Weak detonation solutions of a combustion model.
(112) Tong Li, University of Iowa (909-76-187)

Special Session on Theta Correspondences and Automorphic Forms, I

3:00 PM – 5:50 PM
Organizer: David C. Manderscheid, University of Iowa

3:00 PM The theta correspondence for $GSp(2)$ and $GO(4)$.
(113) Brooks Keilwkeit Roberts, University of Toronto (909-11-90)

3:30 PM Theta liftings and special values of Hecke $L$-functions.
Tonghai Yang, Institute for Advanced Study (909-11-139)

4:00 PM Twisted symmetric-square $L$-functions and the nonexistence of Siegel zeroes on $GL(3)$.
William D. Banks, McGill University (909-11-125)

4:30 PM Shimura integrals for metaplectic covers of $GSp(4)$.
(116) Preliminary report.
Solomon Friedberg, University of California, Santa Cruz (909-11-175)

5:00 PM Representations of non-linear groups.
(117) Jeffrey Adams, University of Maryland, College Park (909-22-198)

5:30 PM Theta correspondence for unitary groups over $R$.
(118) Annegren Paul, University of Maryland, College Park (909-22-48)

Special Session on Geometric and Analytic Methods in Several Complex Variables, I

3:00 PM – 5:50 PM
Organizer: Franc Forstneric, University of Wisconsin, Madison

3:00 PM A Poincaré theorem in several complex variables.
(119) John P. D’Angelo, University of Illinois, Urbana-Champaign (909-32-08)

3:30 PM Infinitesimal CR automorphisms and uniqueness results. Preliminary report.
M. Salah Baouendi, P. Ebenfelt* and Linda Preiss Rothschild, University of California at San Diego, La Jolla (909-32-132)

4:00 PM Dynamics of birational maps of $P^2$.
(121) Jeffrey Diller, Cornell University (909-32-07)

4:30 PM Solutions of Cauchy Riemann equations on a pseudoconvex domain with non smooth boundary. Preliminary report.
Seongan Yie, Purdue University, West Lafayette (909-32-06)

5:00 PM The tangential Cauchy-Riemann operator on the boundary of convex domains in $C^n$.
Khalid Filali-Adib, San Diego, California (909-32-09)

5:30 PM Proper holomorphic mappings between domains in complex $n$-space.
Xiaojun Huang, Mathematical Sciences Research Institute, Berkeley (909-32-34)
Saturday, March 23

Special Session on Moments and Operators, III

8:00 AM - 10:50 AM
Organizers: Raul E. Curto, University of Iowa
Pale E. T. Jorgensen, University of Iowa
Paul S. Muhly, University of Iowa

8:00 AM
Moment problems and prediction.
(125) L. C. Gohberg, Tel Aviv University, Israel, and Henry J. Landau*, AT&T Bell Laboratories, Murray Hill, New Jersey (909-42-131)

8:30 AM
Quadrature domains and operator theory.
(126) Liming Yang, University of Hawaii, Honolulu, and John E. McCarthy*, Washington University (909-47-112)

9:00 AM
Positive-definite functions on free semigroups.
(127) Gelu Fanica Popescu, University of Texas, San Antonio (909-47-82)

9:30 AM
The truncated complex moment problem.
(128) Preliminary report.
Lawrence A. Fialkow, State University of New York, College at New Paltz (909-47-26)

10:00 AM
One-term solutions of certain moment problems.
(129) Jingbo Xia, State University of New York, Buffalo (909-47-102)

10:30 AM
The complex moment problem and subnormality.
(130) F. H. Szafraniec, Jagiellonian University, Poland (909-47-114)

Special Session on Mostly Finite Geometries, III

8:00 AM - 10:50 AM
Organizer: Norman L. Johnson, University of Iowa

8:00 AM
p-Ranks of finite geometric structures. Preliminary report.
(131) G. Eric Moorhouse, University of Wyoming (909-51-232)

8:30 AM
Building a cyclic q-clan. Preliminary report.
(132) Stanley E. Payne*, University of Colorado, Denver, Tim Penttila and Gordon F. Royle, University of Western Australia, Australia (909-51-80)

9:00 AM
On completing a union of 3-spaces to a plane.
(133) Preliminary report.
Julia Nowlin Brown, York University (909-51-251)

9:30 AM
Virtual derivation. Preliminary report.
(134) Robert Allen Liebler, Colorado State University (909-51-238)

10:00 AM
Weighted circles in EG(2, q).
(135) F. A. Sherk, University of Toronto (909-51-249)

10:30 AM
Parallelisms of PG(3, q).
(136) Alan R. Prince, Heriot-Watt University, United Kingdom (909-51-226)

Special Session on Physical Knot Theory, III

8:00 AM - 10:50 AM
Organizers: Jonathan K. Simon, University of Iowa
Gregory Buck, Saint Anselm’s College

8:00 AM
Knot energies by ropes. Preliminary report.
(137) Claus Ernst*, Western Kentucky University, Yuanan Diao, Kennesaw State College, and Esais J. Janse van Rensburg, York University (909-57-65)

8:30 AM
In search of a good polygonal knot energy function.
(138) Preliminary report.
Yuanan Diao*, Kennesaw State College, Claus Ernst, Western Kentucky University, and Esais J. Janse van Rensburg, York University (909-57-87)

9:00 AM
Energies for polygonal knots. Preliminary report.
(139) Yuanan Diao, Kennesaw State College, Claus Ernst, Western Kentucky University, and Esais J. Janse van Rensburg*, York University (909-65-101)

9:30 AM
Equilateral polygonal knots. Preliminary report.
(140) Kenneth C. Millett, University of California, Santa Barbara (909-57-247)

10:00 AM
Möbius energy of Hopf links and the Morse theory of electrons on S^2. Preliminary report.
Robert Barnard Kusner*, University of Massachusetts, Amherst, John M. Sullivan, University of Minnesota, Minneapolis, James Lawrence and Nick Schmitt, University of Massachusetts, Amherst (909-57-255)

10:30 AM
Discretizations of Möbius knot energies.
(142) John M. Sullivan, University of Minnesota, Minneapolis (909-57-254)

Special Session on Commutative Ring Theory, III

8:00 AM - 10:50 AM
Organizer: Daniel D. Anderson, University of Iowa

8:00 AM
The residue fields of a zero-dimensional ring.
(143) William J. Heinzer, Purdue University, West Lafayette, David C. Lantz*, Colgate University, and Roger A. Wiegand, University of Nebraska, Lincoln (909-13-252)

8:30 AM
Minimal generating sets for ideals in local domains.
(144) Kurt D. Herzinger, University of Nebraska, Lincoln (909-13-116)

9:00 AM
The S_2-fication of a commutative ring. Preliminary report.
(145) Joseph P. Brennan, North Dakota State University (909-13-118)

9:30 AM
Unique factorization of bonds and other cashflows. Preliminary report.
(146) Douglas L. Costa, University of Virginia (909-13-165)

10:00 AM
Characterizing when R[X] is completely integrally closed. Preliminary report.
(147) Thomas G. Lucas, University of North Carolina, Charlotte (909-13-154)

10:30 AM
Properties of the projective line over the integers.
(148) Aihua Li, Loyola University, and Sylvia Margaret Wiegand*, University of Nebraska, Lincoln (909-13-216)

Special Session on Research in Mathematics by Undergraduates

8:00 AM - 10:50 AM
Organizer: Carl C. Cowen, Purdue University, West Lafayette

8:00 AM
Informal discussion
(149) Janice M. Winner, University of Kentucky (909-13-88)

9:00 AM
Improved bounds for the reliability of d-dimensional consecutive-k-out-of-n systems.
(150) Laura Kay Potter, University of Northern Iowa (909-60-15)

9:30 AM
Redundant matrices for linear transformations.
(151) Carl C. Cowen and Daniel E. Crosby*, Purdue University, West Lafayette (909-15-148)
Program of the Sessions – Iowa City, IA, Saturday, March 23 (cont’d.)

10:00 AM  p-Adic Bessel functions and harmonic analysis.
          (166) Paul J. Sally, Jr., University of Chicago (909-22-240)
10:30 AM  Current densities in relativistic few-body systems.
          (167) F. Coester, Argonne National Laboratories, Argonne, Illinois (909-81-146)

Special Session on Geometry and Cohomology, III

8:30 AM – 10:20 AM
Organizer: Walter I. Seaman, University of Iowa

8:30 AM  On the incompleteness of Berger’s list of holonomy representations. Preliminary report.
         (168) Quoshin Chi*, Washington University, Sergey Merkulov, University of Glasgow, United Kingdom, and Lorenz J. Schwachhoefer, University of Leipzig, Germany (909-53-79)
9:00 AM  On symmetries of constant mean curvature surfaces.
         (169) Josef F. Dorfmeister*, University of Kansas, and Guido Haak, Technical University of Berlin, Germany (909-53-205)
9:30 AM  Seiberg-Witten invariants of complex surfaces with the reversed orientation.
         (170) Tedi C. Draghici, Michigan State University (909-57-68)
10:00 AM  Dupin hypersurfaces with four principal curvatures.
         (171) Preliminary report.
         (171) Gary R. Jensen*, Washington University, and Thomas E. Cecil, College of the Holy Cross (909-53-110)

Special Session on Topology of 3-manifolds, III

8:30 AM – 10:50 AM
Organizers: Charles Frohman, University of Iowa
           Ying-Qing Wu, University of Iowa

8:30 AM  Dehn surgery. Preliminary report.
         (172) C. M. Gordon, University of Texas, Austin (909-57-258)
9:00 AM  On mutative 3-manifolds.
         (173) Yongwu Rong, George Washington University (909-57-60)
9:30 AM  The Kauffman bracket skein module and SL2(F) representations of f(M).
         (174) Doug Bullock, Boise State University (909-57-54)
10:00 AM  Elementary moves on Heegaard diagrams.
         (175) Feng Luo, Rutgers University, New Brunswick (909-57-53)
10:30 AM  On graph manifolds.
         (176) Hyam Rubinstein, Melbourne University, Australia, Shicheng Wang* and Fengchun Yu, Beijing University, People’s Republic of China (909-57-63)

Special Session on Theta Correspondences and Automorphic Forms, II

8:30 AM – 10:50 AM
Organizer: David C. Manderscheid, University of Iowa

8:30 AM  Exceptional θ-correspondences.
         (177) Kay Magaard*, Wayne State University, and Gordan Savin, University of Utah (909-22-50)
9:00 AM  Minimal representations, shared orbits and dual pair correspondences.
         (178) Jing-Song Huang, Hong Kong University of Science and Technology, Hong Kong (909-22-93)
9:30 AM  K-types of minimal representations (p-adic case).
         (179) Gordan Savin, University of Utah (909-22-49)

Special Session on Arrangements of Hyperplanes, III

8:30 AM – 10:50 AM
Organizers: Michael J. Falk, Northern Arizona University
           Richard C. Randell, University of Iowa

8:30 AM  Intersection theory in Ω(\log D). Preliminary report.
         (154) Roberto Silvotti, State University of New York, Stony Brook (909-52-241)
9:00 AM  Ordered configurations of roots of real polynomials.
         (155) Volkmar Welker, Institute for Experimental Mathematics, Germany (909-57-127)
9:30 AM  Intersection lattices of discriminantal arrangements. Preliminary report.
         (157) Margaret M. Bayer, University of Kansas (909-52-178)
10:00 AM  Complex hyperplane arrangements.
         (158) Helene Barcelo* and E. C. Ihrig, Arizona State University (909-52-195)
10:30 AM  A graph-dependent condition for a pattern of matrices allowing a line sum constant matrix.
         (152) Michael E. Holcomb*, Oklahoma State University, Stillwater, and David P. Stanford, College of William & Mary (909-15-229)

Special Session on Derivatives and Financial Mathematics, II

8:30 AM – 10:50 AM
Organizer: John F. Price, Maharishi International University

8:30 AM  On an interior-point column-generation algorithm for stochastic financial optimization.
         (159) Yinyu Ye, University of Iowa (909-90-74)
9:00 AM  Pricing options when asset return follows a “colored” Brownian process.
9:30 AM  Path structure of the bond price process in the Heath, Jarrow, and Morton model.
         (161) Valery Alexandrovich Kholodnyi, Integrated Energy Services, Fairfield, Iowa, and Milan N. Lukic*, University of Wisconsin, Milwaukee (909-60-211)
10:00 AM  Testing the Heath, Jarrow and Morton model for interest rates.
         (162) Mukarram Attari, University of Iowa (909-90-78)
10:30 AM  Problem session

Special Session on Group Representations and Mathematical Physics, III

8:30 AM – 10:50 AM
Organizer: Tuong Ton-That, University of Iowa

8:30 AM  Computing cohomology using covariant differential operators. Preliminary report.
         (163) Ronald J. Stanke, Baylor University (909-22-158)
9:00 AM  Quantization of collective dynamics.
         (164) George Rosensteel, Tulane University (909-22-193)
9:30 AM  Algebras of growth one.
         (165) Efim Zelmanov, Yale University (909-22-270)
10:00 AM  Explicit models for small unitary representations.  
           (180) Siddhartha Sahi, Rutgers University, New 
                   Brunswick (909-22-174)
10:30 AM  Caperiads. Preliminary report.  
           (181) S. Rallis, Ohio State University, Columbus 
                   (909-11-227)

**Special Session on Geometric and Analytic Methods in**  
**Several Complex Variables, II**

8:30 AM - 10:50 AM
Organizer: Franc Forstneric, University of Wisconsin, Madison
8:30 AM  An estimate on pseudoconvex boundaries.  
           Preliminary report.  
           (182) Emil J. Straube, Texas A & M University, College 
                   Station (909-32-184)
9:00 AM  The Cauchy-Riemann equation on singular spaces.  
           (183) John Erik Fornaess and Estela A. Gabosto, 
                   University of Michigan, Ann Arbor (909-32-220)
9:30 AM  Divergence of the normalization for real 
           Lagrangian surfaces near complex tangents.  
           (184) Xianghong Gong, Mathematical Sciences Research 
                   Institute, Berkeley (909-32-21)
10:00 AM  Proper holomorphic mappings.  
           (185) Victoria Pambuccian, Indiana University, 
                   Bloomington (909-32-199)
10:30 AM  The Ahlfors map and Szegö kernel for an annulus.  
           (186) Thomas J. Tegtmeyer, Purdue University, West 
                   Lafayette, and Anthony D. Thomas*, University of 
                   Wisconsin, Platteville (909-30-22)

**Special Session on Nonlinear Partial Differential**  
**Equations, III**

9:00 AM - 10:50 AM
Organizers: Lihe Wang, University of Iowa  
           Gerhard O. Strohmer, University of Iowa
9:00 AM  Weak continuity of multilinear operators and 
           homogenization.  
           (187) Sijue Wu, Northwestern University (909-35-263)
9:30 AM  The Plateau Problem for boundary curves with 
           connectors.  
           (188) Henry C. Wente, University of Toledo (909-49-250)
10:00 AM  Topological decomposition of Sobolev functions. 
           Preliminary report.  
           (189) Ed W. Stredulinsky*, University of Wisconsin, 
                   Richland Center, and Peter Michael Laurent, 
                   University of Rome La Sapienza, Italy (909-35-261)
10:30 AM  Multi-dimensional diffusion waves for the 
           Navier-Stokes equations of compressible flow.  
           (190) David C. Hoff* and Kevin R. Zumbrun, Indiana 
                   University, Bloomington (909-35-37)

**Special Session on Current Issues in Nonlinear**  
**Conservation Laws, III**

9:30 AM - 10:50 AM
Organizer: Suncica Canic, Iowa State University
9:30 AM  Mass conserving front tracking for miscible two 
           phase flow.  
           (191) Kou Kang Chang, Indiana University, Bloomington, 
                   and W. Brent Lindquist*, State University of New 
                   York, Stony Brook (909-76-40)
10:00 AM  Viscous shock profiles and post-shock oscillations.  
           (192) Smadar Karni, Courant Institute of Mathematical 
                   Sciences, New York University (909-76-137)
10:30 AM  A class of positive difference schemes for 
           symmetrizable systems of conservation laws in any 
           number of space dimensions.  
           Peter D. Lax* and Xu-Dong Liu, Courant Institute of 
           Mathematical Sciences, New York University 
           (909-76-97)

**Invited Address**

11:00 AM - 11:50 AM
(194) Unique continuation for solutions to partial 
     differential equations.  
     Daniel T. Tatley, Northwestern University 
     (909-35-03)

**Invited Address**

1:30 PM - 2:50 PM
(195) Rotation sets in dynamical systems.  
     Michal Misiurewicz, Indiana University-Purdue 
     University, Indianapolis (909-54-02)

**Special Session on Mostly Finite Geometries, IV**

2:30 PM - 6:50 PM
Organizer: Norman L. Johnson, University of Iowa
2:30 PM  Informal discussion.  
           (196) Quasiregular collineation groups and related Schur 
                   rings.  
           Yutaka Hiramine, University of Iowa (909-51-91)
3:00 PM  Partial geometries and Steiner designs.  
           (197) Vladimir D. Tonchev, Michigan Technological 
                   University (909-51-119)
4:00 PM  Blueprints for classical quadrangles and hexagons. 
           Preliminary report.  
           (198) Michael Andrew Abramson, Bowling Green State 
                   University (909-51-225)
4:30 PM  The Tverberg algebra of a generalized 
           quadrangle. Preliminary report.  
           (199) Sylvia A. Hobart, University of Wyoming 
                   (909-05-231)
5:00 PM  Classification results for ovoids in 
           $O_7^-(q)$.  
           (200) Athula Gunawardena, Wayne State College 
                   (909-05-32)
5:30 PM  Morphisms of buildings and related geometries.  
           Preliminary report.  
           (201) Peter M. Johnson, University of London, United 
                   Kingdom (909-51-248)
6:00 PM  Informal discussion

**Special Session on Group Representations and**  
**Mathematical Physics, IV**

2:30 PM - 6:20 PM
Organizer: Tuong Ton-That, University of Iowa
2:30 PM  Geometry and analysis on nonconvex tubes. 
           (202) Simon G. Gindikin, Rutgers University, New 
                   Brunswick (909-22-183)
3:00 PM  Invariant theory and the oscillator representation.  
           (203) Kenneth I. Gross, University of Vermont 
                   (909-22-188)
3:30 PM  Nonlinear dynamical systems which are not 
           integrable.  
           (204) Robert Gilmore, Drexel University (909-22-222)
4:00 PM  Group representation theory, number theory and 
           wavelet inverse theory. Preliminary report.  
           (205) Brian DeFacio*, University of Missouri, Columbia, 
                   and Jon A. Sjogren, Bolling AFB, District of 
                   Columbia (909-20-83)
Program of the Sessions - Iowa City, IA, Saturday, March 23 (cont'd.)

4:30 PM  
(206) **Law of commutative ring theory, IV**  
*Special Session on Commutative Ring Theory, IV*  
*Organizer: Daniel D. Anderson, University of Iowa*

- **Laws of trigonometry in symmetric spaces.**  
  Helmer Aslaksen*, National University of Singapore, Singapore, and Hsueh-Ling Huynh, AT&T Bell Laboratories, Murray Hill, New Jersey (909-53-166)
- **Generalised Casimir operators.**  
  Helmer Aslaksen, Eng-Chye Tan and Chen-Bo Zhu*, National University of Singapore, Singapore (909-17-142)
- **A new set of operator-valued Bessel functions.**  
  Preliminary report.

5:00 PM  
(207) **Special Session on Moments and Operators, IV**  
**Preliminary report.**

5:30 PM  
(208) **On some reciprocity theorems for infinite-dimensional dual pairs of groups.**  
Tuong Ton-That, University of Iowa (909-22-208)

6:00 PM  
(209) **Factorization in rings and modules.**  
Organizer: Daniel D. Anderson, University of Iowa

Special Session on Commutative Ring Theory, IV

2:30 PM - 6:20 PM

- **Factorization in rings and modules.** Preliminary report.
  Daniel D. Anderson, University of Iowa, and Silvia Valdes-Leon*, University of Southern Maine (909-13-145)
- **Cohomological varieties, lifting, and Tor on a complete intersection.** Preliminary report.
  David Allen Jorgensen, University of Nebraska, Lincoln (909-13-117)
- **Ideals of integer-valued polynomial rings.** Preliminary report.
  Alan Loper, Ohio State University, Newark (909-13-123)
- **A strictly algebraic approach to the Jacobian Conjecture.**
  Eloise Ann Hamann, San Jose State University (909-13-28)
- **Gaussian polynomials and content ideals.**
  William J. Heinzer* and Craig L. Huneke, Purdue University, West Lafayette (909-13-143)
- **Gaussian polynomials and content invertibility.**
  Sarah Glaz, University of Connecticut, Storrs (909-13-23)
- **The depth of a tensor product of modules.**
  Craig L. Huneke, Purdue University, West Lafayette, and Roger A. Wiegand*, University of Nebraska, Lincoln (909-13-140)
- **An intersection condition for prime ideals.** Preliminary report.
  Robert Gilmer, Florida State University (909-13-44)

Special Session on Physical Knot Theory, IV

3:00 PM - 6:20 PM

- **Energy minimizing knots in S^3 and H^3.** Preliminary report.
  Jun O'Hara, Tokyo Metropolitan University, (909-57-253)
- **On the energy and length of a knot.** Preliminary report.
  Gregory Buck, Saint Anselm's College (909-57-224)
- **Magnetic flux tubes, elastic rods and uniformly charged loops.** Preliminary report.
  Atta Y.K Chui* and H. K. Moffatt, University of Cambridge, United Kingdom (909-57-267)
- **Cutting the knot: Reconnection in superfluids, dislocations, and flood plains.** Preliminary report.
  Klaus Schwarz, IBM T. J. Watson Research Center, Yorktown Heights, New York (909-57-221)
- **Knotted and linked periodic solutions to ordinary differential equations.** Preliminary report.
  Robert W. Ghrist, Cornell University (909-57-228)
- **Results on harmonic knots.**
  Aaron Keith Trautwein, Carthage College (909-57-152)
6:00 PM The thickness of knots. Preliminary report.
(235) Rick Litherland*, Louisiana State University, Baton Rouge, Oguz C. Durumeric and Jonathan K. Simon, University of Iowa (909-57-269)

**Special Session on Geometry and Cohomology, IV**

3:00 PM – 5:20 PM
Organizer: Walter I. Seaman, University of Iowa

- 3:00 PM Dirac operators on Clifford bundles and jointly seminormal spectra.
  Mircea Martin, University of Kansas (909-58-213)
- 3:30 PM Minimal orbits of metrics and applications.
  Yoshiaki Maeda, Keio University, Japan, Steven Rosenberg, Boston University, and Philippe Tondeur*, University of Illinois, Urbana-Champaign (909-58-67)
- 4:00 PM On Seiberg-Witten solutions. Preliminary report.
  Shuguang Wang, University of Missouri, Columbia (909-57-215)
- 4:30 PM On the dressing action of loop groups on harmonic maps.
  Hongyou Wu, Northern Illinois University (909-53-104)
- 5:00 PM Geodesic length functions and cohomology of mapping class groups. Preliminary report.
  Yining Xia, Northern Illinois University (909-55-29)

**Special Session on Topology of 3-manifolds, IV**

3:00 PM – 5:20 PM
Organizers: Charles Frohman, University of Iowa
  Ying-Qing Wu, University of Iowa

- 3:00 PM Incompressible surfaces in knot exteriors. Preliminary report.
  Marc E. Culler and Peter B. Shalen*, University of Illinois, Chicago (909-57-207)
- 3:30 PM The Burau representations modulo 2. Preliminary report.
  Daryl Cooper and David Darren Long*, University of California, Santa Barbara (909-57-57)
- 4:00 PM Minimal cusp lengths in hyperbolic 3-manifolds. Preliminary report.
  Colin C. Adams, Williams College (909-57-25)
- 4:30 PM Almost normal surfaces in 3-manifolds.
  Michelle M. Stocking, University of California, Davis (909-57-58)
- 5:00 PM Rank, Heegaard genus, and the Meridional generator conjecture.
  Steven A. Bleiler*, Portland State University, and Amelia Jones, Vassar College (909-54-141)

**Special Session on Nonlinear Partial Differential Equations, IV**

3:00 PM – 4:50 PM
Organizers: Lihe Wang, University of Iowa
  Gerhard O. Strohmer, University of Iowa

- 3:00 PM A transonic flow problem.
  Yuxi Zheng, Indiana University, Bloomington (909-82-124)
- 3:30 PM Navier-Stokes equations in thin three dimensional domains with various boundary conditions.
  Roger Temam and Mohammed B. Ziane*, Indiana University, Bloomington (909-35-167)
- 4:00 PM Head-media interaction in magnetic recording.
  Avner Friedman, University of Minnesota, Minneapolis, and Bei Hu*, University of Notre Dame (909-35-16)
- 4:30 PM Compressible flows under the influence of gravity. Preliminary report.
  Gerhard O. Strohmer*, University of Iowa, and Wojciech M. Zajaczkowski, Academy of Science, Poland (909-35-161)

**Special Session on Current Issues in Nonlinear Conservation Laws, IV**

3:00 PM – 4:50 PM
Organizer: Suncica Canic, Iowa State University

- 3:00 PM Remarks on Mach configurations for the small-disturbance equation.
  Cathleen S. Morawetz, Courant Institute of Mathematical Sciences, New York University (909-76-109)
- 3:30 PM Steady states of the Vlasov-Poisson-Fokker-Planck system.
  Robert T. Glassey, Indiana University, Bloomington, John W. Schaeffer, Carnegie Mellon University, and Yuxi Zheng*, Indiana University, Bloomington (909-82-126)
- 4:00 PM A numerical method for a free-boundary problem arising in weak shock reflection.
  Dregon Mirkovic* and Suncica Canic, Iowa State University (909-76-120)
- 4:30 PM Diffraction of weak shocks: Linear and weakly nonlinear scalings.
  Esteban G. Tabak*, Courant Institute of Mathematical Sciences, New York University, and Ruben R. Rosales, Massachusetts Institute of Technology (909-76-128)

**Special Session on Theta Correspondences and Automorphic Forms, III**

3:00 PM – 5:50 PM
Organizer: David C. Manderscheid, University of Iowa

- 3:00 PM Minimal representations of exceptional p-adic groups.
  Karl E. Rumeihart, Ohio State University, Columbus (909-11-194)
- 3:30 PM The minimal representation of SO(4,3) over a local non-archimedian field.
  Julia Rina Roskies, Stanford University (909-11-173)
- 4:00 PM Theta representations and the Rankin-Selberg method. Preliminary report.
  Daniel Willis Bump, Stanford University (909-11-200)
- 4:30 PM A remark on certain periods on GSp(4). Preliminary report.
  Masaaki Furusawa, Johns Hopkins University (909-11-192)
- 5:00 PM The Siegel-Weil formula for the metaplectic group.
  W. Jay Sweet, Jr., Florida International University (909-22-203)
  Tomasz Przebinda, University of Oklahoma (909-22-169)
General Session

3:00 PM - 4:25 PM

3:00 PM
- Peano postulates for a finite set.
  Jack M. Anderson* and Sam F. Adli, South Dakota State University (909-03-236)

3:15 PM
- Frobenius matrix approximation with linearly singular values.
  Yves Nievergelt, Eastern Washington University (909-15-89)

3:30 PM
- Propagation of wedge-extendibility by geometric methods.
  Charles A. Pehlivanian, United States Military Academy (909-32-33)

3:45 PM
- Approximation properties of a strongly nonlinear boundary-value problem on unbounded domains.
  Michael D. Marcozzi, United States Military Academy (909-35-86)

4:00 PM
- Infinite bump solutions of nonlinear Schrödinger equations.
  Neeza Thandi, Dalhousie University (909-35-185)

4:15 PM
- A numerical clustering algorithm and some results on convexity.

Andy R. Magid
Associate Secretary
Norman, Oklahoma
Application for Membership 1996
(January–December)

Date .................................. 19 ..................................

Fields of Interest
If you wish to be on the mailing lists to receive information about publications in fields of mathematics in which you have an interest, please consult the list of major headings below. These categories will be added to your computer record so that you will be informed of new publications or special sales in the fields you have indicated.

EME  Education/Mathematics Education
   00  General
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   08  General algebraic systems
   11  Number theory
   12  Field theory and polynomials
   13  Commutative rings and algebras
   14  Algebraic geometry
   15  Linear and multilinear algebra; matrix theory
   16  Associative rings and algebras
   17  Nonassociative rings and algebras
   18  Category theory; homological algebra
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   20  Group theory and generalizations
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   26  Real functions
   28  Measure and integration
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   31  Potential theory
   32  Several complex variables and analytic spaces
   33  Special functions
   34  Ordinary differential equations
   35  Partial differential equations
   39  Finite differences and functional equations
   40  Sequences, series, summability
   41  Approximations and expansions
   42  Fourier analysis
   43  Abstract harmonic analysis
   44  Integral transforms, operational calculus
   45  Integral equations
   46  Functional analysis
   47  Operator theory
   49  Calculus of variations and optimal control; optimization
   51  Geometry
   52  Convex and discrete geometry
   53  Differential geometry
   54  General topology
   55  Algebraic topology
   57  Manifolds and cell complexes
   58  Global analysis, analysis on manifolds
   60  Probability theory and stochastic processes
   62  Statistics
   65  Numerical analysis
   68  Computer science
   70  Mechanics of particles and systems
   73  Mechanics of solids
   76  Fluid mechanics
   78  Optics, electromagnetic theory
   80  Classical thermodynamics, heat transfer
   81  Quantum theory
   82  Statistical mechanics, structure of matter
   83  Relativity and gravitational theory
   85  Astronomy and astrophysics
   86  Geophysics
   90  Economics, operations research, programming, games
   92  Biology and other natural sciences, behavioral sciences
   93  Systems theory; control
   94  Information and communication, circuits
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Please read the following to determine what membership category you are eligible for, and then indicate below the category for which you are applying.

For **ordinary members** whose annual professional income is below $45,000, the dues are $90; for those whose annual professional income is $45,000 or more, the dues are $120.

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For a **joint family membership**, one member pays ordinary dues, based on his or her income; the other pays ordinary dues based on his or her income, less $20. (Only the member paying full dues will receive the Notices and the Bulletin as a privilege of membership, but both members will be accorded all other privileges of membership.)

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**1996 Dues Schedule (January through December)**

- **Ordinary member** .................................................. $80 $120
- **CMS Cooperative rate** ........................................ $77 $102
- **Joint family member (full rate)** ................................. $90 $120
- **Joint family member (reduced rate)** .......................... $70 $100
- **Contributing member (minimum $180)** ....................... $180
- **Student member (please verify)** ............................... $30
- **Unemployed member (please verify)** ........................ $30
- **Reciprocity member (please verify)** .......................... $60 $90 $120
- **Category-S member** .............................................. $16
- **Multi-year membership** .......................................... $180 for $ for years

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1. **Student Verification** (sign below)
   I am a full-time student at ____________________________ currently working toward a degree.

2. **Unemployed Verification** (sign below) I am currently unemployed and actively seeking employment. My unemployment status is not a result of voluntary resignation or of retirement from my last position.

3. **Reciprocity Membership Verification** (sign below) I am currently a member of the society indicated on the right and am therefore eligible for reciprocity membership.

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**Signature**

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