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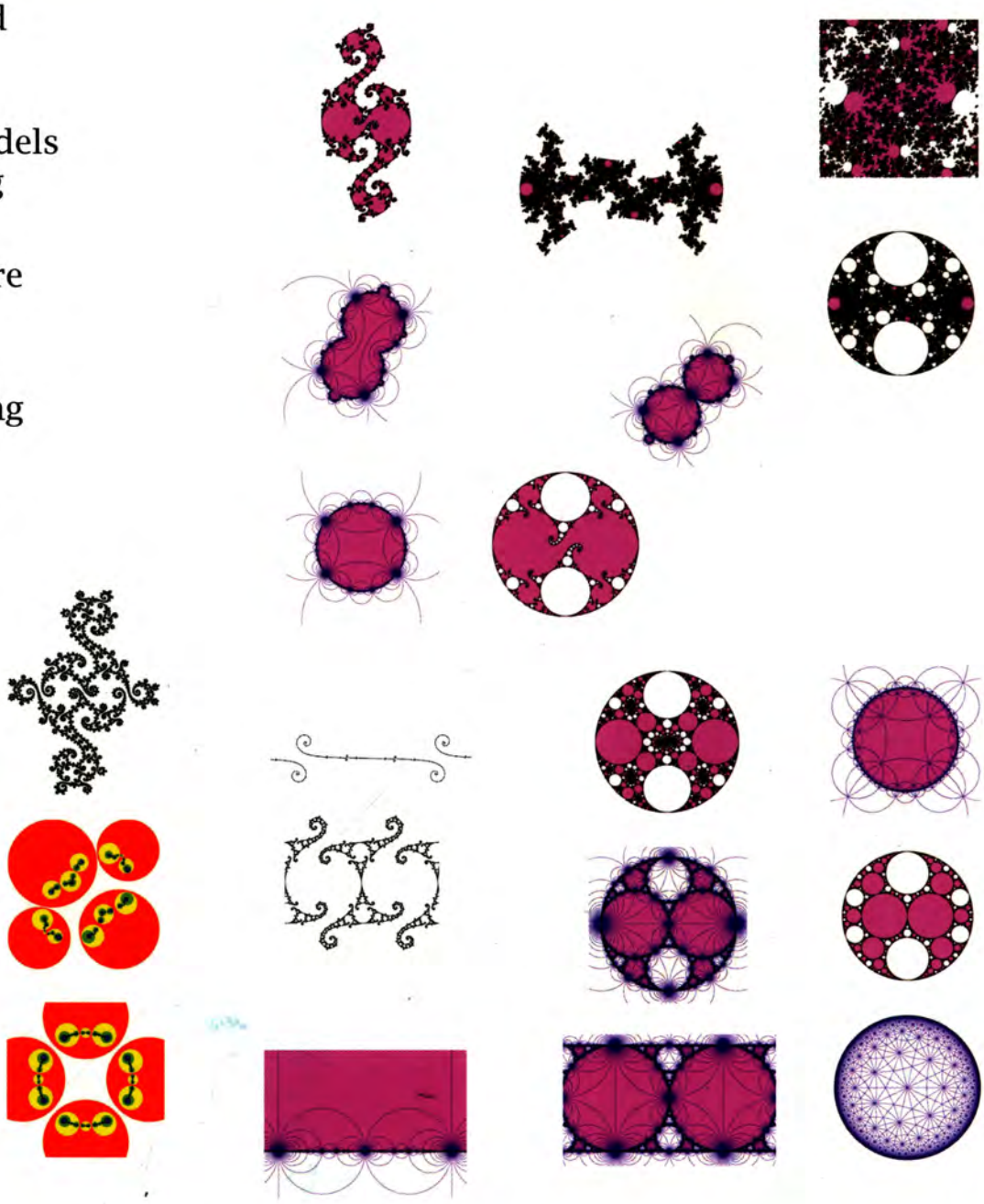

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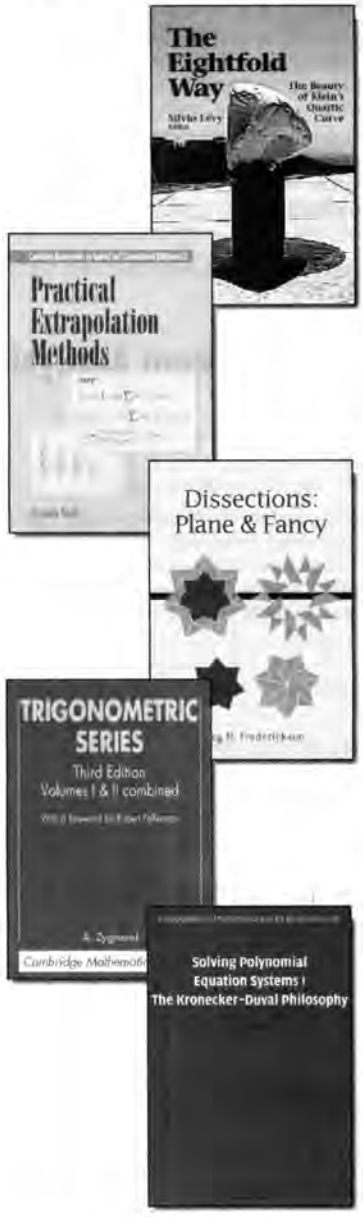

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of the American Mathematical Society

January 2003

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of the American Mathematical Society

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Departments

From the AMS Secretary

The U.S. National Committee for Mathematics

Let me be upfront; most mathematicians probably have no knowledge about the U.S. National Committee for Mathematics (NCM). Indeed, I first heard of the NCM only shortly before being selected as a member.

The NCM is a National Research Council committee whose members are appointed by the president of the National Academy of Sciences. This committee serves as the liaison between the U.S. mathematical community and the International Mathematical Union (IMU). It selects the U.S. delegates to the IMU General Assembly, which is held every four years prior to the International Congress of Mathematicians (ICM), and it proposes resolutions for consideration by the Assembly. (A parallel committee, chaired by Daniel Goroff, promotes mathematics instruction.) So if you have any concerns about how the IMU does its business or suggestions for improvements, contact the NCM. Are you worried about how prizes or speakers are selected or how conferences and officers are chosen? Contact us. As is true with the IMU, the NCM has an interest in promoting worldwide mathematics, particularly in developing countries.

To illustrate, a penalty of living in a period of relative affluence is that students who might normally consider mathematics as a career now look to law or business. To help counter this problem, which could damage mathematics on the international scene, the NCM organized as part of our Pacific Rim initiative a session in Hong Kong, where Ron Graham lectured to high school students, teachers, and administrators on the challenges of mathematics. To help both international and American mathematics, Graham's lecture is on our website, `http://www7.nationalacademies.org/usnc-math/index.html`; at this site you can also find the current list of NCM members.

We all know that to do mathematics, we need to know what mathematics is doing. Unfortunately, many developing countries simply do not have the resources to develop appropriate libraries or provide access to the current literature. Recognizing this reality, the NCM has been lobbying mathematical societies and publishers in the U.S. and elsewhere and successfully promoted a resolution at the General Assembly in Shanghai in August 2002 to encourage making published papers freely available on the Internet no more than five years after publication. Five years is a compromise; while we would like everything available immediately, economic realities dictate some time lag. Also, while our stated concerns are directed toward developing countries, we fully appreciate how this program will benefit many American mathematicians.

Wouldn't it have been nice to have been at the 2002 Beijing ICM? The ICM is where some of the best mathematics and some of the directions for the immediate future are described. OK, so most of us could not attend. However, the NCM is working with Zhi-Ming Ma (chair of the local organizing committee for the Beijing ICM) and the Mathematical Sciences Research Institute in Berkeley to make the ICM plenary talks available on streaming video.

Let me now describe the resolutions proposed by the NCM and our delegation to the IMU General Assembly in Shanghai. One which we worked on with the Association for Women in Mathematics and with the European Women in Mathematics honors Emmy Noether while providing a platform for outstanding mathematicians who also happen to be women. The last three ICMs had an Emmy Noether lecture, and we asked to have this tradition continue for the next two. Our resolution passed by acclamation.

A second resolution reflects the reality that mathematics is a global enterprise that transcends political boundaries. Recently, however, there have been calls for mathematicians to engage in a scientific boycott to protest the policies of a certain government. We should remember that an action of this kind after World War I nearly ruined the IMU and set back mathematics. A related concern is the new constraint on global scientific mobility that accompanies heightened security. While the NCM supports security, the health of mathematics mandates a relatively free flow of mathematics and mathematicians; policies must be balanced and realistic. To capture our concern over all of these issues, the NCM introduced the following resolution: "Notwithstanding these times of heightened tension and security concerns, we urge a continuation of scientific exchange and publication. The IMU opposes efforts either by governments, organizations, or individuals to restrict contacts and interactions in the world mathematical community. Specifically we oppose holding individual mathematicians liable for the actions of their governments. The IMU endorses the principles expressed in the International Council for Science (ICSU) Article 5 of Statutes." After an active General Assembly discussion which reflected the international concern about these issues, our resolution passed with only one informal abstention.

Associated with this resolution is a growing worry by many American mathematicians about visa problems and the increasing difficulties in having students or colleagues from other countries visit and work with us. This is an ongoing issue being addressed by the NCM.

This brief description provides a glimpse into NCM activities. But we want to expand. We are working to more fully involve the main mathematical societies, mathematics departments, and you. If you have any suggestions about how to advance mathematics on the international scene, please let us know!

—Don Saari
University of California at Irvine
Chair of the NCM and the U.S. delegation
to the Shanghai General Assembly
`dsaari@uci.edu`

Letters to the Editor

Kurt Gödel and Grinzing

I found John Dawson's article "Max Dehn, Kurt Gödel, and the Trans-Siberian Escape Route" in the October 2002 issue fascinating. The picture on page 1072 of Gödel and his wife "in Vienna" looks as though it was taken in Grinzing, a well-known wine suburb of Vienna.

Several years ago when my wife and I were wandering through the back streets of Grinzing, we came across a large building that looked as though it had at one time been an apartment house. On the front of the house were two plaques honoring former residents. One was the great conductor (and erstwhile Nazi, I'm afraid) Karl Böhm, and the other was Kurt Gödel. Gödel's plaque commemorated him as the discoverer of the "incompleteness theorem" or "theorems", I don't recall which. Anyway, Gödel did live in Grinzing, and the picture probably was taken there.

Another illustrious Grinzinger (he spent his summers there) was Franz Schubert; his statue can be seen not far from the Gödel-Böhm residence. And a short bus ride away is Heiligenstadt, where Beethoven spent some of his summers and where he wrote his celebrated testimony. A rather civilized place, Vienna! I wonder if there is a plaque in Princeton to indicate Gödel's residence there.

—Paul Zweifel
Virginia Tech
zweifel@member.ams.org

(Received September 21, 2002)

Academic Boycotts

This letter relates to the issues raised by academic boycotts.

ICSU, the International Council for Science, is the umbrella organization that comprises national scientific institutions and international scientific unions such as the International Mathematical Union, the sponsor of the International Congress of Mathematicians. Its membership includes, under varying arrangements, almost all countries in the world that have citizens contributing to scholarly research in the sciences. In the United States the adhering organization is the National Academy of Sciences.

Recently the ICSU Standing Committee on Freedom in the Conduct of Science (SCFCS) felt it appropriate to draft a statement relating to boycotts. The title of the statement is "Israeli Scholars: A Statement by ICSU/SCFCS". Its final sentence addresses the proper business of professional communities such as the worldwide community of professional mathematicians. It quotes the leader in the *London Evening Standard* on July 10, 2002: "Intellectual communities world-wide are in the business of fostering international understanding and co-operation not of penalising each other for the shortcomings of their governments."

—Joan S. Birman
Barnard College and Columbia University
jb@math.columbia.edu

(Received September 26, 2002)

Editor's Note: The text of the ICSU statement cited in the above letter is posted on the Web at http://www.icsu.org/Library/Central/Statem/israeli-schol.html. Drafted and signed by the SCFCS, it was endorsed by the Executive Board of ICSU. It is reprinted below with permission of the executive secretary of the SCFCS.

Israeli Scholars: ICSU/SCFCS Statement

Since its inception in 1931, the International Council for Science (ICSU) has affirmed and vigorously upheld the principle of universality of science based on the human right of scientists throughout the world to participate in scientific activity without any discrimination on the grounds of citizenship, religion, creed, political stance, ethnic origin, race, colour, age or gender. It has argued that the processes of academic research and scholarship, and the unfettered pursuit of knowledge, are of benefit to mankind as a whole. Moreover, they are dependent for their advance upon the freedom of scholars to converse, to make contact, to travel to conferences, to publish their results and to proffer advice. It is, therefore, in the interests of governments, institutions and above all individuals—whether themselves scholars or not—to support this principle of non-discrimination. Bona fide scholars pursuing academic activities should be free to do so without hindrance.

Recent moves to foster an academic boycott of Israeli scientists and the dismissal of two Israeli scholars from their roles on the editorial boards of two journals published in the United Kingdom are a flagrant breach of this principle and have rightly drawn substantial adverse comment from scientists, newspaper columnists and human rights activists in the United Kingdom.

On behalf of the Executive Board of ICSU, we draw attention to these events to remind all our national member academies and research councils and our scientific unions and associates of the critical importance of the principle of non-discrimination and of the need for constant vigil in securing its continuing adoption. We understand the strong feelings generated by conflicts, for example that in the Middle East, and the desire of individuals and groups to avoid contact, actively boycott or otherwise demonstrate distaste or disgust for the actions of nation state governments and others. But to do so through the medium of individual scholars is to sacrifice a profoundly important principle of freedom.

We urge all scholarly communities and not least those in science and technology, to heed the words of the Leader in the *London Evening Standard* on 10 July 2002: "Intellectual communities world-wide are in the business of fostering international understanding and co-operation not of penalising each other for the shortcomings of their governments."

—James C. I. Dooge
Chairman

Peter Schindler
Executive Secretary
ICSU Standing Committee on Freedom in the Conduct of Science

Pile of Crabs

I normally quite enjoy the illustrations on the cover of the *Notices*, but I found the one on the October 2002 issue to be quite disgusting. This was a pile of dead crabs and (lest the point be missed) a mallet clearly there to clobber the unfortunate crustaceans.

Perhaps I should lighten up, but I prefer not to have my favorite professional organization portray the slaughter of fellow creatures as an incentive to attend one of its meetings.

—Dale Rolfsen
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(Received September 27, 2002)

Navier: Blow-up and Collapse

Marco Cannone and Susan Friedlander

"All France knew of the disaster which happened in the heart of Paris to the first suspension bridge built by an engineer, a member of the Academy of Sciences; a melancholy collapse caused by blunders such as none of the ancient engineers—the man who cut the canal at Briare in Henri IV's time, or the monk who built the Pont Royal—would have made; but our administration consoled its engineer for his blunder by making him a member of the Council-general."

—Honoré de Balzac, from Le Curé de Village, *1841*

In the 1820s Claude Louis Marie Henri Navier[1] was a professor at the École des Ponts et Chaussées in Paris, which was the Grande École that trained engineers in nineteenth-century France. At the same time as publishing his famous fluid equations (now known as the Navier-Stokes equations), he designed the first monumental suspension bridge to be built in Paris over the Seine. His bridge developed a crack just before it was to open, and political battles resulted in the removal of the bridge. Accusations were made that Navier was "too much of a theoretical mathematician" and not "practical" like the British bridge builders such as Brunel or Stevenson. This debate was a version of a more general dispute between the French and British approaches to mathematics, physics, and engineering. The different national approaches to science were in fact also reflected by the way Navier (in 1822) and Stokes (in 1845) derived their eponymous equations.

The word "blow-up" of the solutions for the Navier-Stokes equations is familiar to at least a subset of mathematicians, most of whom probably do not know of Navier's bridge. In 1824–6, however, Navier was best known for a two-volume treatise on bridges [13] and the impressive design for the Pont des Invalides over the Seine (Figure 1). The controversy that followed the collapse of this bridge received wide coverage in the French press of the time, had repercussions for the Parisian world of finance, and was detrimental to Navier's reputation.

Marco Cannone is professor of mathematics at the Université de Marne-la-Vallée, France. His email address is cannone@math.univ-mlv.fr.

Susan Friedlander is professor of mathematics at the University of Illinois, Chicago, and an associate editor of the Notices. *Her email address is* susan@math.uic.edu.

[1] *Born in Dijon in 1785, he died in Paris in 1836.*

The Navier-Stokes Equations

The concept of "blow-up" for the Navier-Stokes equations has received considerable publicity recently in the context of one of the "million dollar" prize problems offered by the Clay Mathematics Institute. Briefly stated, an important problem in fluid dynamics is to answer the following question: In three dimensions does the velocity field of a fluid flow that starts smooth remain smooth for all time as the field evolves under the Navier-Stokes equations? A physical quantity such as the velocity, satisfying realistic boundary conditions, conceivably could develop a singularity in finite time, and this phenomenon is referred to as "blow-up". The partial differential equations known as the Navier-Stokes equations have proved to be among the most challenging to mathematicians of all the partial differential equations that arise from physics. More details can be found, for example, in the Clay prize description by Fefferman [5].

The first mathematical description of the motion of an "ideal" fluid was formulated by Euler [4] in 1755 as a statement of Newton's second law of motion applied to a fluid moving under an internal force known as the pressure gradient. The Euler equations governing the time evolution of the velocity vector field $\mathbf{v}(\mathbf{x}(t), t)$ and the (scalar) pressure $p(\mathbf{x}(t), t)$ of an incompressible fluid have the form

Figure 1. Pont des Invalides, taken from the original drawing by Navier in [13].

$$(1)\quad \begin{cases} \frac{\partial \boldsymbol{v}}{\partial t} + (\boldsymbol{v}\cdot\nabla)\,\boldsymbol{v} &= -\nabla p \quad (\boldsymbol{x}\in\mathbb{R}^n, t>0) \\ \nabla\cdot\boldsymbol{v} &= 0 \end{cases}$$

with initial condition

$$\boldsymbol{v}(\boldsymbol{x},0) = \boldsymbol{v}_0(\boldsymbol{x}),$$

where $\boldsymbol{v}_0(\boldsymbol{x})$ is a given divergence-free vector field. Here we restrict our attention to incompressible fluids filling all of $\mathbb{R}^n$, where n is the space dimension, which we take to be 2 or 3. These equations, while important theoretically, omit the effects of friction and bring about, as pointed out by D'Alembert, "a singular paradox which I leave to geometricians to explain" [1]. To incorporate friction, the French mathematician-engineer Navier (Figure 2) published in 1822 a paper [12] with the derivation of the equations of motion for a viscous fluid in which he included the effects of attraction and repulsion between neighboring molecules. From purely theoretical considerations he derived the following modification of the Euler equations:

$$(2)\quad \begin{cases} \frac{\partial \boldsymbol{v}}{\partial t} + (\boldsymbol{v}\cdot\nabla)\,\boldsymbol{v} &= \epsilon\Delta\boldsymbol{v} - \nabla p \quad (\boldsymbol{x}\in\mathbb{R}^n,\ t>0) \\ \nabla\cdot\boldsymbol{v} &= 0, \end{cases}$$

again with initial condition $\boldsymbol{v}(\boldsymbol{x},0) = \boldsymbol{v}_0(\boldsymbol{x})$ for a given divergence-free vector field $\boldsymbol{v}_0(\boldsymbol{x})$ in $\mathbb{R}^n$.

For Navier, ϵ was simply a function of the molecular spacing to which he attached no particular physical significance. His seminal paper [12] was presented at the French Académie des Sciences and was well received. He was elected a member of the Académie in the mechanics section in January 1824.

The equations for the motion of a viscous fluid were rederived by Cauchy in 1828 and by Poisson in 1829. In 1843 Barré de Saint-Venant published a derivation of the equations on a more physical basis that applied not only to the so-called laminar flows considered by Navier but also to turbulent flows. However, the person whose name is now attached with Navier's to the viscous equations is the British mathematician-physicist George Gabriel Stokes[2] (Figure 3). In 1845 he published a derivation of the viscous equations in a manner that is followed in most current texts. Unlike Navier, he made it clear that the parameter ϵ has an important physical meaning: namely, ϵ measures the magnitude of the viscosity (i.e., the friction of the fluid). Interesting details of the history of the fluid equations can be found in the books of Grattan-Guinness [8] and of Rouse and Ince [15].

Since the Navier-Stokes equations incorporate effects of friction, they are physically more realistic than the Euler equations. However, both systems of equations are important for physical and mathematical reasons. For example, Constantin [3] suggests that it is finite-time blow-up in the Euler equations that is the physically more important problem, since blow-up requires large gradients in the limit of zero viscosity (ϵ goes to zero). As Fefferman [5] remarks, finite-time blow-up in the Euler equations is an open and challenging mathematical problem, just as it is for the Navier-Stokes equations.

Two versus Three Dimensions

In this brief article we can give no details about the complexity of the systems of fluid equations (1) and (2), but we will make a few observations that may indicate a little about the challenges the systems pose to mathematicians. The Euler and the Navier-Stokes equations are nonlinear with the same nonlinear term, $(\boldsymbol{v}\cdot\nabla)\boldsymbol{v}$. Exactly this "amount" of nonlinearity appears to be particularly subtle and could imply blow-up in finite time. A question intimately related to the possible loss of regularity of the solutions is given by the possible loss of their uniqueness. The solutions to the Euler and the Navier-Stokes equations are known to be locally regular

[2] *Born in Skreen, County Sligo, Ireland, in 1819, he died in Cambridge in 1903.*

and unique in time, but at the instant T when they cease to be regular (if such an instant exists) the uniqueness could also be lost. The following simple example illustrates blow-up and loss of uniqueness in an equation with a nonlinearity.

Consider the ordinary differential equation

$$\begin{cases} \frac{dy}{dt} &= y^\alpha \\ y(0) &= y_0 \end{cases} \tag{3}$$

for different values of α and y_0. When the nonlinearity is quadratic ($\alpha = 2$) and the initial condition is $y_0 = 1$, the solution is $y = 1/(1-t)$, which blows up at $t = 1$. On the other hand, if $\alpha = 1/2$ and $y_0 = 0$, then this differential equation has infinitely many regular solutions, $y_C = ((t-C)/2)^2$ for $t \geq C$ and $y_C = 0$ otherwise, C being an arbitrary constant such that $0 \leq C \leq \infty$ (with the convention that $y_\infty \equiv 0$). Finally, in the case $\alpha = 1/2$ and $y_0 = 1$, the differential equation has a regular solution, $y = ((t+2)/2)^2$ for $t \geq -2$ and $y = 0$ otherwise, that is unique and that exists for all time.

The effects of nonlinearity in the fluid equations are strikingly different in two dimensions ($2D$) and in three dimensions ($3D$). In fact, existence and uniqueness of regular solutions for all time for the $2D$ Navier-Stokes equations are classical results proved in 1933 by Jean Leray [7], whereas the analog in $3D$ is a Clay prize problem. One crucial difference between $2D$ and $3D$ is the constraint that equations (1) and (2) impose in $2D$ on the evolution of the vorticity, an important physical attribute of fluid motion. The vorticity, which we denote by $\boldsymbol{\omega}(\mathbf{x})$, is $\nabla \times \mathbf{v}$. Taking the curl of (1) and (2) gives the equations for the evolution of the vorticity in an inviscid fluid:

$$\frac{\partial \boldsymbol{\omega}}{\partial t} + (\mathbf{v} \cdot \nabla)\boldsymbol{\omega} = (\boldsymbol{\omega} \cdot \nabla)\mathbf{v} \tag{4}$$

and in a viscous fluid:

$$\frac{\partial \boldsymbol{\omega}}{\partial t} + (\mathbf{v} \cdot \nabla)\boldsymbol{\omega} = (\boldsymbol{\omega} \cdot \nabla)\mathbf{v} + \epsilon \Delta \boldsymbol{\omega}. \tag{5}$$

In $2D$ the vorticity is a scalar field multiplied by a unit vector perpendicular to the $2D$ plane of motion. Hence the term $(\boldsymbol{\omega} \cdot \nabla)\mathbf{v}$ vanishes in $2D$, and although (4) and (5) remain nonlinear, they are significantly simpler than the $3D$ equations. In $2D$ equation (4) becomes

$$\frac{\partial \boldsymbol{\omega}}{\partial t} + (\mathbf{v} \cdot \nabla)\boldsymbol{\omega} \equiv \frac{d\boldsymbol{\omega}}{dt} = \mathbf{0}. \tag{6}$$

Thus in $2D$ the vorticity is a scalar quantity that is conserved along the trajectories of the fluid particles. Conservation of vorticity is a strong constraint on the complexity of the motions governed by the Euler equations. Only a weaker constraint known as Kelvin's circulation theorem exists for $3D$ flows where the term $(\boldsymbol{\omega} \cdot \nabla)\mathbf{v}$ does not vanish and may perhaps be instrumental in creating blow-up for the Euler equations.

An important advance in the theory of partial differential equations was the concept of "weak" solutions introduced by Leray [7], particularly for the Navier-Stokes equations. This permits objects in much larger classes than the space of classical functions to be used to describe the motion of a fluid. It is easier to prove existence of a solution (regular or singular) in a larger class, but such a solution may not be unique! Leray's theory gives the existence of weak, possibly irregular, and possibly nonunique solutions to the Navier-Stokes equations. His approach is based on so-called energy estimates (i.e., bounds on the integral of the square of the velocity) and thus requires the initial data to be in $L^2(\mathbb{R}^n)$ in n dimensions. On the other hand, a completely different approach based on semigroup theory was introduced by Tosio Kato [9] and provides the existence of a global unique regular solution under the restrictive assumption of small initial data. Kato's method is based on scaling-invariance arguments related to the fractal geometric nature of the equations. This theory requires the initial data to be in $L^n(\mathbb{R}^n)$, because this is the only Lebesgue space $L^p(\mathbb{R}^n)$ that is invariant under the appropriate scaling, i.e.,

$$\|f(\mathbf{x})\|_{L^p(\mathbb{R}^n)} = \|\lambda f(\lambda \mathbf{x})\|_{L^p(\mathbb{R}^n)}.$$

Hence the function spaces for Leray's theory and for Kato's theory coincide when $n = 2$, but not when $n = 3$. Thus in $2D$ the theories complement each other, and therefore the solution to the Navier-Stokes equations with initial data in $L^2(\mathbb{R}^2)$ is regular and unique. In $3D$, however, the problem remains mysterious!

Photograph by the authors.

Figure 2. Bust of Claude Louis Marie Henri Navier, from the collection at the École Nationale des Ponts et Chaussées.

Photograph from *Mathematical and Physical Papers*, 1883-1910.

Figure 3. George Gabriel Stokes.

"De l'Entreprise du Pont des Invalides"

We now turn away from the aspects of Navier's work that are most familiar to the mathematical community and start our discussion about the background and events related to Navier the engineer and his ill-fated bridge.

Navier at the École Nationale des Ponts et Chaussées

The beginning of Navier's student career was not stellar. In a typically French procedure, there is a linear ordering of the list of admission at the École Polytechnique, and in 1802–3 Navier was placed 116th out of 117 in the order of merit! Navier's career improved dramatically, however, and by the end of his first year he was one of the top ten students. After a couple of years he joined the Corps at the École des Ponts et Chaussées in Paris, where his great-uncle Emiland Gauthey worked as one of the leading civil engineers in France. During Navier's studies at the École Polytechnique he was taught by and came under the influence of Fourier. Throughout his career Navier was a notable proponent of the important mathematical techniques developed by Fourier. This was not the case for most other engineers of this period. Furthermore, the textbooks that Navier wrote for practicing engineers introduced the basic principles of engineering science to a field that previously had been almost completely empirical.

The main areas of Navier's work concerned hydrodynamics, elasticity theory, and the design and construction of bridges. In 1819 he was teaching mechanics at the École des Ponts et Chaussées, working as a practical engineer, and carrying out theoretical research. His seminal derivation of the viscous fluid equations, written in the early 1820s, was work that he kept somewhat secret from his chief, Becquey, who considered Navier's primary task to be the design of bridges. Even today it seems that there is a tendency in France, not only at the Grandes Écoles, to classify scientists as either theoretical or practical and to discourage the melding of the two attributes. Navier was able to counter this tendency and achieved a synthesis of the practical and the theoretical. He obtained distinction and recognition both from scientists of the French Académie des Sciences and from engineers. As we will describe, however, his theoretical achievements were held against him in the "affair of the collapsing bridge".

The Birth of Modern Suspension Bridges

Although suspension bridges date to antiquity in several ancient cultures,[3] the "modern" iron chain suspension bridge sees its direct forerunner in the constructions of James Finley, an American inventor and builder. Finley was a skilled engineer who worked in an environment very different from that of Navier at a Grande École, namely rural America in 1800. Finley was practical and empirical, successfully seeking to produce workable, simple, and generic designs that could be constructed by rural blacksmiths. An indication of his success is that by 1820 he had a number of patents, and over forty chain suspension bridges had been built in the U.S. The innovations of Finley were taken up and extended in Britain by Samuel Brown, a retired naval captain, who determined through experiments the most efficient shape for the iron links in a suspension bridge cable. He became a leading builder of suspension bridges, including in 1820 the Union Bridge over the river Tweed, whose span of 436 feet was nearly twice the longest span of any bridge that had been built in the U.S. The Union Bridge was shortly followed by other engineering feats in Britain, including the bridges built by such pioneers of the industrial revolution as Brunel, Stevenson, and Telford. Many more details concerning the history of the suspension bridge can be found in the book of Kranakis [10] and the paper of Picon [14].

Navier "Mathematicising" the Topic

When the French government called upon the École des Ponts et Chaussées to assist in the development of suspension bridge technology, it was natural that they looked to Britain. At the request of his superiors, Navier paid two visits to Britain in 1821 and 1823 to study suspension bridges.[4] His investigations resulted in a major book [13] that was published in 1823. In this book Navier brought to the subject for the first time the analytical and abstract approach of the mathematician. He sought to illustrate the power and challenge of abstraction versus an empirical ad hoc approach. He did what applied mathematicians today seek so often to do in constructing a mathematical model. As he remarked, modeling requires "a particular art which consists of replacing the very questions to be resolved by other questions that differ as little as possible and to which mathematics may apply." Navier suggested that results be reformulated so as to specify the theoretical limits within which they should be relevant and that mathematical analysis be used to determine the relationship between important parameters.

The main issues confronting a bridge designer were the equilibrium shape that could be achieved by a balance of the forces acting on components of the bridge and the stability of such an equilibrium to perturbations. Significant sources of such perturbations include traffic over the bridge, thermal expansion/contraction from solar heating, wind-driven oscillations, and forces due to the flow of water

[3] *Navier himself gave charming illustrations of antique bridges in his book [13].*

[4] *Between his visits Navier derived the Navier-Stokes equations.*

in the river. The expertise that Navier brought to these issues was considerable. His book on bridges contained well-known calculations needed to describe the equilibrium of chains and are based on simple differential equations whose approximate solutions are either catenary or parabolic. More sophisticated and original mathematics in his work included the use of Fourier's series solutions. For example, this occurs in the context of the displacement from equilibrium of a perfectly flexible chain (the so-called vibrating string problem), which is governed by the wave equation. Other typical mathematical arguments that can be found in Navier's book are connected with elasticity theory. There was a considerable similarity between the equations describing the distribution of the load in chains and those studied by Navier in his pioneering work on curved elastic rods and elastic rectangles. Again, the primary mathematical tools used by Navier were Fourier series. Cauchy, who is credited as the founder of modern elasticity theory, acknowledged that his research in this field had been inspired by a memoir of Navier published in 1820.

One very important aspect of suspension bridges is their susceptibility to destruction by drastic wind-induced oscillations. Such destruction occurred in Navier's time and also more recently (for example, the spectacular collapse of the Tacoma Narrows bridge in 1940). This topic, however, received little attention from Navier, possibly because it was too difficult to analyze with the tools he had available. In fact, it remains to this day a very subtle problem involving resonant nonlinear oscillations and turbulence in the wind, a problem that challenges the expertise of modern fluid dynamics.

The Collapse of Navier's Dream: Politics and Controversies

Not only did Navier present the theory of the suspension bridge in his major treatise [13], he also put forward a design for a monumental suspension bridge to be built across the Seine, connecting the Hôtel des Invalides (Napoleon's tomb) with the Champs Elysées. This bridge had a span of 155 meters and incorporated all of Navier's theory and knowledge acquired from his studies in Britain. It was to be a state-of-the-art achievement in both technology and artistic design, with a fashionable Egyptian[5] motif. The bridge was to be called the Pont des Invalides.[6] In choosing this site for his bridge, Navier was not motivated by practical issues: in fact, there was no great need for a bridge in this position, as there was in the east of Paris. Rather, he considered the grandeur and esthetics of a construction that would add to the "gloire" of France and the Corps des Ponts et Chaussées. He wished to demonstrate both that a bridge of beauty could be made from iron (rather than stone) and that it could be made following the dictates of theoretical analysis. To illustrate this, we juxtapose two quotations of Navier (from the translations in [10]):

> There exists no urgent necessity to construct a bridge to the Champs Elysées: there is no obligation to build a suspension bridge in Paris. But if it is desired that one be built, let it be made into a monument; let the character of grandeur be given to this work that the style of the construction admits of; let its disposition be calculated with the idea of forming an edifice approved by artists, agreeable to the public, and honorable to the administration.

> ...this study (of suspension bridges) would not have been possible without the progress made in mathematical analysis in recent times, and without the institutions by means of which those charged with the direction of public works are initiated into the most advanced ideas of mathematics.

In 1823 Navier presented meticulous plans to his superiors in the Corps des Ponts et Chaussées. Every detail was designed on the basis of a theoretical analysis in which Navier had sufficient confidence that he did not resort to the usual engineering practice of "overbuilding" (i.e., deciding what was needed in terms of strength and then multiplying the result by a number considerably greater than one). A committee of experts reported very favorably on Navier's project, convinced that "theory everywhere illuminates practice." They decided that because of its novel and nonessential nature, the bridge should be privately rather than publicly funded. Investors were sought in a company that would finance the building of the bridge in return for the rights to collect all the tolls for fifty-five years. Final approval was given by Becquey and the minister of the interior, the project was

[5] *In 1822 Navier derived the Navier-Stokes equations, Fourier published his fundamental research on the heat equation, and Champollion deciphered the Egyptian hieroglyphics.*

[6] *Today the site is occupied by Pont Alexandre III, constructed in 1890, whereas Pont des Invalides is the name given to the next bridge downstream, a stone arch constructed in 1850. Beautiful pictures and descriptions of the bridges of Paris can be found in [11].*

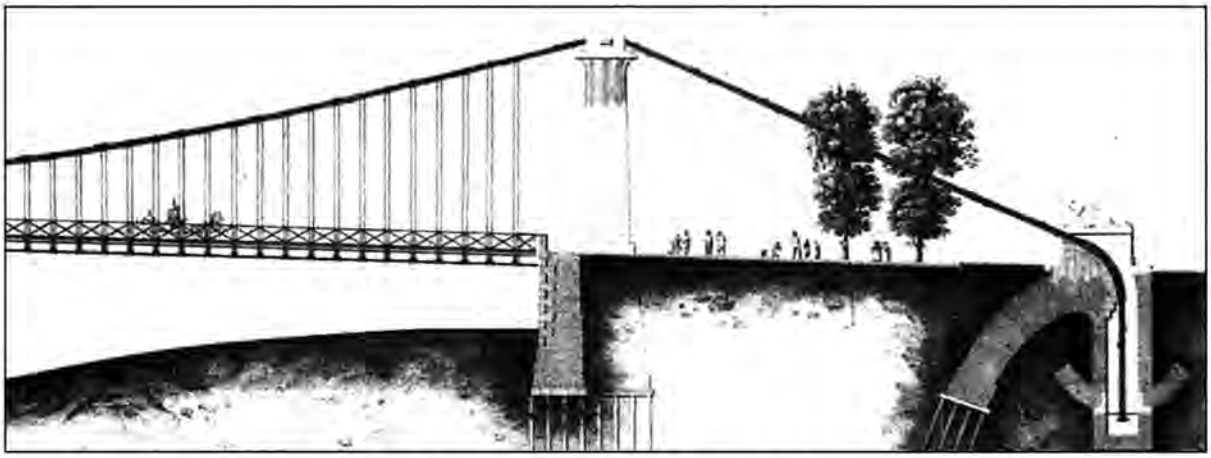

Figure 4. A portion of the bridge, as designed by Navier, showing the anchorage (see [13]).

open to bidding in April 1824, and in August building began.

Progress on the construction was good, and there was much general interest in this novel edifice connecting the two most fashionable districts in Paris. By September 1826 the bridge was almost complete. As Grattan-Guinness [8] reports, the *Moniteur Universel* told its readers: "...there is still about 5 weeks of work. But soon, stripped of its scaffolding, it will be possible to appreciate it quite complete, and we do not doubt that this first sight will sharply excite the interest of Parisians." However, just as this news bulletin was to appear, disaster struck. On the night of 6–7 September 1826 the buttress of the bridge in the right bank "cracked" when the surrounding earth was flooded due to a broken water pipe from a nearby pumping station. Now the strength of these buttresses in Navier's design had in fact already been questioned by the committee of experts. Even in July when the roadway was attached to the suspended chains, small cracks had appeared in the anchorages where the cables changed direction to descend vertically to their anchors (Figure 4). It was agreed that the buttresses would have to be strengthened. After the flooding this became imperative.

At first it was assumed that repairs would be carried out and that the bridge would be completed, but politics and financial issues intervened. A dispute developed between the Corps and the contractor over who had financial responsibility for the repairs. A financier threatened to sue the Corps. Sarcastic articles appeared in the press against the Corps, and Navier was referred to as "that eminent man of science whose calculations fail in Paris." The Paris City Council, which for various political reasons had opposed the project from the beginning, seized the opportunity to attack it. The accident caused panic among the investors. The principal financial backer died, and no one could be found to replace him. Navier pleaded in public and in private to complete his project. But he was unsuccessful, and after many acrimonious discussions and accusations the bridge was eventually dismantled.

A government committee was formed to investigate the technical and financial ramifications of the accident to the Pont des Invalides. Criticism was levied at the Corps for being too attached to theory and for being too autocratic and elitist, as compared to the British and American engineering establishments. It was suggested that the chains must have been too heavy for the buttresses if they could not withstand a "slight accident". In contrast, the superior achievements of British bridge builders were praised for not "mathematicising" the problem.[7]

Navier wrote numerous letters and a report,[8] vigorously defending all engineering aspects of the design. However, he became the scapegoat for the public relations disaster for the Corps, which later (unfairly) passed him over for promotion.

The most comprehensive recent book on Navier's bridge is that of Kranakis [10]. In this excellent work she examines Navier's design for the buttresses and asks why Navier did not see a need for extra stonework or earthwork, despite the fact that each cable would bear a huge tension of over 1,000,000 pounds. Navier calculated the resultant of a sum of forces exerted by the cables and concluded that a comparatively slim buttress positioned at exactly the correct point could provide the necessary

[7] *"In all other countries, in Germany, England, Italy, where institutions like ours do not exist, works of this character are better done and far less costly than in France. Those three nations are remarkable for new and useful inventions in this line. I know it is the fashion to say, in speaking of our Écoles, that all Europe envies them; but for the last fifteen years Europe, which closely observes us, has not established others like them. England, that clever calculator, has better schools among her working population, from which come practical men who show their genius the moment they rise from practice to theory." H. de Balzac [2].*

[8] *This report appears as an appendix to the second edition of Navier's book on suspension bridges [13].*

resistance. However, even though his design was novel and untried, Navier did not appear to have tested it on a scale model, nor did he "overbuild" to compensate for possible error. His own statements suggest that this was rash. In particular, he noted that the resistance of the earth could only be calculated accurately for the vertical forces. For the horizontal forces the resistance depended significantly on the cohesion of the earth, "the evaluation of which is subject to great uncertainty."[9] Hindsight suggests that Navier's concept, in which the cables descend vertically to the anchorage, was probably workable (for example, this was successfully used in the Brooklyn Bridge). However, his implementation in the design for the Pont des Invalides may indeed have relied on a theoretical model that approximated reality but with insufficient accuracy for what was demanded of it.

Although the affair of the Pont des Invalides was a major setback in Navier's career and must have caused him personal distress, he continued to be a prominent scientist consulted by the French government on issues of science and technology. In 1831 he became a Chevalier de la Legion d'Honneur. He was a man of strong political views, following an ideology based on society taking advantage of science and technology. After a lifetime of what must have been very hard work producing remarkable and diverse achievements, he died at the relatively early age of fifty-one.

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Photographic Credit

Pont des Invalides (DG 750 (D.12.320), fol 4684 (planche XII), 4684 (page de titre)). All the original records and plans of Navier's bridge are at the École des Ponts et Chaussées, which moved from the original building at Rue des Saints-Pères in Paris to the campus at Champs-sur-Marne, where the first author's Université de Marne-la-Vallée is located.

[9] *This is particularly ironic because the movement of a liquid-particle suspension (e.g., the flooded earth) receives attention from modern fluid dynamicists, who use the Navier-Stokes equations with modifications of Navier's frictional term.*

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Variational PDE Models in Image Processing

Tony F. Chan, Jianhong (Jackie) Shen, and Luminita Vese

Image processing, traditionally an engineering field, has attracted the attention of many mathematicians during the past two decades. From the point of view of vision and cognitive science, image processing is a basic tool used to reconstruct the relative order, geometry, topology, patterns, and dynamics of the three-dimensional (3-D) world from two-dimensional (2-D) images. Therefore, it cannot be merely a historical coincidence that mathematics must meet image processing in this era of digital technology.

The role of mathematics is determined also by the broad range of applications of image processing in contemporary science and technology. These applications include astronomy and aerospace exploration, medical imaging, molecular imaging, computer graphics, human and machine vision, telecommunication, autopiloting, surveillance video, and biometric security identification (such as fingerprints and face identification). All these highly diversified disciplines have made it necessary to develop common mathematical foundations and frameworks for image analysis and processing. Mathematics at all levels must be introduced to address the crucial criteria demanded by this new era—genericity, well-posedness, accuracy, and computational efficiency, just to name a few. In return, image processing has created tremendous opportunities for mathematical modeling, analysis, and computation.

This article gives a broad picture of mathematical image processing through one of the most recent and very successful approaches—the variational PDE (partial differential equation) method. We first discuss two crucial ingredients for image processing: image modeling or representation, and processor modeling. We then focus on the variational PDE method. The backbone of the article consists of two major problems in image processing that we personally have worked on: inpainting and segmentation. By no means, however, do we intend to give a comprehensive review of the entire field of image processing. Many of the authors' articles and preprints related to the subject of this paper can be found online at our group homepage [11], where an extended bibliography is also available.

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Image Processing as an Input-Output System

Directly connected to image processing are two dual fields in contemporary computer science: computer vision and computer graphics. Vision (whether machine or human) tries to reconstruct the 3-D world from observed 2-D images, while

graphics pursues the opposite direction by designing suitable 2-D scene images to simulate our 3-D world. Image processing is the crucial middle way connecting the two.

Abstractly, image processing can be considered as an input-output system

$$Q_0 \longrightarrow \boxed{\text{Image Processor } \mathcal{T}} \longrightarrow Q$$

Here $\mathcal{T}$ denotes a typical image processor: for example, denoising, deblurring, segmentation, compression, or inpainting. The input data Q_0 can represent an observed or measured single image or image sequence, and the output $Q = (q_1, q_2, \cdots)$ contains all the targeted image *features*.

For example, the human visual system can be considered as a highly involved multilevel image processor $\mathcal{T}$. The input Q_0 represents the image sequence that is constantly projected onto the retina. The output vector Q contains all the major features that are important to our daily life, from the low-level ones such as relative orders, shapes, and grouping rules to high-level feature parameters that help classify or identify various patterns and objects.

Table 1 lists some typical image processing problems.

The two main ingredients of image processing are the input Q_0 and the processor $\mathcal{T}$. As a result, the two key issues that have been driving mainstream mathematical research on image processing are (a) the modeling and representation of the input visual data Q_0, and (b) the modeling of the processing operators $\mathcal{T}$. Although the two are independent, they are closely connected to each other by the universal rule in mathematics: the structure and performance of an operator $\mathcal{T}$ is greatly influenced by how the input functions are modeled or represented.

Image Modeling and Representation

To efficiently handle and process images, we need first to understand what images really are mathematically and how to represent them. For example, is it adequate to treat them as general L^2 functions or as a subset of L^2 with suitable regularity constraints? Here we briefly outline three major classes of image modeling and representation.

Random fields modeling. An observed image u_0 is modeled as the sampling of a random field. For example, the Ising spin model in statistical mechanics can be used to model binary images. More generally, images are modeled by some Gibbs/Markovian random fields [10]. The statistical properties of fields are often established through a filtering technique and learning theory. Random field modeling is the ideal approach for describing natural images with rich texture patterns such as trees and mountains.

$\mathcal{T}$	Q_0	Q
denoising+deblurring	$u_0 = Ku + n$	clean & sharp u
inpainting	$u_0\|_{\Omega\setminus D}$	entire image $u\|_\Omega$
segmentation	u_0	"objects" $[u_k, \Omega_k], k = 1, 2, \ldots$
scale-space	u_0	multiscale images $(u_{\lambda_1}, u_{\lambda_2}, \ldots)$
motion estimation	$(u_0^{(1)}, u_0^{(2)}, \ldots)$	optical flows $(\vec{v}^{(1)}, \vec{v}^{(2)}, \ldots)$

Table 1. Typical image processors and their inputs and outputs. The symbols represent (1) K: a blurring kernel, and n: an additive noise, both assumed in this paper to be linear for simplicity; (2) u_0: the given noisy or blurred image; (3) Ω: the entire image domain, and D: a subset where image information is missing or inaccessible; (4) $[u_k, \Omega_k]$: Ω_k's are the segmented individual "objects", while u_k's are their intensity values; (5) λ_k's are different scales, and u_λ can be roughly understood as the projection of the input image at scale λ; (6) $u_0^{(n)}$'s denote the discrete sampling of a continuous "movie" $u_0(x, t)$ (with some small time step h) and $\vec{v}^{(n)}$'s are the estimated optical flows (i.e., velocity fields) at each moment.

Wavelet Representation. An image is often acquired from the responses of a collection of microsensors (or photo receptors), either digital or biological. During the past two decades, it has been gradually realized (and experimentally supported) that such local responses can be well approximated by wavelets. This new representation tool has revolutionized our notion of images and their multiscale structures [12]. The new JPEG2000 protocol for image coding and the successful compression of the FBI database of fingerprints are its two most influential applications. The theory is still being actively pushed forward by a new generation of geometric wavelets such as curvelets (Candés and Donoho) and beamlets (Pennec and Mallat).

Regularity Spaces. In the linear filtering theory of conventional digital image processing, an image u is considered to be in the Sobolev space $H^1(\Omega)$. The Sobolev model works well for homogeneous regions, but it is insufficient as a global image model, since it "smears" the most important visual cue, namely, edges. Two well-known models have been introduced to recognize the existence of edges. One is the "object-edge" model of Mumford and Shah [13], and the other is the BV image model of Rudin, Osher, and Fatemi [15]. The object-edge model assumes that an ideal image u consists of disjoint homogeneous object patches $[u_k, \Omega_k]$ with $u_k \in H^1(\Omega_k)$ and regular boundaries $\partial\Omega_k$ (characterized by one-dimensional Hausdorff measure). The BV image model assumes that an ideal image has bounded total variation $\int_\Omega |Du|$. Regularity-based image models

are generally applicable to images with low texture patterns and without rapidly oscillatory components.

Modeling of Image Processors

How images are modeled and represented very much determines the way we model image processors. We shall illustrate this viewpoint through the example of denoising $u = \mathcal{T}u_0$: $u_0 = u + n$, assuming for simplicity that the white noise n is additive and homogeneous, and there is no blurring involved.

When images are represented by wavelets, the denoising processor $\mathcal{T}$ is in some sense "diagonalized" and is equivalent to a simple engineering on the individual wavelet components. This is a celebrated result of Donoho and Johnstone on threshold-based denoising schemes.

Under the statistical/random field modeling of images, the denoising processor $\mathcal{T}$ becomes MAP (*Maximum A Posteriori*) estimation. By Bayes's formula, the posterior probability given an observation u_0 is

$$p(u|u_0) = p(u_0|u)p(u)/p(u_0).$$

The denoising processor $\mathcal{T}$ is achieved by solving the MAP problem $\max_u p(u|u_0)$. Therefore, it is important to know not only the random field image model $p(u)$ but also the mechanism by which u_0 is generated from the ideal image u (the so-called *generative* data model). The two are crucial for successfully carrying out Bayesian denoising.

Finally, if the ideal image u is modeled as an element in a regular function space such as $H^1(\Omega)$ or $\mathrm{BV}(\Omega)$, then the denoising processor $\mathcal{T}$ can be realized by a variational optimization. For instance, in the BV image model, $\mathcal{T}$ is achieved by

$$\min_u \int_\Omega |Du| \text{ subject to } \frac{1}{|\Omega|}\int_\Omega (u-u_0)^2\,dx \le \sigma^2,$$

where the white noise is assumed to be well approximated by the standard Gaussian $N(0,\sigma^2)$. This well-known denoising model, first proposed by Rudin, Osher, and Fatemi, belongs to the more general class of *regularized* data-fitting models.

Just as different coordinate systems that describe a single physical object are related, different formulations of the same image processor are closely interconnected. Again, take denoising for example. It has been shown that the wavelet technique is equivalent to an approximate optimal regularization in certain Besov spaces (Cohen, Dahmen, Daubechies, and DeVore). On the other hand, Bayesian processing and the regularity-based variational approach can also be connected (at least formally) by Gibbs's formula in statistical mechanics (see (3) in the next section).

Variational PDE Method

Having briefly introduced the general picture of mathematical image processing, we now focus on the variational PDE method through two processors: inpainting and segmentation.

For the history and a detailed description of current developments of the variational and PDE method in image and vision analysis, see two special issues in *IEEE Trans. Image Processing* [7 (3), 1998] and *J. Visual Comm. Image Rep.* [**13** (1/2), 2002] and also two recent monographs [1], [18].

In the variational or "energy"-based models, nonlinear PDEs emerge as one derives formal Euler-Lagrange equations or tries to locate local or global minima by the gradient descent method. Some PDEs can be studied by the viscosity solution approach [8], while many others still remain open to further theoretical investigation.

Compared with other approaches, the variational PDE method has remarkable advantages in both theory and computation. First, it allows one to directly handle and process visually important geometric features such as gradients, tangents, curvatures, and level sets. It can also effectively simulate several visually meaningful dynamic processes, such as linear and nonlinear diffusions and the information transport mechanism. Second, in terms of computation, it can profoundly benefit from the existing wealth of literature on numerical analysis and computational PDEs. For example, various well-designed shock-capturing schemes in Computational Fluid Dynamics (CFD) can be conveniently adapted to edge computation in images.

Variational Image Inpainting and Interpolation

The word *inpainting* is an artistic synonym for image interpolation; initially it circulated among museum restoration artists who manually restore cracked ancient paintings. The concept of digital inpainting was recently introduced into digital image processing in a paper by Bertalmio, Sapiro, Caselles, and Ballester. Currently, digital inpainting techniques are finding broad applications in image processing, vision analysis, and digital technologies such as image restoration, disocclusion, perceptual image coding, zooming and image super-resolution, error concealment in wireless image transmission, and so on [2], [4], [9]. Figure 1 shows an example of error concealment.

We now discuss the mathematical ideas and methodologies behind variational inpainting techniques. Throughout this section, u denotes the original complete image on a 2-D domain Ω, and u_0 denotes the observed or measured portion of u, which can be either noisy or blurry, on a subdomain or general subset D. The goal of inpainting is to recover u on the entire image domain Ω

as faithfully as possible from the available data u_0 on D.

From Shannon's Theorem to Variational Inpainting

Interpolation is a classical topic in approximation theory, numerical analysis, and signal and image processing. Successful interpolants include polynomials, harmonic waves, radially symmetric functions, finite elements, splines, and wavelets. Despite the diversity of the literature, there exists one most widely recognized result due to Shannon, known as *Shannon's Sampling Theorem.*

Theorem *(Shannon's Theorem). If a signal $u(t)$ is band-limited within $(-\omega, \omega)$, then*

$$u(t) = \sum_{n=-\infty}^{\infty} u\left(n\frac{\pi}{\omega}\right) \operatorname{sinc}\left(\frac{\omega}{\pi}t - n\right).$$

That is, if an analog signal $u(t)$ (with finite energy or, equivalently, in $L^2(\mathbb{R})$) does not contain any high frequencies, then it can be perfectly interpolated from its properly sampled discrete sequence $u_0[n] = u(n\pi/\omega)$ (where ω/π is known as the Nyquist frequency).

All interpolation problems share this "if-then" structure. "If" specifies the space where the target signal u is sought, while "then" gives the reconstruction or interpolation procedure based on the discrete samples (or, more generally, any partial information about the signal).

Unfortunately, for most real applications in signal and image processing, one cannot expect a closed-form formula as clean as Shannon's. This is due to at least two factors. First, in vision analysis and communication, signals like images are intrinsically not band-limited because of the presence of *edges* (or Heaviside-type singularities). Second, for most real applications, the given incomplete data are often noisy and become blurred during the imaging and transmission processes. Therefore, in the situation of Shannon's Theorem, we are dealing with a class of "bad" signals u with "unreliable" samples u_0.

Naturally, for image inpainting, both the "if" and "then" statements in Shannon's Theorem need to be modeled carefully. It turns out that there are two powerful and interdependent frameworks that can carry out this task: one is the variational method, and the other is the Bayesian framework [10].

In the Bayesian approach the "if" statement specifies both the so-called *prior* model and the *data* model. The prior model specifies how images are distributed a priori or, equivalently, which images occur more frequently than others. Probabilistically, it specifies the prior probability $p(u)$. Let u_0 denote the incomplete data that are observed, measured, or sampled. Then the second part of "if" is to model how u_0 is generated from u or

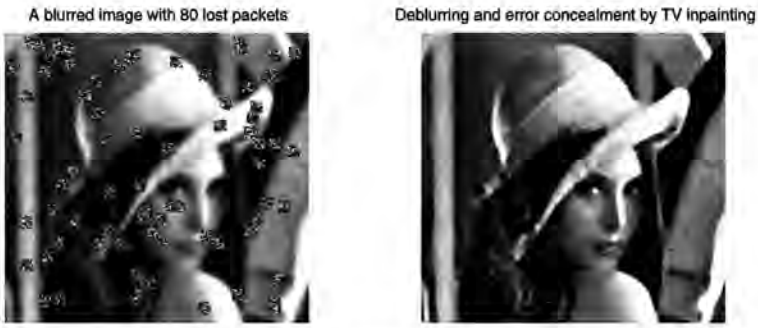

Figure 1. TV inpainting for the error concealment of a blurry image.

to specify the conditional probability $p(u_0|u)$. Finally, in the Bayesian framework, Shannon's "then" statement is replaced, as indicated earlier, by the *Maximum A Posteriori* (MAP) optimization given by Bayes's formula:

$$\max_u p(u|u_0) = p(u_0|u)p(u)/p(u_0). \tag{1}$$

(It is equivalent to maximizing the product of the prior model and the data model, since the denominator is a fixed normalization constant once u_0 is given.) To summarize, Bayesian inpainting means finding the most probable image given its incomplete and possibly distorted observation.

The variational approach resembles the Bayesian methodology, but now everything is expressed deterministically. The Bayesian prior model $p(u)$ becomes the specification of the regularity of an image u, while the data model $p(u_0|u)$ now measures how well the observation u_0 fits if the original image is indeed u. Regularity is enforced through "energy" functionals: for example, the Sobolev norm $E[u] = \int_\Omega |\nabla u|^2\, dx$, the total variation (TV) model $E[u] = \int_\Omega |Du|$ of Rudin, Osher, and Fatemi, and the Mumford-Shah free-boundary model $E[u, \Gamma] = \int_{\Omega\setminus\Gamma} |\nabla u|^2\, dx + \beta H^1(\Gamma)$, where H^1 denotes the one-dimensional Hausdorff measure. The quality of data fitting $u \to u_0$ is often judged by an error measure $E[u_0|u]$. For instance, the *least square* measure prevails in the literature due to the genericity of Gaussian-type noise and the *Central Limit Theorem*: $E[u_0|u] = \frac{1}{|D|}\int_D (Tu - u_0)^2\, dx$, where D is the domain on which u_0 has been sampled or measured, $|D|$ is its area (or cardinality for the discrete case), and T denotes any linear or nonlinear image processor (such as blurring and diffusion). In this variational setting, Shannon's "then" statement becomes a constrained optimization problem:

$$\min E[u] \qquad \text{over all } u \text{ such that } E[u_0|u] \le \sigma^2.$$

Here σ^2 denotes the variance of the white noise, which is assumed to be known by proper statistical

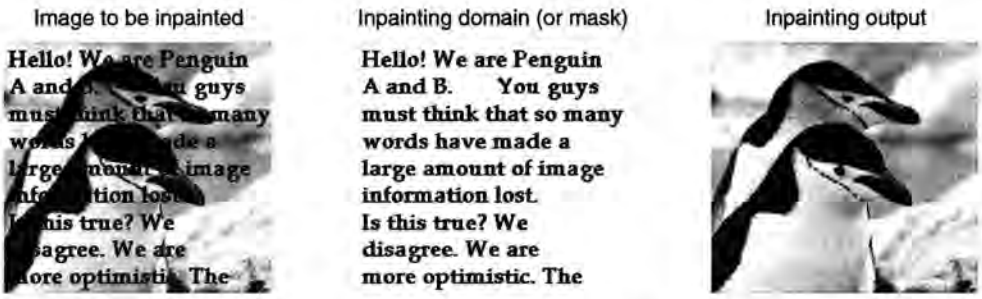

Figure 2. Mumford-Shah inpainting for text removal.

estimators. Equivalently, the model solves the following unconstrained problem using Lagrange multipliers (e.g., Chambolle and Lions):

$$\min_u E[u] + \lambda E[u_0|u]. \tag{2}$$

Generally, λ expresses the balance between regularity and fitting. In summary, variational inpainting searches for the most "regular" image that best fits the given observation.

The Bayesian approach is more universal in the sense of allowing general statistical prior and data models, and it is powerful for restoring both artificial images and natural images (or *textures*). But to learn the prior model and the data model is usually quite expensive. The variational approach is ideal for dealing with regularity and geometry and tends to work best for man-made indoor and outdoor scenes and images with low textures. The two approaches (1) and (2) can be at least formally unified under Gibbs's formula in statistical mechanics:

$$E[\cdot] \propto -\beta \log p(\cdot), \quad \text{or} \quad p(\cdot) \propto e^{-E[\cdot]/\beta}, \tag{3}$$

where $\beta = kT$ is the product of the Boltzmann constant and temperature, and $\propto$ means equality up to a multiplicative or additive constant. (However, the definability of a rigorous probability measure over "all" images is highly nontrivial because of the multiscale nature of images. Recent efforts can be found in the work of Mumford and Gidas.)

Variational Inpainting Based on Geometric Image Models

In a typical image inpainting problem, u_0 denotes the observed or measured incomplete portion of a clean "good" image u on the entire image domain Ω. A simplified but already very powerful data model in various digital applications is blurring followed by noise degradation and spatial restriction:

$$u_0|_D = (Ku + n)_D,$$

where K is a continuous blurring kernel, often assumed to be linear or even shift-invariant, and n is an additive white noise field assumed to be close to Gaussian for simplicity. The information $u_0|_{\Omega\setminus D}$ is missing or inaccessible. The goal of inpainting is to reconstruct u as faithfully as possible from $u_0|_D$.

The data model is explicitly given by

$$E[u_0|u, D] = \frac{1}{|D|}\int_D (Ku - u_0)^2\,dx. \tag{4}$$

Therefore, from the variational point of view, the quality of an inpainting model crucially depends on the prior model or the regularity energy $E[u]$.

The TV prior model $E[u] = \int_\Omega |Du|$ was first introduced into image processing by Rudin, Osher, Fatemi in [15]. Unlike the Sobolev image model $E_2[u] = \int_\Omega |\nabla u|^2\,dx$, the TV model recognizes one of the most important vision features, the "edges". For example, for a cartoon image u showing the night sky ($u = 0$) with a full bright moon ($u = 1$), the Sobolev energy blows up, while the TV energy $\int_\Omega |Du|$ equals the perimeter of the moon, which is finite. Therefore, in combination with the data model (4), the variational TV inpainting model minimizes

$$E_{\text{tv}}[u|u_0, D] = \alpha\int_\Omega |Du| + \lambda\int_D (Ku - u_0)^2\,dx. \tag{5}$$

The admissible space is $\text{BV}(\Omega)$, the Banach space of all functions with bounded variation. It is very similar to the celebrated TV restoration model of Rudin, Osher, and Fatemi [15]. In fact, the beauty and power of the model exactly lie in the provision of a unified framework for denoising, deblurring, and image reconstruction from incomplete data. Figure 1 displays the computational output of the model applied to a blurry image with simulated random packet loss due to the transmission failure of a network.

The second well-known prior model is the object-edge model of Mumford and Shah [13]. The edge set Γ is now explicitly singled out, unlike in the TV model, and an image u is understood as a combination of both the geometric feature Γ and the piecewise smooth "objects" u_i on all the connected components Ω_i of $\Omega \setminus \Gamma$. Thus in both the Bayesian and the variational languages, the prior model consists of two parts (applying (3) for the transition between probability and "energy"):

$$p(u, \Gamma) = p(u|\Gamma)p(\Gamma) \quad \text{and}$$
$$E[u, \Gamma] = E[u|\Gamma] + E[\Gamma].$$

In the Mumford-Shah model the edge regularity is specified by $E[\Gamma] = H^1(\Gamma)$, the one-dimensional Hausdorff measure, or in most computational applications, $E[\Gamma] = \text{length}(\Gamma)$, assuming that Γ is Lipschitz. The smoothness of the "objects" is naturally characterized by the ordinary Sobolev norm: $E[u|\Gamma] = \int_{\Omega\setminus\Gamma} |\nabla u|^2\, dx$. Therefore, in combination with the data model (4), the variational inpainting model based on the Mumford-Shah prior is given by

$$\inf_{u,\Gamma} E_{\text{ms}}[u,\Gamma|u_0,D] = \alpha \int_{\Omega\setminus\Gamma} |\nabla u|^2\, dx + \beta H^1(\Gamma) + \lambda \int_D (Ku - u_0)^2\, dx. \tag{6}$$

Figure 2 shows one application of this model for text removal. Notice that edges are preserved and smooth regions remain smooth.

Numerous applications have demonstrated that, for classical applications in denoising, deblurring, and segmentation, both the TV and the Mumford-Shah models perform sufficiently well even by the high standard of human vision. But inpainting does have special characteristics. We have demonstrated in [2], [4], [9] that for large-scale inpainting problems, high-order image models which incorporate the curvature information become necessary for more faithful visual effects.

The key to high-order geometric image models is Euler's elastica curve model:

$$e[\gamma] = \int_\gamma (a + b\kappa^2)\, ds, \quad a, b > 0,$$

where κ denotes the scalar curvature. Birkhoff and de Boor called it the "nonlinear spline" model in approximation theory. It was first introduced into computer vision by Mumford. Unlike straight lines (for which $b = 0$), the elastica model allows smooth curves because of the curvature term, which is important for computer vision and computer graphics.

By imposing the elastica energy on each individual level line of u (at least symbolically or by assuming that u is regular enough), we obtain the so-called elastica image model:

$$\begin{aligned} E_{\text{el}}[u] &= \int_{-\infty}^{\infty} e[u \equiv \lambda]\, d\lambda \\ &= \int_{-\infty}^{\infty} \int_{u\equiv\lambda} (a + b\kappa^2)\, ds\, d\lambda \\ &= \int_\Omega (a + b\kappa^2) |\nabla u|\, dx. \end{aligned} \tag{7}$$

In the last integrand the curvature is given by $\kappa = \nabla \cdot [\nabla u/|\nabla u|]$. (Notice that in the absence of the curvature term, the above formula is exactly the *co-area* formula for smooth functions (e.g., Giusti). This elastica prior model was first studied for inpainting by Masnou and Morel, and by Chan, Kang, and Shen [2], and as expected it improves the TV inpainting model.

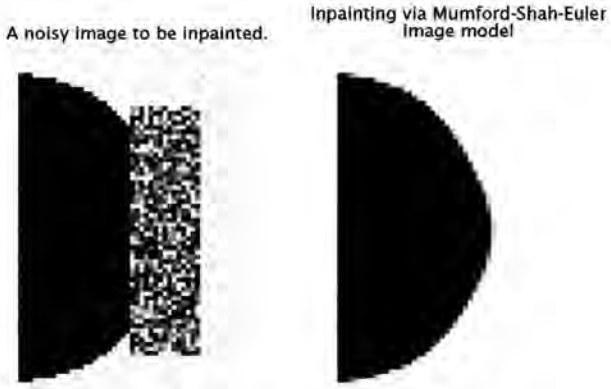

Figure 3. Smooth inpainting by the Mumford-Shah-Euler model.

Similarly, the Mumford-Shah image model E_{ms} can be improved by replacing the length energy by Euler's elastica energy:

$$E_{\text{mse}}[u,\Gamma] = \alpha \int_{\Omega\setminus\Gamma} |\nabla u|^2\, dx + e[\Gamma].$$

This was first applied to image inpainting by Esedoglu and Shen [9]. Figure 3 shows one example of applying this image prior model to the inpainting of an occluded disk. Both the TV and Mumford-Shah inpainting models would complete the interpolation with a straight-line edge and introduce visible corners as a result. The elastica model restores the smooth boundary.

The improved performance of curvature-based models comes at a price in terms of both theory and computation. The existence and uniqueness of the TV and Mumford-Shah inpainting models can be studied in a fashion similar to the classical restoration and segmentation problems. But theoretical study on high-order models is only beginning. The difficulty lies in the involvement of the second-order geometric feature of curvature and in the identification of a proper function space to study the models. Secondly, in terms of computation, the calculus of variation on the curvature term leads to fourth-order highly nonlinear PDEs, whose fast and efficient numerical solution imposes a tremendous challenge.

We conclude this section with a brief discussion of computation, especially for the TV and Mumford-Shah inpaintings.

For the TV inpainting model E_{tv}, the Euler-Lagrange equation is formally (or assuming that u is in the Sobolev space $W^{1,1}$) given by

$$-\nabla \cdot \left[\frac{\nabla u}{|\nabla u|}\right] + \mu K^* \chi_D (Ku - u_0) = 0. \tag{8}$$

Here K^* denotes the adjoint of the linear blurring kernel K, the multiplier $\chi_D(x)$ is the indicator of D, and $\mu = 2\lambda/\alpha$. The boundary condition along $\partial\Omega$

is Neumann adiabatic to eliminate any boundary contribution during the integration-by-parts process. This nonlinear PDE can be solved iteratively by the freezing technique: if $u^{(n)}$ denotes the current inpainting at step n, then the updated inpainting $u^{(n+1)}$ solves the linearized PDE

$$-\nabla \cdot \left[\frac{\nabla u^{(n+1)}}{|\nabla u^{(n)}|} \right] + \mu K^* \chi_D (K u^{(n+1)} - u_0) = 0.$$

In practice the intermediate diffusivity coefficient $1/|\nabla u^{(n)}|$ is often modified to $1/\sqrt{|\nabla u^{(n)}|^2 + \epsilon^2}$ for some small conditioning parameter ϵ or by the mandatory ceiling and flooring between ϵ and $1/\epsilon$. The convergence of such algorithms has been well studied in the literature (e.g., Chambolle and Lions, and Dobson and Vogel). There are also many other possible techniques in the literature for solving (8) (e.g., Vogel and Oman, and Chan, Mulet, and Golub). We need only to relate (8) to the conventional TV restoration case.

The computation of the Mumford-Shah inpainting model is also very interesting. For inpainting, unlike segmentation, one's direct interest is only in u, not in Γ. Such understanding makes the Γ-convergence approximation theory perfect for inpainting. According to Ambrosio and Tortorelli, by introducing an edge signature function $z(x) \in [0,1]$, $x \in \Omega$, and having $E[u|\Gamma] = \alpha \int_{\Omega \setminus \Gamma} |\nabla u|^2 \, dx$ replaced by $E[u|z] = \alpha \int_\Omega z^2 |\nabla u|^2 \, dx$, one can approximate the length energy in the Mumford-Shah model by a quadratic integral in z (up to a constant multiplier):

$$E_\epsilon[z] = \beta \int_\Omega \left(\frac{\epsilon |\nabla z|^2}{2} + \frac{(z-1)^2}{2\epsilon} \right) dx, \quad \epsilon \ll 1.$$

Thus the Mumford-Shah inpainting model is approximated by

$$E_\epsilon[u, z | u_0, D] = E[u|z] + E_\epsilon[z] + \lambda E[u_0 | u, D],$$

which is a quadratic integral in both u and z! It leads to a coupled system of linear elliptic-type PDEs in both u and the edge signature z, which can be solved efficiently using any numerical elliptic solver. The example in Figure 2 was computed by this scheme.

Finally, we mention some of the major applications of the inpainting and geometric image interpolation models developed above. These include digital zooming, primal-sketch-based perceptual image coding, error concealment for wireless image transmission, and progressive disocclusion in computer vision [2], [4], [9]. Extensions to color or more general hyperspectral images and nonflat image features (i.e., ones that live on Riemannian manifolds) are also currently being studied in the literature. Other approaches to the inpainting problem can be found in the papers by Bertalmio, Sapiro, Caselles, and Ballester, and by Bertalmio, Bertozzi, and Sapiro. In particular, it has been interestingly found in the latter paper that the earlier PDE model by Ballester, Bertalmio, Caselles, Sapiro, and Verdera is closely related to the stream function–vorticity equation in fluid dynamics.

Variational Level Set Image Segmentation

Images are the proper 2-D projections of the 3-D world containing various objects. To successfully reconstruct the 3-D world, at least approximately, the first crucial step is to identify the regions in images that correspond to individual objects. This is the well-known problem of image segmentation. It has broad applications in a variety of important fields such as computer vision and medical image processing.

Denote by u_0 an observed image on a 2-D Lipschitz open and bounded domain Ω. Segmentation means finding a visually meaningful edge set Γ that leads to a complete partition of Ω. Each connected component Ω_i of $\Omega \setminus \Gamma$ should correspond to at most one real physical object or pattern in our 3-D world, for example, the white matter in brain images or the abnormal tissues in organs. In some applications, one is interested also in the clean image patches u_i on each Ω_i of the segmentation, since u_0 is often noisy.

Therefore, there are two crucial ingredients in the mathematical modeling and computation of the segmentation problem. The first is how to formulate a model that appropriately combines the effects of both the edge set Γ and its segmented regions $\{\Omega_i, i = 1, 2, \cdots\}$. The other is to find the most efficient way to represent the geometry of both the edge set and the regions and to represent the segmentation model as a result. This of course reflects the general philosophy in the introduction.

In the variational PDE approach, these two issues have found good answers in the literature: for the first, the celebrated segmentation model of Mumford and Shah [13] and for the second, the level-set representation technology of Osher and Sethian [14]. In what follows we detail our recent efforts in advancing the application of the level-set technology to various Mumford-Shah-related image segmentation models. Much of the work can be found in our papers (e.g., [3], [5], [17], [19] and many more on our group homepage [11]) and also in related works by Yezzi, Tsai, and Willsky; Paragios and Deriche; Zhu and Yuille; and Cohen, Bardinet, and Ayache [6], [7].

We start with a novel active-contour model whose formulation is independent of intensity edges defined by the gradients, in contrast to most conventional ones in the literature. We then explain how this model can be efficiently computed based on the multiphase level-set method. In the second part we extend these results to the level-set formulation and

computation of the general Mumford-Shah segmentation model for piecewise-smooth images. In the last part we present our recent work on extending the previous models to logical operations on multichannel image objects.

Active Contours without Edges and Multiphase Level Sets

The active contour is a powerful tool in image and vision analysis for boundary detection and object segmentation. The key idea is to evolve a curve so that it eventually stops along the object edges of the given image u_0. The curve evolution is controlled by two sorts of energies: the internal energy defining the regularity of the curve and the external energy determined by the given image u_0. The latter is often called the feature-driven energy.

In almost all classical active-contour models, the feature-driven energies rely heavily on the gradient feature $|\nabla u_0|$ or on its smoothed version $|\nabla G_\sigma * u_0|$, where G_σ denotes a Gaussian kernel with a small variance σ. They work well for detecting gradient-defined edges but fail for more general classes of edges such as the boundary of a nebula in some astronomical images or the top image in Figure 4.

Our new model, *active contours without edges*, first introduced in [5], is independent of the gradient information and therefore can handle more general types of edges. The model is to minimize the energy

$$E_2[c_1, c_2, \Gamma | u_0] = \int_{\text{int}(\Gamma)} |u_0(x) - c_1|^2 \, dx + \int_{\text{ext}(\Gamma)} |u_0(x) - c_2|^2 \, dx + \nu |\Gamma|, \tag{9}$$

where ν denotes a given positive weight, the c's are unknown constants, int(Γ) and ext(Γ) denote the interior and exterior of Γ, and $|\Gamma|$ is its length. The subscript 2 in E_2 indicates that it deals with two-phase images, i.e., ones whose "objects" can be completely indexed by the interior and exterior of Γ.

In the level-set formulation of Osher and Sethian [14], Γ is embedded as the zero-level set $\{\phi = 0\}$ of a Lipschitz continuous function $\phi : \Omega \to \mathbb{R}$. Consequently, $\{\phi > 0\}$ and $\{\phi < 0\}$ define the interior Ω^+ and exterior Ω^- of the curve. (The level-set approach is computationally superior to other curve representations, because it lets one directly work on a fixed rectangular grid and it allows automatic topological changes such as merging and breaking.) Denote by H the 1-dimensional Heaviside function: $H(z) = 1$ if $z \geq 0$ and 0 if $z < 0$. Then the energy in our model becomes

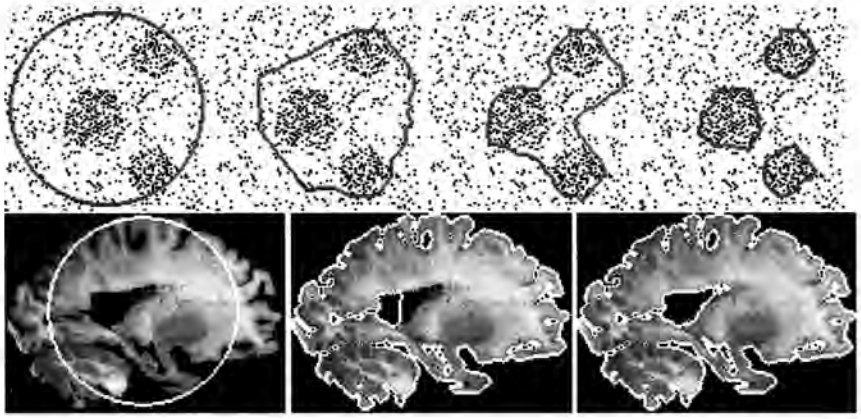

Figure 4. Top: Detection of a simulated minefield by our new active-contour model. Bottom: Segmentation of an MRI brain image. Notice that the interior boundaries are automatically detected.

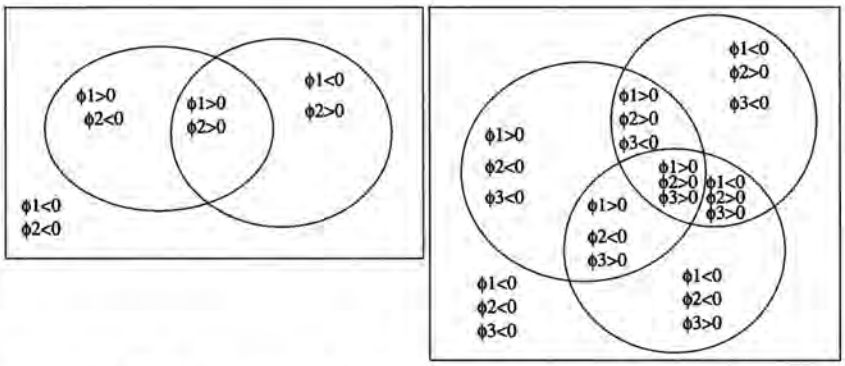

Figure 5. Left: Two curves given by $\phi_1 = 0$ and $\phi_2 = 0$ partition the domain into four regions based on indicator vector $(\text{sign}(\phi_1), \text{sign}(\phi_2))$. **Right: Three curves given by $\phi_1 = 0$, $\phi_2 = 0$, and $\phi_3 = 0$ partition the domain into eight regions based on the triple** $(\text{sign}(\phi_1), \text{sign}(\phi_2), \text{sign}(\phi_3))$.

$$E_2[c_1, c_2, \phi | u_0] = \int_\Omega |u_0(x) - c_1|^2 H(\phi) \, dx + \int_\Omega |u_0(x) - c_2|^2 (1 - H(\phi)) \, dx + \nu \int_\Omega |\nabla H(\phi)| \, dx.$$

Minimizing $E_2[c_1, c_2, \phi | u_0]$ with respect to c_1, c_2, and ϕ leads to the Euler-Lagrange equation:

$$\frac{\partial \phi}{\partial t} = \delta(\phi) \Big[\nu \, \text{div}\Big(\frac{\nabla \phi}{|\nabla \phi|}\Big) - |u_0 - c_1|^2 + |u_0 - c_2|^2 \Big],$$

$$c_1(t) = \frac{\int_\Omega u_0(x) H(\phi(x)) \, dx}{\int_\Omega H(\phi(x)) \, dx},$$

$$c_2(t) = \frac{\int_\Omega u_0(x)(1 - H(\phi(x))) \, dx}{\int_\Omega (1 - H(\phi(x))) \, dx},$$

with a suitable initial guess $\phi(0, x) = \phi_0(x)$. In numerical implementations the Heaviside function $H(z)$ is often regularized by some $H_\varepsilon(z)$ in $C^1(\mathbb{R})$ that converges as $\varepsilon \to 0$ to $H(z)$ in some suitable sense. As a result, the Dirac function $\delta(z)$ in the last

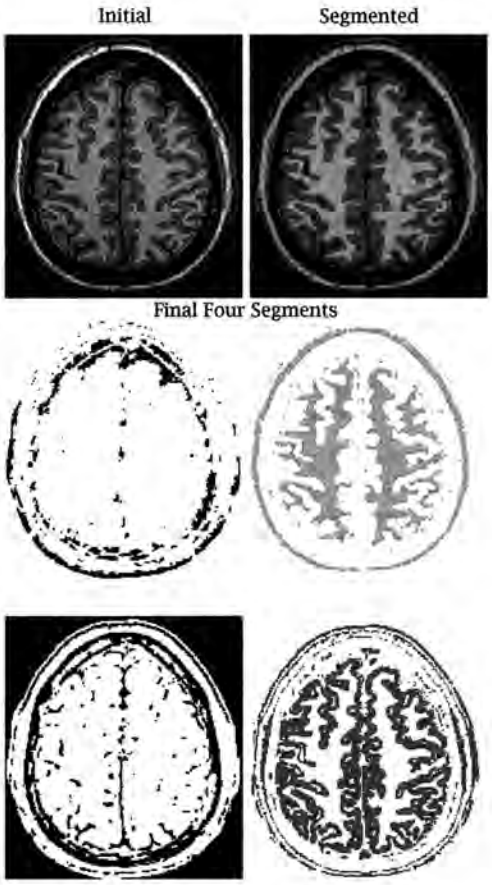

Figure 6. The original and segmented images (top row), and the final four segments (the rest).

equation is regularized to $\delta_\varepsilon(z) = H'_\varepsilon(z)$. We have discovered in [5] that a carefully designed approximation scheme can even allow interior contours to emerge, a challenging task for most conventional algorithms. Also notice that the length term in the energy has led to the mean-curvature motion.

The model performs as an active contour in the class of piecewise-constant images taking only two values; it looks for a two-phase segmentation of a given image. The internal energy is defined by the length, while the external energy is independent of the gradient $|\nabla u_0|$. Defining the segmented image by $u(x) = c_1 H(\phi(x)) + c_2(1 - H(\phi(x)))$, we realize that the energy model is exactly the Mumford-Shah segmentation model [13] restricted to the class of piecewise-constant images. However, our model was initially developed from the active-contour point of view.

Two typical numerical outputs of the model are displayed in Figure 4. The top row shows that our model can segment and detect objects without clear gradient edges. The bottom one shows that it can also capture complicated boundaries and interior contours.

For more complicated situations where multiple objects occlude each other and multiphase edges such as T-junctions emerge, the above two-phase active-contour model is insufficient, and we need to introduce multiple level-set functions. Therefore, we have generalized the above framework to multiphase active contours or, equivalently, the piecewise-constant Mumford-Shah segmentation with multiphase regions:

$$\inf_{u,\Gamma} E_{\text{ms}}[u,\Gamma|u_0] = \sum_i \int_{\Omega_i} |u_0 - c_i|^2\,dx + \nu|\Gamma|. \tag{10}$$

Here the Ω_i's denote the connected components of $\Omega \setminus \Gamma$, and $u = c_i$ on Ω_i. Notice that Γ can now be a general set of edge curves, including for example the T-junction class.

Generally, consider m level-set functions $\phi_i : \Omega \to \mathbb{R}$. The union of the zero-level sets of the ϕ_i represents the edges in the segmented image. Using these m level-set functions, one can define up to $n = 2^m$ phases, which form a disjoint and complete partitioning of Ω. Therefore, each point $x \in \Omega$ belongs to one and only one phase. In particular, there is no vacuum or overlap among the phases. This is an important advantage compared with the classical multiphase representation, where a level-set function is associated to each phase and more level-set functions are needed as a result. Figure 5 shows two typical examples of multiphase partitioning corresponding to $m = 2$ and $m = 3$.

We now illustrate the multiphase level-set approach through the example of $n = 4$ and $m = 2$. Let $c = (c_{11}, c_{10}, c_{01}, c_{00})$ denote a constant vector and $\Phi = (\phi_1, \phi_2)$ the two-phase level-set vector. Then we are looking for an ideal image u in the form of

$$\begin{aligned} u = {} & c_{11}H(\phi_1)H(\phi_2) + c_{10}H(\phi_1)(1-H(\phi_2)) \\ & + c_{01}(1-H(\phi_1))H(\phi_2) + c_{00}(1-H(\phi_1))(1-H(\phi_2)). \end{aligned}$$

The Mumford-Shah segmentation energy becomes

$$\begin{aligned} E_4[c,\Phi|u_0] = {} & \int_\Omega |u_0(x) - c_{11}|^2 H(\phi_1)H(\phi_2)\,dx \\ & + \int_\Omega |u_0(x) - c_{10}|^2 H(\phi_1)(1 - H(\phi_2))\,dx \\ & + \int_\Omega |u_0(x) - c_{01}|^2 (1 - H(\phi_1))H(\phi_2)\,dx \\ & + \int_\Omega |u_0(x) - c_{00}|^2 (1 - H(\phi_1))(1 - H(\phi_2))\,dx \\ & + \nu \int_\Omega |\nabla H(\phi_1)|\,dx + \nu \int_\Omega |\nabla H(\phi_2)|\,dx. \end{aligned} \tag{11}$$

Its minimization leads to the Euler-Lagrange equations. First, with Φ fixed, the c minimizer can be explicitly worked out as before:

$$c_{ij}(t) = \text{average of } u_0 \text{ on } \{(2i-1)\phi_1 > 0,\ (2j-1)\phi_2 > 0\},\quad i,j = 0,1.$$

In turn, this new c information leads to the Euler-Lagrange equations for Φ:

$$\frac{\partial \phi_1}{\partial t} = \delta(\phi_1)\Big[\nu \operatorname{div}\Big(\frac{\nabla \phi_1}{|\nabla \phi_1|}\Big) - \big((u_0 - c_{11})^2 - (u_0 - c_{01})^2\big)H(\phi_2) - \big((u_0 - c_{10})^2 - (u_0 - c_{00})^2\big)(1 - H(\phi_2))\Big],$$

$$\frac{\partial \phi_2}{\partial t} = \delta(\phi_2)\Big[\nu \operatorname{div}\Big(\frac{\nabla \phi_2}{|\nabla \phi_2|}\Big) - \big((u_0 - c_{11})^2 - (u_0 - c_{01})^2\big)H(\phi_1) - \big((u_0 - c_{10})^2 - (u_0 - c_{00})^2\big)(1 - H(\phi_1))\Big].$$

Notice that the equations are governed both by the mean curvatures and by jumps of the data-energy terms across the boundary.

Figure 6 shows an application of the model to the medical analysis of a brain image. Displayed are the final segmented image and its associated four phases. Our model successfully identifies and segments the white and the gray matters.

Recently the above models and algorithms have been extended to multichannel, volumetric, and texture images (e.g., Chan, Sandberg, and Vese [3]). Let us give a little more detail about texture segmentation from our work. Texture images are general images of natural scenes, such as grasslands, beaches, rocks, mountains, and human body tissues. They typically carry certain coherent structures in scales, orientations, and local frequencies. To segment texture images using the above models, we first apply Gabor's filters to extract these coherent structures. The filter responses create a new vectorial (or multichannel) feature image in the form of $U(x) = (u_\alpha(x), u_\beta(x), \cdots, u_\gamma(x))$, where the Greek letters stand for the filter signatures, and typically each takes a value of (scale, orientation, local frequency). We then apply the vectorial active-contour-without-edges model to the segmentation of U. Figure 7 shows one typical example.

Piecewise-Smooth Mumford-Shah Segmentation

The most general Mumford-Shah piecewise-smooth segmentation [13] is defined by

$$\inf_{u,\Gamma} E_{\text{ms}}[u,\Gamma|u_0] = \int_\Omega |u - u_0|^2\,dx + \mu \int_{\Omega\setminus\Gamma} |\nabla u|^2\,dx + \nu|\Gamma|, \tag{12}$$

where μ and ν are positive parameters. It allows the segmented "objects" to have smoothly varying intensities instead of being strictly constant. We

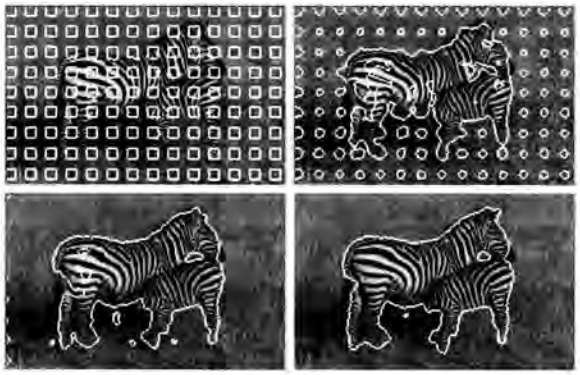

Figure 7. An example of texture segmentation (at increasing times).

now show how to carry out the model based on the multiphase level-set approach [5]. As before, we start with the two-phase situation where a single level-set function ϕ is sufficient, followed by the more general multiphase case.

In the two-phase situation, the ideal image u is segmented to $u^\pm$ by the level-set function ϕ:

$$u(x) = u^+(x)H(\phi(x)) + u^-(x)(1 - H(\phi(x))).$$

We assume that both u^+ and u^- are C^1 functions up to the boundary $\{\phi = 0\}$. Substituting this expression into (12), we obtain

$$E[u^+,u^-,\phi|u_0] = \int_\Omega |u^+ - u_0|^2 H(\phi)\,dx + \int_\Omega |u^- u_0|^2(1 - H(\phi))\,dx + \mu\int_\Omega |\nabla u^+|^2 H(\phi)\,dx + \mu\int_\Omega |\nabla u^-|^2(1 - H(\phi))\,dx + \nu\int_\Omega |\nabla H(\phi)|. \tag{13}$$

First, with ϕ fixed, the variation on $E[u^+,u^-,\phi|u_0]$ leads to the two Euler-Lagrange equations for $u^\pm$ separately:

$$\begin{aligned} u^\pm - u_0 &= \mu\triangle u^\pm \quad \text{on } \pm\phi > 0,\\ \frac{\partial u^\pm}{\partial \vec{n}} &= 0 \qquad\quad \text{on } \{\phi = 0\}. \end{aligned} \tag{14}$$

(Here $\pm$ takes either of the values + and −, but uniformly across the formula.) They act as denoising operators on the homogeneous regions only. Notice that no smoothing is done *across* the boundary $\{\phi = 0\}$, which is very important in image analysis.

Next, keeping the functions u^+ and u^- fixed and minimizing $E[u^+,u^-,\phi|u_0]$ with respect to ϕ, we obtain the motion of the zero-level set:

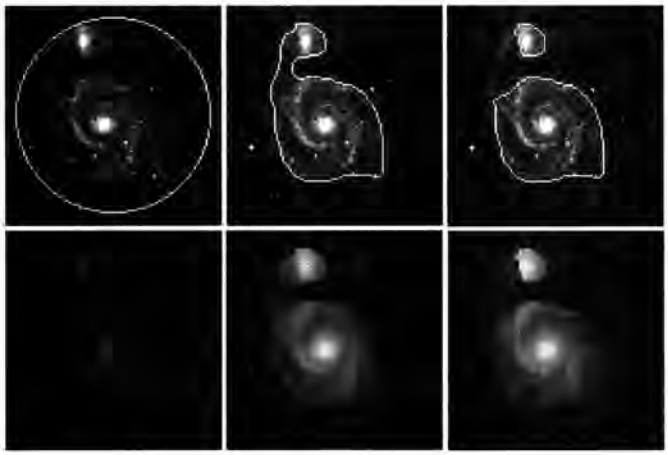

Figure 8. Numerical result from the piecewise-smooth Mumford-Shah level-set algorithm with one level-set function.

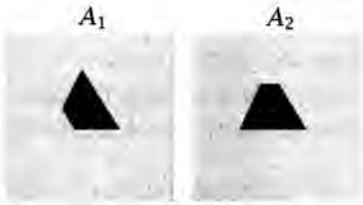

Figure 9. A synthetic example of an object in two different channels. Notice that the lower left corner of A_1 and the upper corner of A_2 are missing.

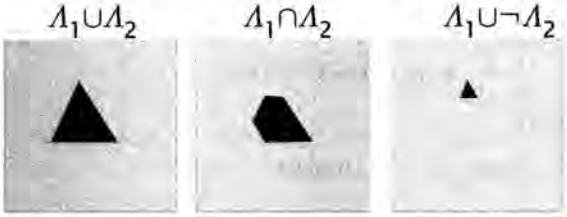

Figure 10. Different logical combinations for the sample image: the union, the intersection, and the differentiation.

$$\frac{\partial \phi}{\partial t} = \delta(\phi)\left[\nu \nabla \left(\frac{\nabla \phi}{|\nabla \phi|}\right) - (|u^+ - u_0|^2 + \mu|\nabla u^+|^2 - |u^- u_0|^2 - \mu|\nabla u^-|^2)\right],$$

with some initial guess $\phi(t = 0, x)$. The above equation is actually computed at least near a narrow band of the zero-level set. As a result, computationally we have to continuously extend both u^+ and u^- from their original domains $\{\pm\phi > 0\}$ to a suitable neighborhood of the zero-level set $\{\phi = 0\}$. Figure 8 displays an application of the model in astronomical image analysis. Although the nebula itself does not seem to be a smooth object, the piecewise-smooth model can still correctly capture the main features.

As in the previous section, there are cases where the boundaries forming a complete partition of the image cannot be represented by a single level-set function. Then one has to turn to the multi-phase approach. In our papers, thanks to the planar Four-Color Theorem, we have been able to conclude that *two* level-set functions are sufficient for all multi-phase partition problems.

By the Four-Color Theorem one can color all the regions in a partition using only four colors, so that any two adjacent regions are color distinguishable. Identifying a phase with one color, we see that two level-set functions ϕ_1 and ϕ_2 are sufficient to produce four "colors": $\{\pm\phi_1 > 0, \pm\phi_2 > 0\}$. Therefore, they can completely segment a general image with a multiphase boundary set Γ given by $\{\phi_1 = 0\}$ or $\{\phi_2 = 0\}$. As before, we do not have the problems of "overlapping" or "vacuum" as in the works by Zhao, Chan, Merriman, and Osher. Note that in this formulation, generally each "color" can still have many isolated components. Therefore, the segmentation is complete only after one applies an extra step of the well-known topological processor for finding the connected components of an open set.

In this four-phase formulation, the ideal image u is segmented into four disjoint but complete parts $u^{\pm\pm}$, each defined by one of the four phases:

$$\{\pm\phi_1 > 0, \pm\phi_2 > 0\}.$$

Overall, by using the Heaviside function, we obtain the following synthesis formula:

$$\begin{aligned} u =& u^{++}H(\phi_1)H(\phi_2) + u^{+-}H(\phi_1)(1 - H(\phi_2)) \\ &+ u^{-+}(1 - H(\phi_1))H(\phi_2) \\ &+ u^{--}(1 - H(\phi_1))(1 - H(\phi_2)), \end{aligned}$$

for all $x \in \Omega$. We can express the energy function of u and $\Phi = (\phi_1, \phi_2)$ in a similar way and derive the corresponding Euler-Lagrange equations.

Notice the remarkable feature of this single model, which includes both the original energy formulation and the elliptic and evolutionary PDEs: it naturally combines all three image processors—active contour, segmentation, and denoising.

Logic Operators for Multichannel Image Segmentation

In a multichannel image $u(x) = (u_1(x), u_2(x), \cdots, u_n(x))$, a single physical object can leave different traces in different channels. For example, Figure 9 shows a two-channel image containing a triangle that is, however, incomplete in each individual channel. For this example, most conventional segmentation models for multichannel images (e.g., Guichard, Sapiro, Zhu and Yuille) would output the complete triangle, i.e., the union of both channels. The union is just one of the several possible logical operations for multichannel images. For example, the intersection and the

differentiation are also very common in applications, as illustrated in Figure 10.

In this section we outline our recent efforts in developing logical segmentation schemes for multichannel images based on the active-contour-without-edges model [16].

First, we define two logical variables to encode the information inside and outside the contour Γ separately for each channel i:

$$z_i^{in}(u_0^i, x, \Gamma) = \begin{cases} 1, & \text{if } x \text{ is inside } \Gamma \text{ and not on the object,} \\ 0, & \text{otherwise;} \end{cases}$$

$$z_i^{out}(u_0^i, x, \Gamma) = \begin{cases} 1 & \text{if } x \text{ is outside } \Gamma \text{ and on the object,} \\ 0 & \text{otherwise.} \end{cases}$$

Such different treatments are motivated by the energy minimization formulation. Intuitively speaking, in order for the active contour Γ to evolve and eventually capture the *exact* boundary of the targeted logical object, the energy should be designed so that both partial capture and overcapture lead to high energies (corresponding to $z_i^{out} = 1$ and $z_i^{in} = 1$ separately). Imagine that the target object is tumor tissue: then in terms of decision theory, over and partial captures correspond respectively to *false alarms* and *misses.* Both are to be penalized.

In practice we do not have precise information of "the object" to be segmented. One possible way to approximate z_i^{in} and z_i^{out} is based on the interior (Ω^+) and exterior (Ω^-) averages $c_i^{\pm}$ in channel i:

$$z_i^{in}(u_0^i, x, \Gamma) = \frac{|u_0^i(x) - c_i^+|^2}{\max_{y\in\Omega^+} |u_0^i(y) - c_i^+|^2},$$

for $x \in \Omega^+$, and

$$z_i^{out}(u_0^i, x, \Gamma) = \frac{|u_0^i(x) - c_i^-|^2}{\max_{y\in\Omega^-} |u_0^i(y) - c_i^-|^2},$$

for $x \in \Omega^-$.

The desired truth table can then be described using the z_i^{in}'s and z_i^{out}'s. Table 2 shows three examples of logical operations for the two-channel case. Notice that "true" is represented by 0 inside Γ. The method is designed so as to encourage energy minimization when the contour tries to capture the targeted object inside. Also note that the "z_i^{in}" terms and the "z_i^{out}" terms play asymmetric but complementary roles. For example, the union $A_1 \cup A_2$ corresponds to the union of the "in" terms and the *intersection* of the "out" terms. Similarly, the intersection $A_1 \cap A_2$ corresponds to the intersection of the "in" terms and the *union* of the "out" terms.

We then design continuous objective functions to smoothly interpolate the binary truth table. This

Truth table for the two-channel case							
	z_1^{in}	z_2^{in}	z_1^{out}	z_2^{out}	$A_1 \cup A_2$	$A_1 \cap A_2$	$A_1 \cap \neg A_2$
x inside Γ (or $x \in \Omega^+$)	1	1	0	0	1	1	1
	1	0	0	0	0	1	1
	0	1	0	0	0	1	0
	0	0	0	0	0	0	1
x outside Γ (or $x \in \Omega^-$)	0	0	1	1	1	1	0
	0	0	1	0	1	0	1
	0	0	0	1	1	0	0
	0	0	0	0	0	0	0

Table 2. The truth table for two channels. Notice that inside Γ "true" is represented by 0. It is designed so as to encourage the contour to enclose the targeted logical object at a lower energy cost.

is because in practice, as mentioned above, the z's are approximated and take continuous values. For example, possible interpolants for the union and intersection are

$$f_{A_1\cup A_2}(x) = \sqrt{z_1^{in}(x) z_2^{in}(x)} + \left(1 - \sqrt{(1 - z_1^{out}(x))(1 - z_2^{out}(x))}\right),$$

$$f_{A_1\cap A_2}(x) = 1 - \sqrt{(1 - z_1^{in}(x))(1 - z_2^{in}(x))} + \sqrt{z_1^{out}(x) z_2^{out}(x)}.$$

The square roots are taken to keep the functions of the same order as the original scalar models. It is straightforward to extend the two-channel case to more general n-channel ones.

The energy functional E for the logical objective function f can be expressed by the level set function ϕ. Generally, as just shown above, the objective function can be separated into two parts,

$$\begin{aligned} f &= f(z_1^{in}, z_1^{out}, \cdots, z_n^{in}, z_n^{out}) \\ &= f_{in}(z_1^{in}, \cdots, z_n^{in}) + f_{out}(z_1^{out}, \cdots, z_n^{out}). \end{aligned}$$

The energy functional is then defined by

$$\begin{aligned} E[\phi | c^+, c^-] &= \mu \text{length}(\phi = 0) \\ &\quad + \lambda \int_\Omega [f_{in}(z_1^{in}, \cdots, z_n^{in}) H(\phi) \\ &\quad + f_{out}(z_1^{out}, \cdots, z_n^{out})(1 - H(\phi))]\, dx. \end{aligned}$$

Here each $c^{\pm} = (c_1^{\pm}, \cdots, c_n^{\pm})$ is in fact a multichannel vector. The associated Euler-Lagrange equation is similar to the scalar model:

$$\frac{\partial \phi}{\partial t} = \delta(\phi)\left[\mu \text{div}\left(\frac{\nabla \phi}{|\nabla \phi|}\right) - \lambda \left(f_{in}(z_1^{in}, \cdots, z_n^{in}) - f_{out}(z_1^{out}, \cdots, z_n^{out})\right)\right],$$

with suitable boundary conditions as before. Even though the form often looks complicated for a typical application, its implementation is very similar to that of the scalar model.

Numerical results support our above efforts. Figure 9 shows two different occlusions of a triangle.

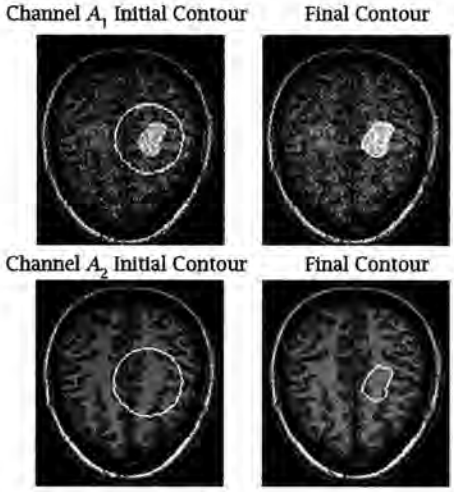

Figure 11. Region-based logical model on a medical image. In the first channel, A_1, the noisy image has a "brain tumor", while channel A_2 does not. The goal is to spot the tumor that is in channel A_1 but not in A_2, i.e., the differentiation $A_1 \cap \neg A_2$. In the right-hand column we observe that the tumor has been successfully captured.

We are able to successfully recover the union, the intersection, and the differentiation of the objects in Figure 10 using our model. In Figure 11 we have a two-channel image of the brain. In one channel we have a "tumor" with some noise, while the other channel is clear. The images are not registered. We want to find $A_1 \cap \neg A_2$ so that the tumor can be observed. This happens to be a very complicated example, as there are a lot of features and textures. However, the model finds the tumor successfully.

Conclusion

In this article we have discussed some recent developments in one successful approach to mathematical image and vision analysis, the variational PDE method. Besides the inpainting and segmentation problems discussed here, some other problems for which this method is well suited are adaptive image enhancement and scale-space theory, geometric processing of curves and surfaces, optical flows of motion pictures, and dynamic object tracking. Advantages of the method include faithful modeling and processing of vision geometry and its related visual optimization, effective simulation of dynamic visual processes such as selective diffusion and information transport, and close interaction with the rich literature of numerical analysis and computational PDEs. This subject shows that mathematics has a key role to play in addressing real-world problems in science and technology. Some challenges for the future are further theoretical study on the variational and PDE models developed in recent years, more intrinsic integration with stochastic modeling and applied harmonic analysis such as geometric wavelets, and more systematic investigation on the computation and numerical analysis of geometry-based variational optimizations and PDEs.

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Can Numbers Ensure Honesty? Unrealistic Expectations and the U.S. Accounting Scandal

Mary Poovey

Recent economic events in Asia, South America, and the U.S. have made it clear that over the last twenty years a new axis of power has emerged, which is now making itself felt all over the world. This axis runs through large multinational corporations, many of which avoid national taxes by incorporating in tax havens like Hong Kong [1]. It runs through investment banks, through nongovernmental organizations like the International Monetary Fund, through state and corporate pension funds, and through the wallets of ordinary investors. This axis of financial power contributes to economic catastrophes like the 1998 meltdown in Japan and Argentina's default in 2001, and it leaves its traces in the daily gyrations of stock indexes like the Dow Jones Industrials and London's Financial Times Stock Exchange 100 Index (the FTSE). Intrinsically, this axis of power is neither good nor evil. In some countries, like China, it has helped raise the nation's overall standard of living, and in others, like the U.S., it has allowed some people to retire early or with more money than they ever dreamed possible. But it has also widened the gap worldwide between rich and poor. It has led countries all over the globe to abandon their welfare societies in favor of a U.S.-style shareholder culture, where basic services, like health care, are individual responsibilities [2]. And, as we saw in the spring and summer of 2002, it has permitted—even encouraged—corporate crime on a scale that takes one's breath away, not to mention the life savings of thousands of individual workers as well [3].

This new axis of financial power has many dimensions, many causes, and many effects. In this essay I will be able to discuss only a small part of what one analyst has called "financialization" [4] and I call the culture of finance. Specifically, I will discuss some of the ways that the culture of finance uses numbers and mathematics to reorganize the relationship between value and temporality. By translating concepts that were once time-dependent, like risk, into numbers and mathematical equations, financialization is generating a new form of value which produces huge profits for those who know how to play by its rules while inflicting huge losses on others, who often do not.

The starting point for my discussion is an obvious historical observation: the emergent culture of finance differs from an economy of production in that finance generates profit primarily through investment, through moving and trading currencies, and through placing complex wagers that future prices will rise or fall. This is in stark contrast to an economy of production, which generates profits by turning labor power into products that are priced and exchanged in the market. Finance obviously played a crucial role in the economy of production, which dominated the overall wealth of the U.S. until 1995 and which still dominates the gross domestic products of most nations. By the same token, production—both agricultural production and manufacturing—is necessary for the emergent culture of finance, because even investors have to eat, wear clothes, and buy things. Nevertheless, what we have seen in the U.S. since 1995 is a change

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in the ratio between the wealth generated by production and the wealth created by finance: in 1995 the sector composed of finance, insurance, and real estate overtook the manufacturing sector in America's gross domestic product. By the year 2000 this sector led manufacturing in profits. Not incidentally, in the same year this sector also became one of the biggest donors to federal elections in the U.S., and its representatives spent enormous sums of money lobbying Congress in Washington [5].

Some of the instruments I am about to describe are vehicles for trading on stock, options, or futures markets; they are investment vehicles or products. Others are instruments for recording profits and losses; they are bookkeeping or accounting vehicles. I describe these two kinds of instruments together because in this emergent culture of finance, representations, like the figures an accountant enters in a company's books or the numbers a trader enters in a computer, no longer necessarily reflect or point to actual transfers of cash or commodities. Instead, representations and exchanges are increasingly conflated: sometimes such representations cause exchanges to occur, sometimes the representation replaces the exchange, and sometimes a representation actually constitutes what counts as the "exchange" itself. This conflation of representation and exchange has all kinds of material effects, as we will see in a moment, for when representation can influence or take the place of exchanges, the values at stake become notional too: they can grow exponentially or collapse at the stroke of a key.

This conflation of representation and exchange has several historical origins. It has occurred partly because new markets, like futures markets, have been taking advantage of old accounting rules. When, for example, derivatives trades are recorded by rules intended to track the exchange of goods and services, the accounts do not have to list the most leveraged and hence most financially loaded parts of the transactions. The conflation of representation and exchange has also become possible because the primary form of representation used in financial markets, quantification, is an inherently abstracting process: in order to depict an exchange in numbers, one must abstract some features that are considered essential (because they are amenable to quantification) and marginalize all others (because they are not quantifiable). Mathematics, of course, by operationalizing quantification takes the level of abstraction to a new level. At this level, equations, typically run by software programs, become more important than the exchanges that might otherwise be performed in time and space. In the new culture of finance where quantification rules, the numbers one writes and the computations a computer performs upon them generate the only value that matters, even if this value is notional or so large that it could never be conveyed in actual currency.

All of the investment and accounting instruments I am about to describe are currently legal in the U.S. (although as I write, Congress has just passed legislation regulating some of them [6]). I will describe these instruments in an order of ascending complexity, and as I do I will also fill in some of the history by which they developed. In the available space I can describe only five of the countless financial instruments currently in use: day trading, stock options, mark to marketing accounting, adjustment to bad debt reserve, and derivatives. As I discuss these five instruments I will also describe five additional features unique to the culture of finance: earnings reports, growth forecasting, off-balance sheet partnerships, deregulation, and pricing risk (the Black-Scholes equations).

Day Trading

The simplest of these financial instruments is the practice of day trading, in which an individual investor creates an imaginary, purely notional future in order to get rich now [7]. In this practice the day trader purchases shares in some company through an online brokerage firm; the trader then provokes other investors to buy the stock by promoting it, usually anonymously, in another Internet venue (a chat room). As other investors buy, the price of the share rises, and the original investor—the day trader—sells the purchased shares just as, or just before, the price begins to collapse. This practice of bidding up stocks to sell them is as old as the securities market itself, but it acquired new velocity and popularity in the tech boom of the 1990s. In that decade more individuals had access to the Internet, fees for individual trades were reduced, and, most importantly, the U.S. government required companies to release earnings information directly to the public instead of just to industry insiders. The imaginary future from which the day trader profits consists of the company's future earnings. The trader promises these profits in the chat room "tips", but the company will never deliver them, because as soon as the day trader takes the profits thus far earned, share prices collapse and in extreme cases the company does too. In such transactions the big losers are the investors who get in late or who buy stock for the long run, even if the "long run" proves to be a few hours instead of a few minutes.

Stock Options

In day trading we see the rudimentary dynamics of the culture of finance, for in this practice the representation of future profits actually generates those profits—at least for a moment and for the

trader quick enough to take the money and run. On the corporate scene, the same dynamic can also work, but the scale is larger and the mechanisms more complex. The simplest of these corporate mechanisms are stock options, which many U.S. companies have used since the 1980s to give employees incentives or to supplement wages. Think of a stock option as an objectification that simultaneously signifies the value the company assigns to good work and rewards the employee for such work. Since good work these days often entails some amorphous quality like "creativity" or "the ability to inspire confidence" instead of a measurable achievement like meeting a sales quota, the value of the objectification (hence the value of the reward) now floats upon a sea of representations and market factors that yield a number (or dollar amount) only when the clock is stopped, when the options are sold. Here is how this works. A typical stock option gives its holder the right to buy a share of the company's stock in the future at a fixed price, the strike price; this price is generally set at or just below the market price at the time the option is issued. If the company's share price rises, the holder can exercise the option; purchase stock at the strike price, which is now below market price; and immediately sell the shares for a profit. In this transaction the "value" of the employee's work floats upon the share price; it is calibrated to the amount the share price rises while the employee holds the option, and the dollar amount of this value is set when—and only when—he sells the shares and takes his profit.

Companies claim that they issue stock options to employees at all levels, from the corporate executive officer (the CEO) to janitors, but recent studies show that the vast majority go to top executives [8]. The CEO and other executives have the power to influence the price of shares—and thus the measure of their own value. In this sense, stock options resemble day trading: the value that both the day trader and the executive can extract depends upon the price to which they can push the cost of a share and the timing with which they realize their gains. The company executive and the day trader both use representations of future profits to push the share price higher. Whereas the day trader uses the informal, ephemeral, and wholly unregulated venue of the Internet chat room to post these predictions, the company executive urges share prices higher through a combination of well-placed hints to financial insiders and the publication of "forward-looking" statements in the company's quarterly reports [9]. While investors may eventually feel cheated by predictions that turn out to be unwarranted, corporate executives are not liable for defrauding the public through such statements; in 1995 Congress passed the Private Securities Reform Act, which exempted corporate executives from liability for "forward-looking" statements that turn out to be misleading [10]. By law, then, no representation of the future can be too far off the mark, even when it helps create the value it claims to describe—momentarily and, as with the day trader again, for those who know when to cash in and get their money out.

Company executives' rosy predictions function as a form of insider knowledge, which can influence share prices both directly, when current investors decide to buy more shares, and indirectly through the reports issued by financial analysts. The direct influence is easy to understand: a current shareholder reads an executive's forward-looking statement, decides that the executive has insider information that points to higher earnings, and buys more shares. The indirect influence takes a little more explaining, for it travels through the intermediary of at least two levels of financial analysts. Financial analysts are supposedly objective sources of market information who advise individual and corporate investors about what to buy. The information that financial analysts provide purports to be objective in two senses: it is supposedly disinterested, in the sense of being provided by someone not employed by the company whose prospects are being evaluated, and it is theoretically based on mathematical models that convert past performance and countless other factors into predictors about future profits.

Even though they are theoretically independent, however, these financial analysts actually depend upon a variety of sources, including company executives, to provide the information they represent as privileged. And even though they do use mathematical models computed electronically, all analysts also rely on other skills which are not objective in any sense, including market experience, intuition, and a general "feel" for market conditions. The financial analysts who work for large investment companies, moreover, rarely compose, run, or understand the computer programs that assist their "feel" for the market. Instead, these analysts rely both on the "quants" (the mathematicians) who write the programs and on another, more specialized, set of financial analysts. These specialized analysts belong to a new sector of finance called growth forecasting. There are currently two U.S. organizations that generate growth forecasts for every publicly traded company every quarter of the year: ThomsonFinancial/First Call and WhisperNumber.Com. To see what these growth forecasters do and why they are so important, we need to take a short detour through the history of financial reporting.

Beginning in the mid 1980s, in the midst of the hostile takeovers provoked by deregulation (which I will discuss in a moment), two financial analysts, Robert A. G. Monks and Nell Minow, suggested that

"New from accounting, sir. Two and two is four again."

corporations ought to be run for the benefit of their shareholders and that companies and CEOs ought to be evaluated by quarterly earnings reports [11]. Earnings reports and share prices are not the only way to evaluate a company's performance, of course. One could also look at the cash generated by its ongoing operations or even at a composite of factors, including productivity in relation to expenditure, and so on. But the earnings report has two particular virtues for the purposes of evaluation: first, the earnings report can be summarized in a single figure, which makes it seem simple to evaluate profitability; earnings can be recorded as gains or losses per share. Second, the earnings report can actually help enhance the company's future, because a good earnings report ensures access to affordable sources of capital, which are critical to ongoing operations and growth. When the U.S. stock market began to rise in the mid-1990s, more ordinary citizens began to invest in individual stocks, media coverage of investment mushroomed, and analysts struggled to package their information (and their services) in ways that would seem usable to all investors. The earnings number served this purpose well, for its brevity and simplicity spoke to the ordinary investor and its aura of privileged information appealed to everyone not in the know. The earnings figure even had a benchmark that enabled investors to evaluate the numbers that appeared in companies' earnings reports. This benchmark was set in the mid-1990s, when Jack Welch, the CEO of General Electric, declared that a successful company should be able to sustain an annual growth rate of 15 percent. Few investors realized that almost no companies actually met this figure, even in the 1990s. According to a report conducted by Credit Suisse First Boston, a major investment bank, average corporate growth during that decade was little better than 7 percent, and only one in eight large corporations managed to achieve continuous, year-upon-year growth of any size [11, p. 70]. Nevertheless, the benchmark had the predictable effect on CEOs' representations of their companies' future growth (their "forward-looking" statements) as well as on investors: most large companies continued to predict that their earnings would grow by 15 percent a year, and most investors continued to look for that figure.

The benchmark of 15 percent is a rather crude assessment index, for it is a fixed and universal standard. While analysts and investors do refer to this for general evaluations, in order to assess a company's earnings report with any specificity, they need a number generated especially for that company. This is what growth forecasters do: they combine data about companies' past performances with information picked up from corporate and investment insiders to produce an earnings prediction. This earnings prediction is also expressed in a single number: the number of pennies each company's dividend is likely to rise or fall in the quarter. As the end of the business quarter approaches, the ThomsonFinancial/First Call numbers parade across the bottom of televised programs like Bloomberg Marketline, and as soon as a company issues its report, analysts and investors react to the relation between the prediction and the report. Since the growth forecaster's prediction is based partly on insider information, a company executive's "forward-looking" statement can indirectly influence the analyst's report—which means that, in one sense, an investor is comparing one number directly supplied by the CEO, who stands to profit from a rise in stock prices, with another number that the CEO has influenced. Both numbers carry an aura of precision simply because they are numbers, and the latter in particular also carries the aura of objectivity, because the lines of influence that link the company to the growth forecaster are invisible to the investor.

The numbers provided by the growth forecasters have extraordinary power, for when a company meets or exceeds the forecasters' prediction, investors tend to buy and share prices rise. They continue to have this influence even though most economists agree that earnings, even if stated accurately, have no predictive value and that rapidly growing profits are not necessarily even signs of corporate health. This means that the number most investors interpret derives its meaning only in relation to those other numbers that growth forecasters compile, not in relation to the past, present,

or future of the company itself. It also means that, just as corporate executives want the quarterly numbers to be high now, even though they may be hiding debts that will fall due in the future, so investors evaluate these numbers as if they promised future profit, even though they have no predictive value at all. Thus the current fixation on earnings reports, which is one basis of the value of corporate executives' stock options, routinely puts the future under erasure by assessing its value now. When I say that the future is under erasure, I mean to imply that the fixation on earnings reports can keep the future from occurring, even as it continues to hold out the promise that it will. I think that the laid-off employees of Enron, especially those who lost their retirement funds when the company collapsed, would agree that the future promised by the glowing earnings reports will now never occur or vanish from their imaginations as something that once might have happened.

Mark to Marketing Accounting

Company executives can influence the relationship between the number that appears in the quarterly earnings report and the number the growth analysts provide by devices that are more formal than just a few well-placed hints. Because a company's earnings report is always based on a certain amount of interpretation and guesswork, no matter how well informed, a company's financial officers can actively adjust the number they report to make it coincide with the growth analyst's prediction. This is called "backing-in" to an earnings figure [12]. One way that financial officers back-in to the all-important earnings figure is by mark to marketing accounting [13]. This practice, which allows a company to record profits before they are realized, is often adopted when a company creates off-balance-sheet partnerships [14]. Such partnerships can be used in various ways: to raise money for the parent company through the sale of bonds or to purchase a stake in the parent company's future gains on some investment. These partnerships also decrease the parent company's visible risk by moving part of its holdings and much of its debt onto the balance sheets of companies that look like they are separate, so that this risk can be assumed by outside investors or written off as bad debt.

To understand the origins of this kind of structured financing, it is useful to detour again, this time through the history of deregulation in the U.S. Because the effects of deregulation have been particularly visible in the energy sector, I will use the deregulation of energy as my example [15]. Deregulation first began to affect the petroleum industry in the early 1980s, when congressmen from the oil-producing states pressured the board that oversees the accounting industry (the Financial Accounting Standards Board, or FASB) not to impose tough standards for financial reporting in that industry. In particular, congressmen lobbied for relief from a provision, still in place in 1978, that required utilities to enter into long-term power deals at fixed prices in order to guarantee customers a constant source of power and to prohibit price gouging. These fixed prices were typically high, because they were set just below the cost of building a new power plant. During the 1980s these restrictions were lifted, and it became possible to trade energy on the open market as if it were a commodity like any other. This is what companies like Enron did: they transformed energy supplies into "products" that could be bought and sold. Because deregulation created a discrepancy between the high prices that utility companies had contracted to pay and the lower prices set by the market, companies trading energy stood to make millions. They did so by purchasing energy on the open market for a low price, then selling it immediately for another price which was higher than the current market price but lower than the existing contract price. Such deals were lucrative because energy contracts were futures contracts: energy is a product that the buyer needs over time, not all at once. Thus companies like Enron guaranteed buyers, like the state of California, future prices for energy which were set above the price that Enron paid but below the price California might have to pay if it had to honor existing contracts, which were set at the relatively high price required for building plants to generate energy.

For energy companies this constituted a change from producing energy, which was the old way of doing business, to trading for it, and under existing accounting rules this change enabled the company to book an entire 10–15-year profit immediately instead of waiting for payments to come in. This is the benefit of mark to marketing accounting: it counts anticipated profits as present gains. To raise the capital necessary to purchase the energy it traded and to finance the debt such bonds incurred, Enron formed off-balance-sheet partnerships with fancy names like Raptor and Condor. It created these partnerships by giving them Enron stock in exchange for a promissory note; Enron immediately booked this promissory note as an asset. In addition to raising capital in this way and servicing debt, these partnerships also enabled Enron to keep its debt off its own balance sheet, because bookkeeping rules did not require the partnership to list its debts as belonging to the parent company.

Adjustment to Bad Debt Reserve

Deregulation also allowed company accountants to exercise other kinds of accounting creativity. A second creative maneuver is called adjustment to bad debt reserve [11]. Instead of manipulating the

recording of future profits, as mark to marketing accounting does, adjustment to bad debt reserve uses a stroke of the pen to make up for company shortfalls. Specifically, the provision allows a company accountant to represent part of the reserve fund, which the company sets aside in case some of its creditors default, as profit. Thus, in a quarter in which the company's earnings threaten not to reach the figure growth analysts have projected, company accountants can move part of its reserve into its profit column simply by deciding that fewer creditors are likely to default in this quarter. Like mark to marketing accounting, adjustment to bad debt reserve helps a CEO back-in to his company's projected earnings figure, and since the number of defaulters is always an estimate, the new number, which is also an estimate, is no more intrinsically accurate or flawed than the old one. In the long run, of course, if it becomes obvious that a company has not produced the earnings it recorded, it has to restate or reclassify its numbers, and when it does so, investors typically punish it severely. On June 28, 2002, for example, when Xerox announced that it was reclassifying $6.4 billion in revenue from the 1990s, its share price fell sharply. In the last twenty years the number of such restatements has risen dramatically: in 1981 three companies had to restate their earnings; in 2001 one hundred fifty-eight companies were forced to do so [16].

Derivatives

Thus far the role that mathematics has played in these financial instruments has been as much inspirational as practical: people tend to believe that numbers embody objectivity even when they do not see (or understand) the calculations by which particular numbers are generated. In my final example, mathematical principles are still invisible to the vast majority of investors, but mathematical equations become the prime movers of value. The belief that makes it possible for mathematics to generate value is not simply that numbers are objective but that the market actually obeys mathematical rules. The instruments that embody this belief are futures options or, in their most arcane form, derivatives.

In the simplest terms, derivatives are contracts with fixed expiration dates whose price is determined by the value of some underlying asset, like the price of a currency or a megawatt hour [17]. Instead of representing the ownership of some commodity as shares do, derivatives represent wagers on the direction that prices for some commodity will take: up or down. Derivatives can be used for hedging, for speculation, or for both. An options trader can sell a derivatives contract before the date of expiration or simply allow the option to expire; the trader makes this decision not so much by observing the direction of prices as by assessing the mathematical probability that the price will rise or fall enough to make the wager profitable. Derivatives do not involve the exchange of principal; most of them are traded over the counter (not on any public exchange), and because a trader initially puts down only a small percentage of the contract cost (the good faith deposit or the initial margin), an extraordinary degree of financial leverage is attached to futures and derivatives. Because of their notional quality and because of the secrecy in which they are typically traded, the volume of derivatives is difficult to measure; but taking currency trades, one of their most common forms, as an index, we can begin to glimpse their size. The International Bank of Settlements estimates that in 2001 the total value of derivatives contracts traded approached one hundred trillion dollars, which is approximately the value of the total global manufacturing production for the last millennium. In fact, one reason that derivatives trades have to be electronic instead of involving exchanges of capital is that the sums being circulated exceed the total quantity of the world's physical currencies [18].

Futures trading probably originated in seventeenth-century Japan, but modern futures and derivatives differ from their predecessors in that modern derivatives articulate a set of mathematical equations, computed electronically, that objectify and price risk. The mathematical analysis that made it possible to price risk was first developed in the 1950s as part of Henry Markowitz's innovative approach to investing called portfolio theory. Markowitz argued that one could quantify risk if one conceptualized it as the magnitude of price swings around a mean; the variance in returns on assets can thus be plotted, and one can assemble a portfolio of stocks that will allow large returns while minimizing risk. According to portfolio theory, "high variance, or excessive risk, [is] something to be avoided. The conclusion of portfolio theory, now emblazoned in the mantra to 'diversify,' is that the return on a diversified portfolio will be the average volatility of these holdings" [19, p. 28].

For the next twenty years financial experts refined Markowitz's formula for pricing risk. In 1973 two economists produced a set of equations, the Black-Scholes equations, that provided the first strictly quantitative instrument for calculating the prices of options in which the determining variable is the volatility of the underlying asset. These equations enabled analysts to standardize the pricing of derivatives in exclusively quantitative terms. From this point it was no longer necessary for traders to evaluate individual stocks by predicting the probable rates of profit, estimating public demand for a particular commodity, or subjectively getting a feel for the market. Instead, a futures trader could engage in trades driven purely by mathematical equations and selected by a software program. These

trades can take several forms [20]. In the strategy called spread trading, for example, the trader buys one contract and sells another for the same commodity at the same time. Since one contract will typically make money and the other lose, the trader tries to get the spread, or the difference between the two contracts' prices, to work in his favor. A derivatives trader can also hedge investments with a straddle, which enables the trader to buy a call (buy) and a put (sell) option on the same underlying investment at the same strike price, thus enhancing the probability that the trader will make money whether the price goes up or down. Or a trader can use a strangle, by buying a call and a put on the same underlying investment with different strike prices, each of which is far enough from the market price to make it statistically improbable that the option will be exercised. If someone does exercise an option the trader sold, the trader can then meet the ensuing obligation by exercising another option already purchased.

Unlike all of the other financial instruments I have discussed, futures and derivatives options do not need to use representations about future or current earnings to make other investors believe and buy. As I have already argued, these other instruments have to inspire belief in investors because those investors' purchases drive the price of shares up or down and thus enhance or deflate the value of one's own shares and stock options. Even if futures and derivatives options do not depend upon inspiring belief in earnings figures, however, they do depend upon belief. Futures and derivatives trading depends upon the belief that the stock market behaves in a statistically predictable way, in other words, that mathematical equations accurately describe the market. Never mind that another set of numbers shows that these equations do not seem to work very well: these statistics reveal that between 75 percent and 90 percent of all futures traders lose money in any given year [20, p. 313]. Whatever the money lost or gained, the belief that the market is statistically predictable drives the mathematical refinement, and this belief inspires derivatives trading to escalate in volume every year.

Conclusion

One appeal of applying mathematical equations to equities trading is that the pricing model provided by equations like the Black-Scholes equations enables the financial community to disaggregate the economic and financial components of commerce and to reassemble from these parts new financial products that combine different risk profiles. These products can then be bought and sold in a bewildering variety of forms and in almost unlimited quantity. What often goes unremarked, however, is that these innovations are producing alongside new trading instruments concepts that are also new or that rework familiar concepts that used to drive investment. Take risk, for example. Risk used to be viewed as uncertainty about the future, an irrational factor that one sought to protect against. Now that risk has been objectified, divided, and reassembled so that it can be traded, it becomes mathematically predictable—that is, rational, abstract, and subject to management through devices like the straddle and the strangle [19].

The use of mathematical equations to generate value is also producing a new temporality. This new temporality is end-stopped (like the life of an options contract) and short term (like the duration of an options "future"). It is also abstract, homogeneous, and self-referential. Time is reworked in this way because in order to price a derivative, the mathematical model has to assume that no unprecedented economic events or conditions will intervene or disrupt the pattern graphed by statistical probability. In other words, in order to work, the mathematical model must assume that a limited and stable set of factors will be at work in the market and that these will generate a normal distribution about a mean; to limit factors that might prove disruptive—to set the a priori conditions for the mathematical equation—some analyst has to establish the beginning and end of a given temporal sequence. He does so by mathematically projecting these points backward and forward from the present. Thus the past and the future resemble and refer to the present in the abstract sense that they are mathematical (logical) projections of it.

Like the other trading instruments I have described, then, derivatives and futures options are conflations of representation and exchange, for the representations of time and risk implicit in these trades create a purely notional trading environment whose only existence is electronic. Nevertheless, these electronic trades can have very real effects, as we have seen with the bankruptcies of Enron and WorldCom. When all of the financial instruments I have described are used together, as they typically are in sophisticated financial institutions, they mobilize both of the beliefs I have described: the belief that numbers are objective and true, and the belief that the market conforms to mathematically produced statistical probabilities. Thus executives at companies like Enron manipulated investors' faith in future profits by backing-in to earnings reports whose figures matched the numbers growth analysts supplied: they issued thousands of stock options to entice other executives to help pump up share prices, they used off-balance-sheet partnerships to book future profits as current gains and to keep debt off their books,

and they used derivatives to hedge their positions and to gamble on making enormous profits.

At the time Enron was doing all this, of course, all of these instruments, including derivatives, were perfectly legal [21]. Derivatives were developed, in fact, specifically to take advantage of deregulation, which also permitted creative accounting to flourish. To this day derivatives remain largely unregulated, for they are too large, too virtual, and too complex for industry oversight boards to police. In 1997–8 the FASB did try to rewrite the rules governing the recording of derivatives, but in the long run they failed: in the 1999–2000 session of Congress, lobbyists for the accounting industry persuaded Congress to pass the Commodities Futures Modernization Act, which exempted or excluded over-the-counter derivatives from regulation by the Commodity Futures Trading Commission, the federal agency that monitors the futures exchanges. Currently, only banks and other financial institutions are required by law to reveal their derivatives positions, and Enron, which never registered as a financial institution, was never required to disclose the extent of its derivatives trading [22].

Taken as an ensemble, all of the financial instruments I have described contribute to the axis of power I invoked at the beginning of this essay. This axis is difficult to police, because it is not centered in any nation state or subject to any transnational regulatory body. It is difficult to track because its effects are so dispersed and ramified and because these effects do not always serve a single or identifiable interest. Deploying mathematical equations through the hair-trigger connectivity of the Internet to move international financial markets, this axis is everywhere and nowhere at once. Even if it is difficult to monitor or see, however, this financial axis wields terrific power—and not just in the realm of the economy. As it reworks the relationship between temporality and value, it also redefines labor, agency, and responsibility. In the new culture of finance, value can be created without labor, agency is transferred to an unstable mixture of mathematical equations and beliefs, and responsibility for disasters is pinned on an individual (a "bad apple") or simply dispersed as analysts blame their investors' losses on flawed computer programs or unforeseeable market forces.

Very few people inside or outside the global financial community question whether the foundational assumptions implicit in financialization are true [23]. In the light of exposures of corporate greed in 2002, investors have begun to suspect that numbers do not always embody objectivity, but few have stopped to question the assumptions that make the largely unseen world of derivatives work: the assumptions that the market obeys the logic of statistical probability and that the estimates that mathematical equations silently make do not matter. But what if markets are too complex for mathematical models? What if irrational and completely unprecedented events do occur, and when they do—as we know they do—what if they affect markets in ways that no mathematical model can predict? What if the regularity that all mathematical models assume effaces social and cultural variables that are not subject to mathematical analysis? Or what if the mathematical models traders use to price futures actually influence the future in ways the models cannot predict and the analysts cannot govern? Perhaps these are the only questions that can challenge the financial axis of power, which otherwise threatens to remake everything, including value, over in the image of its own abstractions. Perhaps these are the kinds of questions that mathematicians and humanists, working together, should ask and try to answer.

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WHAT IS . . .

a Shtuka?

David Goss

Shtuka is a Russian word colloquially meaning "thing". Spelled *chtouca* in the French literature, a mathematical shtuka is, roughly speaking, a special kind of module with a Frobenius-linear endomorphism (as explained below) attached to a curve over a finite field. Shtukas came from a fundamental analogy between differentiation and the p-th power mapping in prime characteristic p. We will follow both history and analogy in our brief presentation here, with the hope that the reader will come to some appreciation of the amazing richness and beauty of characteristic p algebra.

Additive Polynomials

Let L be a field in characteristic p (so L is some extension field of the finite field $\mathbb{F}_p = \mathbb{Z}/(p)$). The binomial theorem implies that the p-th power mapping $\tau(x) := x^p$ satisfies $\tau(\alpha+\beta) = \tau(\alpha)+\tau(\beta)$ for α and β in L (the coefficients of the mixed terms are 0 in L); thus $\tau^j(\alpha+\beta) = \alpha^{p^j} + \beta^{p^j} = \tau^j(\alpha)+\tau^j(\beta)$ for any $j \geq 0$. We view the mappings $x \mapsto \tau^j(x)$ as operators on L and on its field extensions. A *polynomial in* τ is an expression $p(\tau) := \sum_{j=0}^{m} c_j \tau^j$ with $\{c_j\} \subseteq L$; so $p(\tau)(x) = \sum_{j=0}^{m} c_j x^{p^j}$. Like τ and τ^j for $j \geq 0$, the function $x \mapsto p(\tau)(x)$ is an additive map. Thus its kernel, the roots of $p(\tau)(x)$ in a fixed algebraic closure $\bar{L}$ of L, is a finite-dimensional $\mathbb{F}_p$-subspace of $\bar{L}$. The set of polynomials in τ, denoted $L\{\tau\}$, is a left L-vector space and forms a ring under *composition*; notice that $\tau \cdot (c\tau) = c^p\tau^2$, so this ring is not commutative in general. The analogy with the ring of complex differential operators in one variable, which becomes clear with a little thought, motivated much early work of O. Ore, E. H. Moore, and others.

Drinfeld Modules

To define a Drinfeld module we need an algebra A which will play the same role in the characteristic p theory as the integers $\mathbb{Z}$ play in classical arithmetic. For simplicity of exposition we now set $A = \mathbb{F}_p[T]$, the ring of polynomials in one indeterminate T. Let L be as above. A *Drinfeld A-module* ψ of rank d over L [Dr1] is an $\mathbb{F}_p$-algebra injection $\psi: A \to L\{\tau\}$ such that the image of $a \in A$, denoted $\psi_a(\tau)$, is a polynomial in τ of degree d times the degree of a with $d > 0$. Note that ψ is uniquely determined by $\psi_T(\tau)$ and therefore d is a positive integer. Moreover, there is a homomorphism ι from A to L defined by setting $\iota(a)$ equal to the constant term of the polynomial $\psi_a(\tau)$. Drinfeld modules are similar to elliptic curves in that they possess division points (= zeroes of $\psi_a(\tau)(x)$ for $a \in A$), Tate modules, and cohomology. Moreover, like elliptic curves, Drinfeld modules arise analytically (i.e., over the complete field $\mathbb{F}_p((1/T))$) from "lattices" via an exponential function (which is an entire $\mathbb{F}_p$-linear function $e(\tau) = \sum_{j=0}^{\infty} b_j \tau^j$).

A Bit of Algebraic Geometry

For simplicity again, we now assume that L is an algebraically closed field. Consider the projective line $\mathbb{P}^1$ over L. An *affine open subspace* U of $\mathbb{P}^1$ is $\mathbb{P}^1$ minus a finite *nonempty* collection of points. There is a large ring $\Gamma(U)$ of rational functions with no poles in U. A *locally free sheaf* of rank d on $\mathbb{P}^1$ over L is an assignment of a free $\Gamma(U)$-module of rank d to *each* affine open subspace U in a way which is consistent with respect to the restriction of one affine open subspace to another. Notice that the rational functions with no poles anywhere on $\mathbb{P}^1$ are the elements of L, and there are far too

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few of these to classify locally free sheaves. There is, however, a very clever dictionary between the locally free sheaves and certain *graded* modules which arise from homogeneous coordinates (see, e.g., §II.5 of R. Hartshorne's book *Algebraic Geometry*).

Shtukas

In his study of the Korteweg de Vries equation, I. M. Krichever found a remarkable dictionary between certain sheaves on curves and subalgebras of $\mathbb{C}[[t]][d/dt]$ (see, e.g., [M1]). The analogy between τ and d/dt inspired V. G. Drinfeld to look for a similar construction involving Drinfeld modules; the resulting sheaves will give us the shtuka. Let our field L now be equipped with a Drinfeld module ψ of degree d. We make $M := L\{\tau\}$ into a module over $L \otimes_{\mathbb{F}_p} \mathbb{F}_p[T] \simeq L[T]$ as follows: Let $f(\tau) \in M$, $l \in L$, and $a \in A = \mathbb{F}_p[T]$; we then put

$$l \otimes a \cdot f(\tau) := lf(\psi_a(\tau))$$

(so that elements of $\mathbb{F}_p[T]$ always act via the ψ-action). Using a right division algorithm, one shows readily that M is a free $L[T]$-module of rank d. However, M is much richer than $L[T]^d$ because M also has the left action of τ via multiplication in $L\{\tau\}$. This action is *Frobenius-linear*, as $\tau(l \cdot m) = l^p \cdot \tau(m)$ for $l \in L$ and $m \in M$.

The module M possesses a gradation given by the degree (in τ) of an element $f(\tau)$. The action of $L[T]$ given above clearly preserves this gradation. Define $M_j := \{f(\tau) \in M \mid \deg_\tau f(\tau) \le j\}$, $\mathcal{M} := \oplus_{j=0}^{\infty} M_j$, and $\mathcal{M}[1] := \oplus_{j=0}^{\infty} M_{j+1}$. Both $\mathcal{M}$ and $\mathcal{M}[1]$ are graded modules over the graded ring constructed from $L[T]$ in the same fashion as $\mathcal{M}$, and they fit into the dictionary mentioned in the preceding section. Thus both $\mathcal{M}$ and $\mathcal{M}[1]$ give rise to locally free sheaves of rank d on $\mathbb{P}^1$ over L, which we denote by $\mathfrak{M}$ and $\mathfrak{M}'$ respectively. The mapping which injects M_j into M_{j+1} gives an injection λ of $\mathfrak{M}$ into $\mathfrak{M}'$. Moreover, multiplication by τ gives an injection of $\mathfrak{M}$ into $\mathfrak{M}'$ which is Frobenius linear over each affine open subspace. We encapsulate all this by

$$\mathfrak{M} \xhookrightarrow{\lambda} \mathfrak{M}' \xhookrightarrow{\tau} \mathfrak{M}. \tag{1}$$

Diagram (1) is the "shtuka associated to ψ". The cokernel of λ gives rise to trivial modules on affine open subspaces *not* containing the point $\infty \in \mathbb{P}^1$, and the cokernel of τ also gives rise to trivial modules on affine open subspaces not containing a point lying over the prime $\ker \iota$ of A. These are naturally called the "pole" and the "zero" of the shtuka.

When $d = 1$, the locally free sheaves are called "line-bundles", and they come from divisors. Using the Riemann-Roch Theorem and a result of Drinfeld, one can show that the shtuka actually arises from a function on $\mathbb{P}^1$ over L [Th1]. For instance, the function associated to the rank 1 Drinfeld module C given by $C_T(\tau) := \tau$ is just T itself!

While we have worked here with $A = \mathbb{F}_p[T]$, in fact *all* of the above goes through readily when A is replaced by the affine algebra of an arbitrary smooth projective curve X over a finite field minus a fixed closed point. All of the salient issues are touched on in the simple case sketched here. The collection of those algebraic functions on X with poles of finite order forms a field k called the "function field of X". Such function fields are the analogs in finite characteristic of "number fields" defined by adjoining to the rational numbers $\mathbb{Q}$ a finite number of roots of polynomials with rational coefficients. Modern number theory is concerned with the properties of *both* types of fields.

The general notion of a shtuka, which has been crucial to the work of Drinfeld and L. Lafforgue on the Langlands conjectures for k (see [L1] and its references), is just the abstraction of (1) to families $U \times X$ where U is a scheme in characteristic p (see, e.g., [L1]). Moreover, it is possible to describe which shtukas arise from Drinfeld modules (see, e.g., [M1]).

τ-Sheaves

Over the affine line inside $\mathbb{P}^1$ over L, both $\mathfrak{M}$ and $\mathfrak{M}'$ reduce to M itself. The $L[T, \tau]$-module M is called by G. Anderson the "motive of ψ" in *analogy* with the classical theory of motives, and its abstraction to families is called "τ-sheaves". It turns out that τ-sheaves are the correct notion with which to describe characteristic-p-valued L-functions (D. Wan–Y. Taguchi, G. Böckle–R. Pink, F. Gardeyn, G. Böckle) and to study special values of characteristic-p-valued Γ-functions (G. Anderson–W. D. Brownawell–M. Papanikolas). Moreover, τ-sheaves are naturally associated to characteristic-p-valued cusp forms (G. Böckle), much as one associates elliptic curves (and other classical motives) to elliptic cusp forms. Shtukas, and τ-sheaves, are such fundamental ideas that the process of mining their riches is really just beginning!

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Book Review

Indra's Pearls: The Vision of Felix Klein

Reviewed by Albert Marden

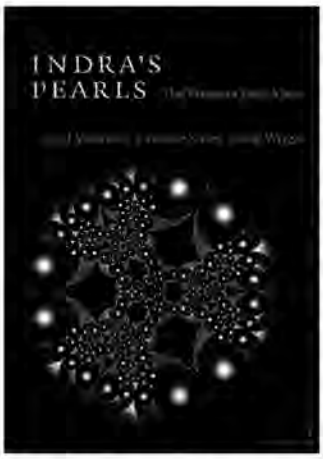
Indra's Pearls: The Vision of Felix Klein
David Mumford, Caroline Series, David Wright
Cambridge University Press, New York, 2002
$50.00, ISBN 0-521-35253-3

It has been a great pleasure to read such a gracefully written, original book of mathematics. Ignoring the mathematics, one can enjoy *Indra's Pearls* as an art book displaying deeply hidden fractal shapes—magical, mysterious, and beautiful.

The authors introduce from scratch a range of topics relevant to the central theme, including

- complex numbers,
- groups of symmetries,
- Möbius transformations,
- combinatorics and number theory of the modular group,
- geometric group theory,
- fractal geometry.

In a nutshell, the book is a walkabout in the space of two-generator Schottky groups and their various degenerations. Discrete groups of Möbius transformations, in particular Schottky groups, act not only on the extended complex plane but on upper half 3-space as well. A discrete group is always associated with a 3-manifold (or orbifold) and is often in addition associated with a surface or surfaces that form the boundary of the 3-manifold. The action



of most groups cannot be fully understood without involving the associated 3-manifolds. Yet it is completely appropriate that in their presentation, the authors have stuck to the group action on $\mathbb{S}^2$; to have done otherwise would have opened a Pandora's box which would have been inconsistent with the elementary nature of the exposition. However, I will describe their work from the more general perspective. I will also round out some of the historical references.

A two-generator Schottky group is associated with a surface of genus two that bounds a handlebody. If one imagines a surface of genus two smoothly embedded in $\mathbb{R}^3$, the region it encloses is called a handlebody of genus two. In fact, two-generator Schottky groups are perhaps the simplest class of "nonelementary" discrete groups. Yet typical phenomena that occur when working with more complicated groups already appear in the two-generator Schottky case and, because of the low dimension, can be fully exhibited on the computer monitor. That is why this is the perfect class to explore visually. The most interesting phenomena occur after the groups are geometrically "degenerated" in certain ways.

Indra's Pearls is a tale of Möbius transformations,

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The author thanks Dick Canary for news of late-breaking developments and Allyn Jackson for editorial assistance.

$$A: z \mapsto \frac{az+b}{cz+d}, \quad ad-bc \neq 0.$$

The Möbius transformations comprise the class of conformal mappings of $\mathbb{C} \cup \infty \equiv \mathbb{S}^2$ onto itself. Each transformation A is associated with a matrix

$$A = \pm \begin{pmatrix} a & b \\ c & d \end{pmatrix} \in \mathrm{SL}(2,\mathbb{C}),$$

normalized so that $ad - bc = 1$. The complex number $a + d$ (defined up to the factor ± 1) is called the *trace of* A.

A Möbius transformation is the composition of an even number of reflections in circles and lines. Being such, it has a natural extension to upper half 3-space. Upper halfspace, endowed with its hyperbolic metric, is a model of hyperbolic 3-space $\mathbb{H}^3$. The totality of extensions form the full group of orientation-preserving isometries of $\mathbb{H}^3$. The subgroup of Möbius transformations that in addition preserve the upper halfplane comprise the group of orientation-preserving isometries of hyperbolic 2-space $\mathbb{H}^2$.

A Möbius transformation, other than the identity, is classified as *elliptic* if conjugate to $z \mapsto e^{i\varphi} z$ with $\varphi \not\equiv 2\pi$, *parabolic* if conjugate to $z \mapsto z + 1$, and *loxodromic* if conjugate to $z \mapsto ke^{i\varphi} z$, $k > 1$. It is those loxodromics with $\varphi \not\equiv 0$ that are responsible for the spirals that are so decorative in the limit sets (see Figure 2).

A discrete group G of Möbius transformations is called a *kleinian group*. If in addition it preserves the upper halfplane (or any disk in $\mathbb{S}^2$), it is called a *fuchsian group*. The *limit set* $\Lambda(G)$ is the set of accumulation points of the orbit of any point O in upper halfspace; the limit set lies in $\mathbb{S}^2$. The group G is called *elementary* if it is a finite group or if $\Lambda(G)$ consists of one or two points. For nonelementary groups, as all the groups we consider will be, the limit set is a closed perfect set in which the loxodromic fixed points are dense. The parabolic fixed points, if any, are dense as well. The complement $\Omega(G) = \mathbb{S}^2 \setminus \Lambda(G)$ is called the *set of discontinuity* or *regular set*. It is the largest open set in $\mathbb{S}^2$ in which G is properly discontinuous.

A two-generator Schottky group is a group G that arises from four mutually disjoint circles, $\{C_1, C_1'; C_2, C_2'\}$, bounding mutually disjoint disks in $\mathbb{C}$. Choose any Möbius transformation that sends the interior of C_i onto the exterior of its partner C_i', $i = 1, 2$, and label the pair A, B. The group $G = \langle A, B \rangle$ so generated is discrete and free. Its limit set $\Lambda(G)$ is totally disconnected with positive Hausdorff dimension and zero area ("fractal dust"). It corresponds to the "boundary" of the Cayley graph of G: each limit point is the limit of a sequence of nested circles. Therefore each limit point corresponds to a unique infinite word in four letters: the two generators plus their inverses. The common exterior of the four circles is a fundamental tile for the action of G on $\Omega(G)$.

Actually the group G so constructed is nowadays called a *classical Schottky group*. This is to distinguish it from the geometrically similar groups where the Schottky circles C_i no longer exist but are replaced by noncircular Jordan curves. Recent work of Hidalgo-Maskit has clarified how this distinction arises.

The quotient $S(G) = \Omega(G)/G$ is a Riemann surface of genus two (see Figure 1); the quotient $\mathcal{M}(G) = (\Omega(G) \cup \mathbb{H}^3)/G$ is a handlebody of genus two, as is a pretzel. Its interior $\mathbb{H}^3/G$ is complete in the projected hyperbolic 3-metric.

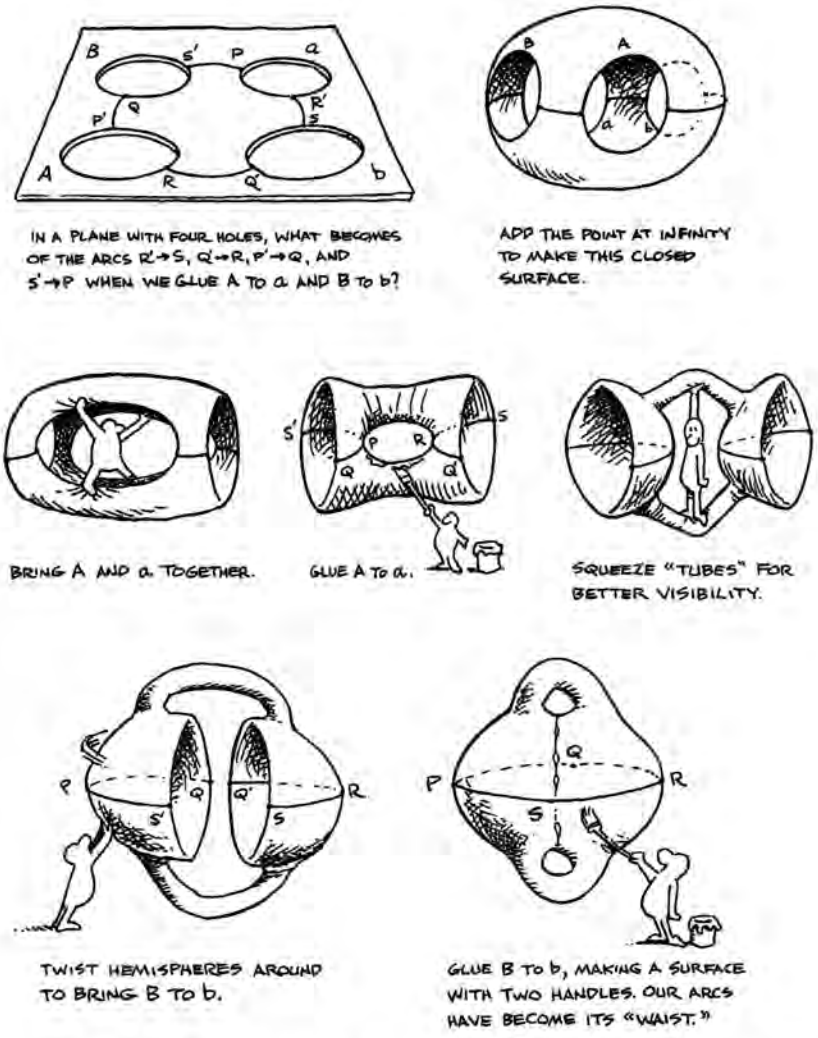

Figure 1. Dr. Stickler is gluing together each pair of Schottky circles so that their common exterior becomes a surface of genus 2 (Fig. 6.15 in the book). Here A, $a = A^{-1}$, B, $b = B^{-1}$ are the generators.

To begin the process of degeneration, find a simple loop $\gamma \subset S(G)$ that divides the surface into two tori, each with one boundary component, yet does *not* bound a topological disk within $\mathcal{M}(G)$.[1] "Pinch" the surface $S(G)$ along γ. This process yields a sequence of isomorphisms onto Schottky groups $\{\theta_n : G \to G_n\}$. The isomorphisms converge to an isomorphism $\theta : G \to G^*$ in the sense that for each generator $A, B \in G$, $\lim \theta_n(A) = \theta(A) = A^*$ exists, and likewise $\theta(B) = B^*$, while G^* is the group generated by these two limits. Such convergence, that is, convergence of generators, is called *algebraic convergence*. If $g \in G$ is an element corresponding to γ, then $\theta(g)$ is parabolic. This means that the commutator $[A^*, B^*]$ is parabolic if A, B are suitably chosen.

In the Hausdorff topology, $\lim \Lambda(G_n) = \Lambda(G^*)$. Instead of one infinitely connected component, $\Omega(G^*)$ has two simply connected components, $\Omega_{top}(G^*)$, $\Omega_{bot}(G^*)$. Each is invariant under the full group G^*. Their quotients, $S_{top}(G^*) = \Omega_{top}(G^*)/G^*$, $S_{bot}(G^*) = \Omega_{bot}(G^*)/G^*$, are once-punctured tori. To complete the picture, the quotient hyperbolic 3-manifold is a product $\mathcal{M}(G^*) \cong S_{bot}(G^*) \times [0, 1]$. Customarily, one of the components of $\partial\mathcal{M}(G^*)$ is referred to as the "top" and the other, the "bottom", as has already been suggested.

With this first pinch we arrive at the class of pinched Schottky groups of the type of G^*. Reverting to the original notation, this is the class of two generator, free, discrete groups of the form $G = \langle A, B \rangle$, where A, B are loxodromic but their commutator $[A, B] = ABA^{-1}B^{-1}$ is parabolic, and $\Omega(G)$ has two simply connected components, each invariant under G. Such a group is called a *quasifuchsian group* because it is the image of a fuchsian group under a quasiconformal mapping. The collection $\mathcal{QF}$ of such groups, modulo conjugation, comprises the *quasifuchsian once-punctured torus space*. The groups depend on two complex parameters that may be taken essentially as the traces of A and B; correspondingly, $\mathcal{QF}$ is a 2-dimensional complex manifold.

In the book this new class first appears by having the four Schottky circles become tangent—or, as the authors say, "kiss"—so as to form a circular quadrilateral. Each pairing transformation A, B must be chosen so as to fix the appropriate point of tangency. The result is called a "kissing Schottky group", and the resultant geometric picture in $\mathbb{C}$ is called "Indra's necklace" (Figures 6.16, 6.1). It is shown how the tangent circles give rise to a tiling of the two domains of discontinuity. In parallel, the authors explain how the "boundary" of the Cayley graph and the limit set congeal to become topological circles. This is because the initial loxodromic commutator becomes parabolic in the limit, fusing two fixed points into one.

Quasifuchsian space $\mathcal{QF}$ is naturally embedded as an open, connected, proper subset of the representation variety $\mathcal{R}(G)$ in $\mathrm{PSL}(2, \mathbb{C})$, modulo conjugation, where $\mathcal{R}(G)$ is formed subject to the restriction that the commutator must remain parabolic. As such, $\mathcal{QF}$ has a relative boundary $\partial\mathcal{QF}$. There are a countable number of special points on the boundary called *cusps*. These correspond to groups with new parabolics and, more particularly, are of the type of H_1 and H_2, to be introduced below.

By the mid-1970s, Troels Jorgensen had worked out a complete picture of $\mathcal{QF}$. He showed that the space can be described in terms of the combinatorics of the faces of the isometric (Ford) fundamental polyhedron for each group. To date, most of his work has not been published, yet it has become widely known and successfully applied, most recently by Makato Sakuma and colleagues to problems concerning 2-bridge knots. Jorgensen gave an alternate description of $\mathcal{QF}$ in terms of a "triangle graph": Each vertex represents a generator, and two generators represent the same vertex if and only if they are equal or inverses, modulo conjugations. Each edge represents a generator pair. The traces of the three vertices of a triangle are related by the Markoff identity. Jorgensen represented his triangle graph in the modular tessellation[2] so that the vertices can be indexed by the Farey series and continued fractions. Jorgensen proved that the Ford polyhedron $\mathcal{P}$ meets each component Ω_{top}, Ω_{bot} in a circular polygon. He associated each of these two polygons with a triangle in his graph and then chose the minimal triangle strip in the graph joining the two triangles. Amazingly, the labeling of this strip not only describes the combinatorics of the faces of $\mathcal{P}$ but also reveals the group element associated with each face. Singly or doubly degenerate groups correspond to half-infinite or infinite geodesic strips. In this theory, the possible geometric limits[3] at a

[1] *Much later, in Chapter 8 (see Figure 8.20), an entirely different degeneration is introduced (called a Riley group): the two generators A, B become parabolic. The corresponding 3-manifold is the connected sum of two pinched solid tori: glue together two bagels with defective holes.*

[2] *The reference is to the famous tiling of the upper half-plane by the orbit of two adjacent ideal triangles under the level 2 congruence subgroup of the modular group, itself a pinched Schottky group, and the Farey series description of its ideal vertices.*

[3] *The sequences can be chosen to converge not only algebraically in the generators to a cusp group G^* but also* geometrically *in that the quotient manifolds converge to the manifold of a Kleinian group $H \supset G^*$. H will be strictly larger if the algebraic convergence to G^* is "tangential".*

cusp, including nonfinitely generated groups, can be deduced from the finite strip representing the cusp.

In particular, Jorgensen recognized that cyclic extensions H^* of certain of his boundary groups H—doubly degenerate groups corresponding to periodic infinite geodesic strips—give rise to manifolds $\mathcal{M}(H^*)$ that are fibered over the circle, with fibers being once-punctured tori. The discovery was a surprise; some had doubted the existence of such hyperbolic manifolds. For one of these groups,[4] H_0, $\mathcal{M}(H^*)$ is homeomorphic to the figure-8 knot complement. This is a consequence of the fact that H^* is conjugate to the group Bob Riley had earlier discovered to be a representation of the figure-8 knot group; this was one of the knot and link groups for which he had found representations in $\mathrm{PSL}(2,\mathbb{C})$. The group H_0 is the doubly degenerate example presented in the book.

Understanding of $\mathcal{QF}$ (and of deformation spaces for general groups) has dramatically increased in recent years. The manifold interiors $\mathbb{H}^3/H$ corresponding to all boundary groups $H \in \partial\mathcal{QF}$, as is the case for groups of $\mathcal{QF}$, are topological products $S \times (0,1)$, where S is a once-punctured torus (Thurston, Bonahon). McMullen showed that the limit set of any $H \in \partial\mathcal{QF}$ is locally connected. McMullen, Canary-Hersonsky proved that cusps are dense there. It follows from the ending lamination conjecture for $\mathcal{QF}$—proved by Yair Minsky, with additional results of Brock, Bromberg, Canary, and Minsky—that any group that "should be" on $\partial\mathcal{QF}$ by virtue of the product topology of its quotient actually is.

We can now do some more pinching. Take any simple loop γ_b in, say, $S_{bot}(G)$ not contractible to a point or a puncture, and "pinch" again. We get an algebraically convergent sequence of quasifuchsian groups, ending up with a group H_1 with the following property. In the limit, the top surface $S_{top}(H_1)$ remains a once-punctured torus. However, $S_{bot}(H_1)$ has become *the* 3-punctured sphere.[5]

Up in $\mathbb{S}^2$ there is still a component $\Omega_{top}(H_1)$ of $\Omega(H_1)$ that is simply connected and invariant under the full group H_1. In place of Ω_{bot} there is a countable union of disks, each preserved by a subgroup of H_1 conjugate to the famous level-two congruence subgroup of the modular group.

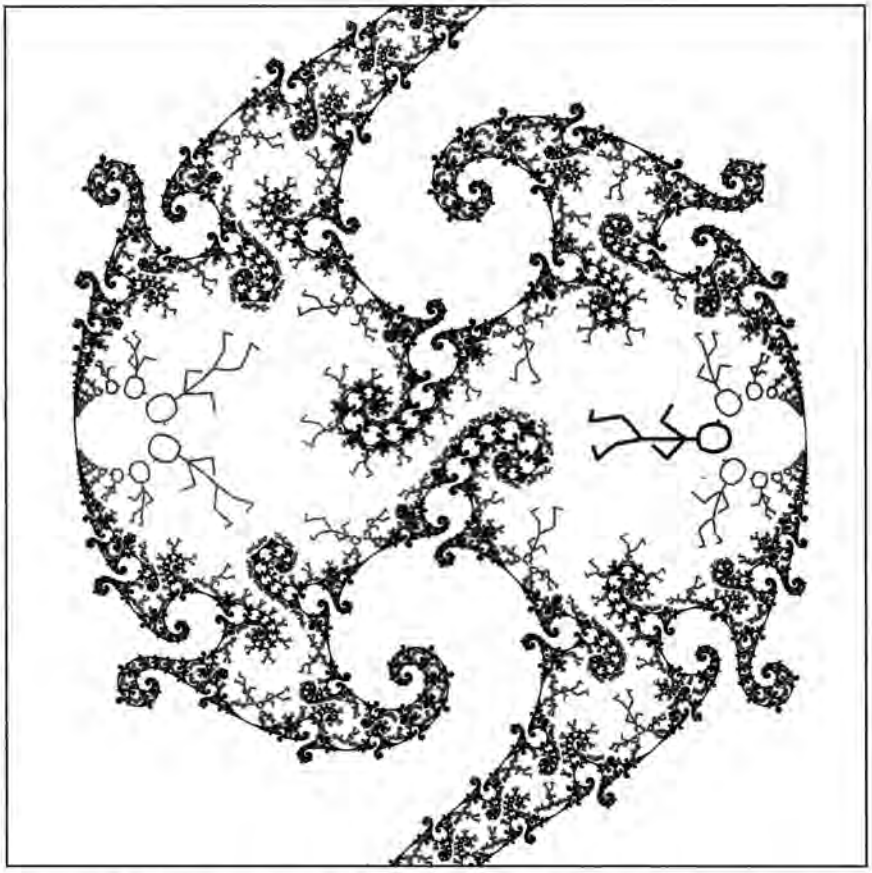

Figure 2. A blow-up of part of the limit set of a once-punctured torus quasifuchsian group. Dr. Stickler is shown being carried around one component of the regular set by the group action (Fig. 8.6 in the book).

The cusp group H_1 itself has a 1-dimensional complex deformation space $\mathcal{QF}_1$, called a *Maskit slice*; S_{bot}, the 3-punctured sphere, is fixed, while the once-punctured torus S_{top} is allowed to vary over all possibilities, making the slice a representative of the once-punctured torus Teichmüller space. There are countably many ways to pinch S_{bot}, and each way gives rise to a "slice".[6] The space $\mathcal{QF}_1$ is the quasiconformal deformation space of H_1. It is not composed of quasifuchsian groups; rather $\mathcal{QF}_1 \subset \partial\mathcal{QF}$. The modular tessellation provides a model for the boundary $\partial\mathcal{QF}_1$, with the Farey series used to index the cusps.

For Teichmüller theory the most useful slices have been the *Bers slices* that are submanifolds of $\mathcal{QF}$. The closure of a Bers slice is homeomorphic to a disk, whereas the closure of a Maskit slice is homeomorphic to a disk minus a boundary point (Minsky). A Bers slice is determined by fixing the conformal type of the once-punctured torus S_{bot} while allowing S_{top} to vary. McMullen showed that cusps are dense on its boundary. Computing a Bers slice is more difficult, since doing so involves

[4] *Actually the group H_0 first appeared, not in Jorgensen's* Annals *paper (as suggested in the book), which featured a family of degenerate groups with elliptic commutators, but in a somewhat later, related paper with the reviewer.*

[5] *There is only one 3-punctured sphere in the sense that any two are Möbius equivalent.*

[6] *There are also slices based on a singly degenerate S_{bot}.*

The Mathematical Cartoonist

The cartoons in *Indra's Pearls* are the creation of freelance cartoonist Larry Gonick. That they convey mathematical ideas so well is no accident: Gonick was once on track to become a mathematician, studying mathematics as an undergraduate and graduate student at Harvard University in the 1960s and 1970s. Today he is known for his wacky, brainy cartoons about science, mathematics, and history.

Gonick began his cartooning career with *Blood from a Stone: A Cartoon Guide to Tax Reform* (New York Public Interest Research Group, 1972), written with Steve Atlas. "It was the dullest subject my coauthor could think of, so it needed cartoons," Gonick remarked. He went on to write political and historical cartoons for Boston newspapers. He moved to San Francisco in 1977 and fell in with the world of "underground comics", a genre exemplified by the work of R. Crumb. Starting in the early 1980s, Gonick coauthored a series of cartoon guides to such subjects as genetics, physics, and the computer. The bestseller of the series is *The Cartoon Guide to Statistics* (HarperCollins, 1994) by Gonick and Woollcott Smith, which has been widely used as a classroom supplement and as a training tool in industry. Gonick has also written a series of cartoon histories; the most recent is the third volume of *The Cartoon History of the Universe* (W. W. Norton), which appeared in fall 2002.

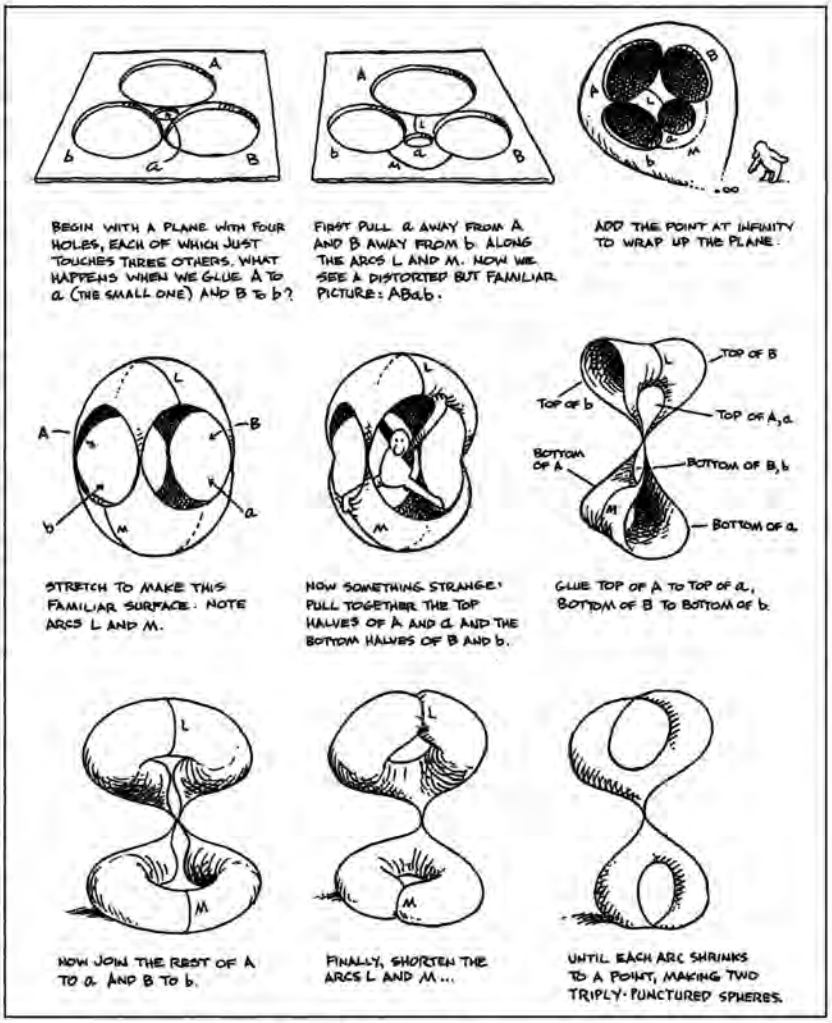

Figure 3. Dr. Stickler is showing how a pair of thrice-punctured spheres is obtained from the exterior of four Schottky "kissing circles" (Fig. 7.7 in the book).

While in college, Gonick got to know David Mumford, one of the authors of *Indra's Pearls*. The two reconnected when Gonick spent 1994–95 as a Knight Science Journalism Fellow at the Massachusetts Institute of Technology, and they collaborated on software designed to visualize four-dimensional space. A few years later, Mumford told Gonick that the 20-year-long project of writing *Indra's Pearls* was finishing up and sent him a copy of the manuscript. "I looked at it and I thought, 'No way,'" Gonick recalled. "If it took them twenty years to do this, it would take them another seven years to finish it. It turned out [Mumford] was right, and I was wrong." Mumford asked Gonick to do some cartoons for the book, and Gonick agreed.

Mumford would send Gonick sketches outlining the ideas the cartoons were supposed to convey. Gonick's use of the figure of "Dr. Stickler" adds a human touch to the drawings and conveys a tactile sense of movement. For example, the first cartoon in the book shows how to make a torus out of a square by identifying the opposite sides of the square. By having Dr. Stickler manipulate the square, with a little pot of glue at hand to stick the sides together, Gonick just about eliminates the possibility that a reader could get confused. The cartoons are not merely accurate; they are perhaps the best way of giving the reader intuition about topological ideas.

The humor and whimsy in the cartoons are not add-ons but derive from the nature of mathematics. During his stint drawing two-page cartoon strips for the science magazine *Discover*, Gonick created several strips based on mathematical ideas, such as transparent proofs, factoring, and DNA computation. The editors did not give him a hard time about strips on deep mathematics. "I was usually able to convince them that the more recherché the subject, the better the strip," he recalled. "Sometimes they would come in with ideas for the strip that were based on the kookiness of an experiment, and I'd say, 'No, there's not enough humor in the experiment being kooky.' There has to be some deep principle at work. That's where the humor comes from."

—Allyn Jackson

numerically solving Schwarzian equations and computing monodromy; nevertheless, this has recently been done by the team of Komori, Sugawa, Wada, and Yamashita.

Return to the group H_1 obtained by pinching $S_{bot}(G)$ and the Maskit slice $\mathcal{QF}_1$ that it determines. We can pinch once more, heading off to a cusp on $\partial\mathcal{QF}_1$: Choose any simple loop $\gamma_t \subset S_{top}(H_1)$ that is not in any parabolic conjugacy class; in particular, γ_t and γ_b do not determine the same conjugacy class within H_1. Pinch γ_t. We end up with a group $H_2 \in \partial\mathcal{QF} \cap \partial\mathcal{QF}_1$ such that not only Ω_{bot} but now also Ω_{top} has become a countable union of round disks. Topologically, the interior $\mathbb{H}^3/H_2$ remains homeomorphic to $S \times (0,1)$, with S a once-punctured torus, while $\partial\mathcal{M}(H_2)$ is the union of two 3-punctured spheres (see Figure 3). The group H_2 is rigid; it cannot be deformed (modulo Möbius equivalence). The limit set $\Lambda(H_2)$ is the union of circles and limits of circles. Particularly significant in understanding the limit set are the parabolic fixed points; these are the points of tangency of the circles.

The authors introduce groups of the type H_2 by means of the *Apollonian gasket*, represented in Figure 7.3 as a beautiful "glowing gasket." It is constructed by means of a symmetric arrangement of the four "kissing circles", which determines three circular triangles. The cartoon Figure 3 well displays the process of pinching leading to a double cusp group.

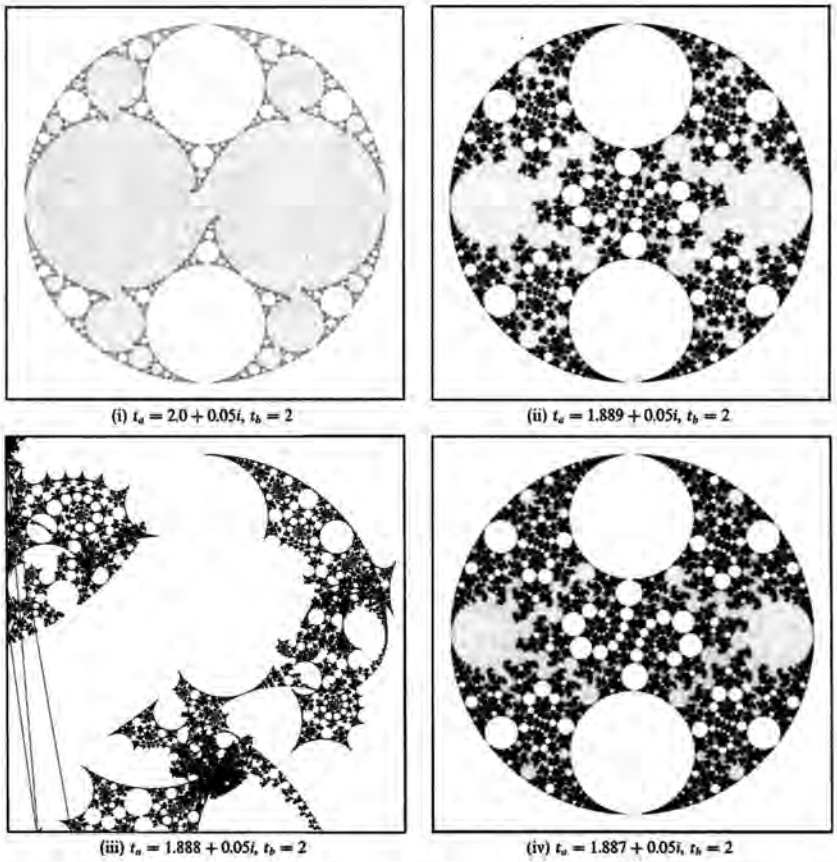

Figure 4. Exploring a Maskit slice $\mathcal{QF}_1$ near a double cusp group of type H_2 on $\partial\mathcal{QF}_1$. The group whose limit set is (i) is close to H_2 while in (iii) the group is just outside $\mathcal{QF}_1$ and is not discrete. The parameters t_a, b_b are traces of generators (Fig. 8.15 in the book).

The first seven chapters (two-thirds of the book) consist of introductory material and detailed discussion of a number of typical examples. Included is a very clear presentation of the modular tessellation and Farey series with related continued fraction expansion. Later in the book it is explained how the rational numbers correspond to slopes of simple curves on a torus and words in the generators.

Chapter 8 begins by introducing a number of parameter systems, involving the trace of two felicitously normalized generators, for $\mathcal{QF}$. These are used to roam about the space, with particular attention paid to the effect on the pictures of changing the generator traces. We find out how to "tighten the spirals" (Figure 8.13) and "raise a crop of spirals" (Figure 8.23). The subtle matter of visualizing "thin necks" is addressed (Figure 8.17). We learn how to estimate the Hausdorff dimension of the limit set. And we are led out to "single cusps" of the type H_1 and "double cusps" of the type H_2 on the boundary.

Chapter 9 is devoted to exploring the boundary of a Maskit slice. Guided by the Farey series indexing of the cusps (now of type H_2), the boundary is traced out. The Schottky heritage of these cusps is still evident in the form of "smushed" Schottky circles (Figure 9.5). In describing the cusps the authors use the term "accidental parabolic", which has come into common use for a "new" parabolic that arises in a boundary group. This is unfortunate terminology, because building and finding such groups is anything but "accidental".

Chapter 10 fills out our knowledge of a Maskit slice boundary. We have a look at the boundary itself and notice its self-similarity (Figure 10.3). We are shown how to approach an irrational (non-cusp) boundary point by a sequence of double cusp groups. We are shown two examples of *singly degenerate groups* (Figures 10.4, 10.6), with indication of how the degeneration of the regular set has occurred: In these examples the top punctured torus boundary component of the 3-manifold has vanished completely, leaving the triply punctured sphere on the bottom. The limit set now has Hausdorff dimension two (Bishop-Jones) but still no interior. In fact, the double cusps of type H_2 are dense on $\partial\mathcal{QF}_1$ (Canary-Culler-Hersonsky-Shalen), and all the other boundary groups are singly degenerate.

We are taken back to quasifuchsian space $\mathcal{QF}$ for an approximation to the *doubly degenerate group* H_0. It is found as the limit of a cleverly symmetrized sequence of double cusp groups on $\partial\mathcal{QF}$. Here both once-punctured tori components of the 3-manifold have vanished. The limit set has become $\mathbb{S}^2$ itself; an approximation appears in Figure 10.1. One finds the original structure buried in the limit set as the lift to $\mathbb{H}^3$ of each fiber $S \times \{x\}$ determines a space-filling curve on $\mathbb{S}^2$ (Cannon-Thurston). By the use of the group, the authors show how to partition $\mathbb{S}^2$ in a way to reflect its Schottky heritage.

Lest the reader come away with the idea that he has understood everything, the final examples should dispel any such thought. There is a striking example of a geometric limit properly containing the algebraic limit at a double cusp (Figure 10.16). Jorgensen's theory could be repeated by requiring the commutator $[A, B]$ to be elliptic of finite order rather than parabolic. Figure 11.1 is an example of a cusp group of this type. For this example the Schottky circles intersect at 45° (Figure 11.2). To cope with the group theoretical complications in developing an algorithm to compute the limit set of such a group, the authors introduce the theory of automatic groups. In this respect, they use a program of Derek Holt that has implemented the theory.

It makes a huge difference that the pictures are of the highest resolution and quality in that we have a clear view for long distances into the fine detail of the limit sets. The many diagrams are drawn with great care, both as to visual impact and to their content. The colorations are not only artful but are used to bring out special mathematical properties.

The authors intend that the book be read and understood by a broad audience, by everyone who is comfortable with high school algebra. A broad audience could certainly understand the earlier chapters. The complexity builds up slowly; techniques and ideas are explained from first principles as they are introduced. But toward the end, less mathematically experienced readers might need help. In the academic world the book could be used as the basis of a college course on "chaos and fractals", or read as an introduction to group actions, or read just for enjoyment by graduate students and, not least, by professors. At the end of each chapter there is a well-chosen set of problems called "projects" that provides the reader with hands-on experience with the theory.

An important aspect of the book is its inclusion of pseudocode which in principle will allow a savvy programmer, or "hacker", to explore for himself the space of these groups. But even a reader who is not interested in computing will find the pseudocode essential in understanding how the pictures are made. The computational aspect is a natural vehicle to draw those with hacker ambition into the mathematical content. Conversely, a mathematical reader who has become intrigued while reading about the subject may be enticed to make his own computer explorations.[7]

Indra's Pearls is not written in the theorem/proof style of a mathematics textbook. Rather, it is a flowing narrative, leavened with wit, whimsy, and lively cartoons by Larry Gonick. A delightful quotation highlights a theme for each chapter. For example, Chapter 3 begins with a quote from Lewis Carroll:

> First accumulate a mass of Facts: and *then* construct a Theory.
>
> *That*, I believe is the true Scientific Method.
>
> I sat up, rubbed my eyes, and began to accumulate Facts.

The chosen style exposes the authors' own love of, and long experience with, the subject, which they have made a great effort to communicate.

The heaven of the great Buddhist god Indra is said to be an infinite web strung with pearls. In each pearl all the others are reflected, in each reflection the infinite number of pearls is seen again. Indra's universe is seen in each pearl and seen over and over again on smaller and smaller scales; the metaphor of the title anticipates the geometry. The three authors, with the support of Cambridge University Press, have produced a book that is as handsome in physical appearance as its content is stimulating and accessible. The book is an exemplar of its genre and a singular contribution to the contemporary mathematics literature.

Note: All figures from *Indra's Pearls* have been reprinted with the permission of Cambridge University Press.

[7] *Masaaki Wada has built a publicly available Mac program, OPTi, which allows the user to explore $\mathcal{QF}$, as parameterized by Jorgensen's "complex probabilities". OPTi in particular indicates the Ford polyhedron corresponding to each point of $\mathcal{QF}$. For information on OPTi, see* `http://vivaldi.ics.nara-wu.ac.jp/~wada/OPTi/index.html`.

On the Work of Madhu Sudan

Avi Wigderson

Madhu Sudan is the recipient of the 2002 Nevanlinna Prize. Sudan has made fundamental contributions to two major areas of research, the connections between them, and their applications.

The first area is coding theory. Established by Shannon and Hamming over fifty years ago, it is the mathematical study of the possibility of, and the limits on, reliable communication over noisy media. The second area is probabilistically checkable proofs (PCPs). By contrast, it is only ten years old. It studies the minimal resources required for probabilistic verification of standard mathematical proofs.

My plan is to briefly introduce these areas, their motivation, and foundational questions and then to explain Sudan's main contributions to each. Before we get to the specific works of Madhu Sudan, let us start with a couple of comments that will set up the context of his work.

- Madhu Sudan works in computational complexity theory. This research discipline attempts to rigorously define and study *efficient* versions of objects and notions arising in computational settings. This focus on efficiency is of course natural when studying computation itself, but it also has proved extremely fruitful in studying other fundamental notions such as proof, randomness, knowledge, and more. Here I will try to explain how the efficiency "eyeglasses" were key in this study of the notions proof (again) and error correction.
- Theoretical computer science is an extremely interactive and collaborative community. Sudan's work was not done in a vacuum, and much of the background to it, conceptual and technical, was developed by other people. The space I have does not allow me to give proper credit to all these people. A much better job has been done by Sudan himself; his homepage (`http://theory.lcs.mit.edu/~madhu/`) contains several surveys of these areas which give proper historical accounts and references. In particular see [13] for a survey on PCPs and [15] for a survey on the work on error correction.

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Probabilistic Checking of Proofs

One informal variant of the celebrated $\mathcal{P}$ versus $\mathcal{NP}$ question asks, Can mathematicians, past and future, be replaced by an efficient computer program? We first define these notions and then explain the PCP theorem and its impact on this foundational question.

Efficient Computation

Throughout, by an *efficient* algorithm (or program, machine, or procedure) we mean an algorithm which runs at most some fixed polynomial time[1] in the *length* of its input. The input is always a finite

[1] *Time refers to the number of elementary steps taken by the algorithm. The choice of "polynomial" to represent efficiency is both small enough to often imply practicality and large enough to make the definition independent of particular aspects of the model, e.g., the choice of allowed "elementary operations".*

string of symbols from a fixed, finite alphabet. Note that an algorithm is an object of fixed size which is supposed to solve a problem on all inputs of all (finite) lengths. A problem is *efficiently computable* if it can be solved by an efficient algorithm.

Definition 1. *The class $\mathcal{P}$ is the class of all problems solvable by efficient algorithms.*

For example, the problems Integer Multiplication, Determinant, Linear Programming, Univariate Polynomial Factorization, and (recently established) Testing Primality are in $\mathcal{P}$.

Let us restrict attention (for a while) to algorithms whose output is always "accept" or "reject". Such an algorithm A solves a *decision* problem. The set L of inputs which are accepted by A is called the *language* recognized by A. Statements of the form "$x \in L$" are correctly classified as "true" or "false" by the efficient algorithm A, deterministically (and without any "outside help").

Efficient Verification

In contrast, allowing an efficient algorithm to use "outside help" (a guess or an alleged proof) naturally defines a proof system. We say that a language L is *efficiently verifiable* if there is an efficient algorithm V (for "Verifier") and a fixed polynomial p for which the following completeness and soundness conditions hold:

- For every $x \in L$ there exists a string π of length $|\pi| \leq p(|x|)$ such that V accepts the joint input (x, π).
- For every $x \notin L$, for every string π of length $|\pi| \leq p(|x|)$, V rejects the joint input (x, π).

Naturally, we can view all strings x in L as theorems of the proof system V. Those strings π which cause V to accept x are legitimate proofs of the theorem $x \in L$ in this system.

Definition 2. *The class $\mathcal{NP}$ is the class of all languages that are efficiently verifiable.*

It is clear that $\mathcal{P} \subseteq \mathcal{NP}$. Are they equal? This is the "$\mathcal{P}$ versus $\mathcal{NP}$" question [5], one of the most important open scientific problems today. Not only mathematicians but scientists and engineers as well daily attempt to perform tasks (create theories and designs) whose success can hopefully be efficiently verified. Reflect on the practical and philosophical impact of a positive answer to the question: if $\mathcal{P} = \mathcal{NP}$, then much of their (creative!) work can be performed efficiently by one computer program.

Many important computational problems, like the Travelling Salesman, Integer Programming, Map Coloring, Systems of Quadratic Equations, and Integer Factorization are (when properly coded as languages) in $\mathcal{NP}$.

We stress two aspects of efficient verification. The purported "proof" π for the statement "$x \in L$" must be short, and the verification procedure must be efficient. It is important to note that all standard (logical) proof systems used in mathematics conform to the second restriction: since only "local inferences" are made from "easily recognizable" axioms, verification is always efficient in the total length of statement and proof. The first restriction, on the length of the proof, is natural, since we want the verification to be efficient in terms of the length of the statement.

An excellent, albeit informal, example is the language MATH of all mathematical statements, whose proof verification is defined by the well-known efficient (anonymous) algorithm REFEREE.[2] As humans we are simply not interested in theorems whose proofs take, say, longer than our lifetime (or the three-month deadline given by EDITOR) to read and verify.

But is this notion of efficient verification—reading through the statement and proof, and checking that every new lemma indeed follows from previous ones (and known results)—the best we can hope for? Certainly as referees we would love some shortcuts as long as they do not change our notion of mathematical truth too much. Are there such shortcuts?

Efficient Probabilistic Verification

A major paradigm in computational complexity is allowing algorithms to flip coins. We postulate access to a supply of independent unbiased random variables which the *probabilistic* (or randomized) algorithm can use in its computation on a given input. We comment that the very rich theories (which we have no room to discuss) of pseudo-randomness and of weak random sources attempt to bridge the gap between this postulate and "real-life" generation of random bits in computer programs.

The notion of efficiency remains the same: probabilistic algorithms can make only a polynomial number of steps in the input length. However, the output becomes a random variable. We demand that the probability of error, on *every* input, never exceed a given small bound ϵ. (Note that ϵ can be taken to be, e.g., $1/3$, since repeating the algorithm with fresh independent randomness and taking majority vote of the answers can decrease the error exponentially in the number of repetitions.)

Returning to proof systems, we now allow the verifier V to be a probabilistic algorithm. As above, we allow it to err (namely, accept false "proofs") with extremely small probability. The gain would be extreme efficiency: the verifier will access only a *constant* number of symbols in the alleged proof. Naturally, the positions of the viewed symbols can

[2] *This system can, of course, be formalized. However, it is better to have the* social *process of mathematics in mind before we plunge into the notions of the next subsection.*

be randomly chosen. What kind of theorems can be proved in the resulting proof system? First, let us formalize it.

We say that a language L has a *probabilistically checkable proof* if there is an efficient probabilistic algorithm V, a fixed polynomial p, and a fixed constant c for which the following completeness and probabilistic soundness conditions hold.

- For every $x \in L$ there exists a string π, of length $|\pi| \leq p(|x|)$, such that V accepts the joint input (x, π) with probability 1.
- For every $x \notin L$, for every string π of length $|\pi| \leq p(|x|)$, V rejects the joint input (x, π) with probability $\geq 1/2$.
- On every input (x, π), V can access at most c bits of π.

Note again that executing the verifier independently a constant number of times will reduce the "soundness" error to an arbitrarily small constant without changing the definition. Also note that randomness in the verifier is essential if it probes only a constant (or even logarithmic) number of symbols in the proof. The reader may verify that such deterministic verification can exist only for easy languages in $\mathcal{P}$.

Definition 3. *The class $\mathcal{PCP}$ is the class of all languages that have a probabilistically checkable proof.*

The main contribution of Sudan and his colleagues to this area is one of the deepest and most important achievements of theoretical computer science.

Theorem 1. (The PCP Theorem [2, 1]). $\mathcal{PCP} = \mathcal{NP}$.

In words, *every* theorem that can be efficiently verified can also be verified probabilistically by viewing only a *fixed number* of bits of the purported proof. If the proof is correct, it will *always* be accepted. If it is wrong (in particular, when the input statement is not a theorem, all "proofs" will be wrong), it will be rejected with high probability despite the fact that the verifier hardly glanced at it.

The proof of the PCP theorem, from a very high-level point of view, takes a standard proof system (a problem in $\mathcal{NP}$) and constructs from it a very robust proof system. A correct proof in the former is transformed to a correct proof in the latter. A false "proof" in the former (even if it has only one bug in a remote lemma, to use the refereeing metaphor again) is transformed to a "proof" littered with bugs, so many that a random sample of a few bits would find one.

This conversion appears related to error-correcting coding (which is our second topic), and indeed it is. However, it is quite a bit more, as the encoded string has a "meaning": it is supposed to be a proof of a given statement, and the coding must keep it so.

The conversion above is efficient and deterministic. So in principle an efficient program can be written to convert standard mathematical proofs to robust ones which can be refereed in a jiffy.

The PCP theorem challenges the classical belief that proofs have to be read and verified fully for one to be confident of the validity of the theorem. Of course one does not expect the PCP theorem to dramatically alter the process of writing and verifying proofs (any more than one would expect automated verifiers of proof systems to replace the REFEREE for journal papers). In this sense the PCP theorem is just a statement of philosophical importance. However, the PCP theorem does have significant implications of immediate relevance to the theory of computation, and we explain this next.

Hardness of Approximation

The first and foremost contribution thus far to understanding the mystery of the $\mathcal{P}$ versus $\mathcal{NP}$ question was the discovery of $\mathcal{NP}$-completeness and its ubiquity by Cook, Levin, and Karp in the early 1970s.

Roughly speaking, a language is $\mathcal{NP}$-complete if it is the hardest in the class $\mathcal{NP}$. More precisely, a language L is $\mathcal{NP}$-complete if *any* efficient algorithm for it can be used to efficiently solve every other language in $\mathcal{NP}$. Note that by definition every $\mathcal{NP}$-complete language is as hard to compute as any other. Moreover, $\mathcal{P} = \mathcal{NP}$ if and only if any $\mathcal{NP}$-complete language is easy, and $\mathcal{P} \neq \mathcal{NP}$ if and only if any $\mathcal{NP}$-complete language is hard.

As it turns out, almost every language known in $\mathcal{NP}$ is known to be either $\mathcal{NP}$-complete or in $\mathcal{P}$. The great practical importance of the $\mathcal{P}$ versus $\mathcal{NP}$ question stems from the fact that numerous outstanding problems in science and engineering turn out to be $\mathcal{NP}$-complete. For computer programmers or engineers required by their boss to find an efficient solution to a given problem, proving it $\mathcal{NP}$-complete is the ultimate excuse for not doing it; after all, it is as hard as all these thousands of other problems which scientists in various disciplines have attempted unsuccessfully.

Knowing the practical world, we suspect that the boss would not be impressed. In real life we need to solve impossible problems too. To do that, we reduce our expectations! An almost universal situation of this type is some optimization problem for which finding the *optimal solution* is $\mathcal{NP}$-complete or harder. In this situation the boss would ask for an efficient algorithm for some "reasonable" *approximation* of the optimal solution. Many success stories exist; an important example is the efficient algorithm for approximating (by any constant factor > 1) the volume of a convex body of high dimension. What about failure? Does the theory of $\mathcal{NP}$-completeness provide any excuses to our poor programmers if they fail again?

For twenty years there was essentially no answer to this question. The complexity of approximation problems was far from understood. It was clear that this area is much richer/murkier than that of decision problems. For illustration, consider the following three optimization problems.

- **Linear Equations:** Given a system of n linear equations, say over the finite field $GF(2)$, determine the maximal number that can be satisfied simultaneously.
- **Set Cover:** Given a collection of subsets of a given finite universe of size n, determine the size of the smallest subcollection that covers every element in the universe.
- **Clique:** Given a finite graph on n vertices, find the size of the largest subset of vertices which are pairwise connected by edges.

For each of these problems, finding the optimal solution is $\mathcal{NP}$-complete. Some naive approximation algorithms have existed for a long time, and no one could improve them. They yield completely different approximation factors.

- **Linear Equations:** A random assignment will satisfy on average half the equations, so it is at most a factor 2 from optimal. Try beating it.
- **Set Cover:** A simply greedy algorithm, collecting subsets so that the next one covers as many yet uncovered elements as possible, will be a factor $\ln n$ from optimal. Try proving it.
- **Clique:** A trivial solution is a 1-vertex clique, which is within a factor n of optimal. Somewhat more elaborate algorithms give a factor $n/(\log n)^2$. Think it pathetic? Try improving it to (the still pathetic?) $n^{0.999}$.

The PCP theorem, as well as many other technical developments of Sudan and other researchers, has paved the way to an almost complete understanding of how well we can approximate different natural optimization problems efficiently. These developments vary PCPs in many ways and study many other "resources" of the proof verification process, beyond the number of queries to the proof and the error probability. In particular, as the following three different theorems show, the trivial approximation algorithms above are essentially the best possible.

- **Linear Equations:** Approximation by a factor of $2-\epsilon$ is $\mathcal{NP}$-hard[3] for every $\epsilon > 0$ [11].
- **Set Cover:** Approximation by a factor of $(1-\epsilon)\ln n$ is $\mathcal{NP}$-hard for every $\epsilon > 0$ [6].
- **Clique:** Approximation by factor of $n^{1-\epsilon}$ is $\mathcal{NP}$-hard for every $\epsilon > 0$ [10].

[3] *We use "hard" rather than "complete", as these problems are not languages in $\mathcal{NP}$ as defined above (but they can be so defined). The meaning remains: an efficient algorithm for the problem would yield $\mathcal{P} = \mathcal{NP}$.*

The connection between PCPs and the hardness of approximation was established in [7]. The basic idea is the following: The PCP theorem provides a natural optimization problem which cannot be efficiently approximated by any factor better than 2. Namely, fix a verifier V (and thus a language L it accepts, as in the PCP theorem). Given x, find the maximum acceptance probability of V on x by any proof π. Clearly, by the definition of probabilistic verification, beating a factor of 2 efficiently means distinguishing between those $x \in L$ and those $x \notin L$. By the theorem, L can be any problem in $\mathcal{NP}$, so such an efficient approximator would yield $\mathcal{P} = \mathcal{NP}$.

This optimization problem serves the same purpose that the satisfiability of Boolean formulae served when discovered as the first $\mathcal{NP}$-complete language. From then on efficient reductions, namely, transformations of one problem to another, could be used to prove completeness. Here, too, reductions are used to get the above theorems on hardness of approximation. However, these reductions are far more intricate than for decision problems; the difference in approximability of these different problems is but the first indication of the richness and complexity of this area.

List Decodable and Implicit Error-Correcting Codes

Unique Decoding

You have some precious information, which you may want to store or communicate. It is represented, say, by K symbols from some fixed alphabet Σ. To protect any part of it from being lost, you are prepared to store/communicate it with redundancy, using N symbols of the same alphabet. Then it will be subject to (a process we view as) an adversary who may destroy or change, say, T of the symbols in the encoding. A decoding process must then be able to recover the original information.

This scenario is the core of a multitude of practical devices you use—CDs, satellite transmissions, Internet communications, and many others. The problem of determining the best achievable relationships between the parameters K, N, and T was raised by Hamming about fifty years ago. In a slightly different scenario, when changes are random, it was raised even earlier by Shannon. The variety of related models and problems constitute the large and active field of coding theory and its close relative, information theory.

Once again, efficiency requirements enrich the problems tremendously. It was only a few years ago that optimal *codes* (having linear-time encoding and decoding algorithms) were developed. These nearly match Shannon's completely nonconstructive bounds and apply as well to the Hamming problem (on which we focus from now on for simplicity).

One central feature of this huge body of work was its focus on *unique decoding*: you want to recover the original information when the corrupted codeword defines it unambiguously. This requires that the encoding of *any* two information words differ in at least $2T+1$ positions.

Is there a meaning to useful decoding when the Hamming distance (the number of differing symbols) is less than $2T+1$ and ambiguity is unavoidable? Can one achieve it efficiently? Why bother?

List Decoding

The questions above were pondered in the past decades. It was realized that ambiguous decoding would be useful if the decoding process generated a short *list* of candidates, one of which is the original information. Moreover, it was realized that *in principle* such a short list exists even if distances between pairs of encodings are close to T. This answers the "why bother?" question immediately: this would drastically improve the ratio between K and N (in this area constant factor improvements are "drastic"). But no nontrivial code was known to support such decoding even remotely efficiently.

Sudan's extremely elegant algorithm to list-decode Reed-Solomon codes completely changed the situation. It started a snowball rolling which transformed large areas in this field in a matter of two years, again led by Sudan and his colleagues. Moreover, once discovered, these codes were applied to solve theoretical problems, mainly within complexity theory, providing completely different answers (that we mention later) to the "why bother?" question.

The Reed-Solomon codes, the old result about unique decoding, and Sudan's result on list-decoding should appeal to any mathematician, whether interested or not in error correction. Here is the setup; the reader can easily relate the parameters below to those above.

Fix a finite field F and an integer $d \le |F|$. My information is a degree d polynomial p over F, and I encode it simply as a table of the values of p on all elements of F. Now suppose an adversary changes the table, the only restriction being to leave at least t of the $|F|$ positions in agreement with p. Can p be recovered from the table efficiently?

For unique decoding, namely, for the table to uniquely define one polynomial, clearly we need $t > |F|/2$ (otherwise we could fill half the table with the values of one polynomial, p_1, and the other half with values of a different polynomial, p_2). When $d < |F|/2$, this bound turns out to be not only necessary but also sufficient!

Theorem 2 [12]. *There is an efficient algorithm that recovers p from any table that agrees with p on $t > |F|/2$ elements of F.*

Note that the decoding problem is a nonlinear one and brute-force search takes time about $|F|^d$, which is prohibitive when d is large. The algorithm above, polynomial in $|F|$ and d, uses (efficient) univariate polynomial factoring over F. Sudan's algorithm uses factorization of bivariate polynomials to list-decode even if the fraction of agreement goes to zero with $|F|$!

Theorem 3 [14, 9]. *There is an efficient algorithm which, for every $\epsilon > \sqrt{d/|F|}$, recovers a list of $O(1/\epsilon^2)$ polynomials containing p from any table that agrees with p on $t > \epsilon|F|$ elements of F.*

Put differently, given *any* function g from F to itself, this algorithm *efficiently* recovers *all* degree d polynomials which agree with g on $\epsilon|F|$ arguments.

Implicit Codes

So we have codes (for unique and list decoding) that achieve near-optimal parameters in wide ranges and whose encoding and decoding takes linear time—essentially the time to read the input and write down the output. What more can we want? The answer is, try to use sublinear time: some root of the input length; better, a logarithm of it; or, even better, constant time, independent of the input length!

If you consider the amounts of data biologists and astronomers have to understand and explain or the amounts of data on the World Wide Web from which we want to gather some useful information, you will realize that sublinear algorithms which look at only a tiny fraction of the data are in vast demand. If you consider the way we search through a phone book or gather simple statistics via sampling, you will realize that at least for very simple tasks such algorithms exist. The importance of such algorithms has made this area grow in recent years, with many more examples of sophisticated algorithms for far less trivial tasks.

Computational complexity suggests a natural way to represent huge objects. A basic object is a function, and a basic representation for it is a program that computes it. Returning to the coding problem, think of K (and hence of N) as being so large that we have neither room nor time to write it down explicitly. The K information symbols we wish to encode are given by a program P which on input at position $i < K$ gives the value of the ith information symbol. Note that such a program can be extremely succinct: it can have size exponentially smaller than K.

The encoder will take P and produce another program Q of the same type; on input $j < N$ it will output the jth symbol in the encoding. Now assume an adversary changes Q to yield a Q' that agrees

with Q only on some small fraction of the inputs. Can we recover P in any reasonable sense? The appropriate sense suggests itself: we should construct a small program P' that for any input $i < K$ may query Q' in a few places and then output the correct ith information symbol. In the list-decoding case, we may provide a few such programs, one of which does the job *for every* i.

Amazingly enough, this can be done! Sudan and his colleagues have provided a strong positive answer to this challenge. Stated informally, what they have done is to construct codes in which such implicit decoding can be done very efficiently. The new programs use very few queries to the corrupted program Q', even if it agrees with Q only on a vanishingly small fraction of the domain. (See [16] for full definitions and statements of results.)

A moment's reflection will convince you that in this setting the recovered programs have to be probabilistic, as otherwise the adversary would know in advance which values of Q' will be queried and will change only them. However, as usual, correct output is guaranteed with arbitrarily high probability.

Applications, Connections, and Techniques

The applications of these results far exceed the domain of error correction. Let me mention a few directly affected areas, without getting into details.

- Program Testing [4]: The ability to design robust programs whose correctness on single inputs can be automatically verified.
- Hardness Amplification [16]: The ability to efficiently convert functions which are hard on rare inputs to functions which are hard on random inputs. Such conversions are important to cryptography and to pseudorandom number generation.
- Computational Learning Theory [8]: Some of the results above can be interpreted as learning concepts from a few examples.
- Probabilistic Proof Systems [3]: The reader may have noticed that the probabilistic verifier in PCPs is a prime example of an algorithm which looks at only a tiny part of its input. These implicit and list-decodable codes play an essential role in the design of PCPs, as well as in other important proof systems not mentioned here.

To conclude, we mention that these topics illuminate the power of algebra in computer science. Many of the constructions use algebraic objects (and theorems about them). The efficient use of these objects often calls for sophisticated algorithms to manipulate them. Again, this has been a major endeavor on the boundary between algebra and computer science, with many other applications and with cross-fertilization in both directions. A look at his home page (`http://theory.lcs.mit.edu/~madhu/`) reveals not only the extent to which Sudan was part of this research but also his investment in collecting, clarifying, and conveying this knowledge in teaching and writing.

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ICM 2002 in Beijing

The 2002 International Congress of Mathematicians (ICM), held in Beijing, China, August 20–29, 2002, was full of firsts. It was the first time an ICM was held in a developing country. It was the first time the top governmental official of the host country came to the ICM opening ceremonies. And for many of the mathematicians attending the congress, it was their first trip to China; even for those who had been to China before, the tremendous changes the country has gone through in recent years made it seem like a new place. The warmth and enthusiasm of the Chinese organizers reflected not only the country's long-standing reverence for learning and knowledge but also its recognition that strengthening China's scientific research capacity is critical to the country's future development. "This was a very special and indeed unique ICM," said Jacob Palis, president of the International Mathematical Union.

With 4,260 registered participants, this was the largest ICM ever held. A total of forty-six satellite conferences—also a record number—drew about 4,000 participants, half of whom also attended the congress. The satellite conferences were held all over Asia, including in Shanghai, Tianjin, Hanoi, Kyoto, Lhasa, Macau, and Taipei; one was even held in Moscow. About half the ICM participants were from developing countries, including about 1,700 Chinese mathematicians. Around US$126,000 collected through donations by AMS members went toward travel grants that allowed about eighty young mathematicians from developing countries to attend the ICM. The congress was held at the Beijing International Convention Center, located in the northern part of the city near the sports complex built for the Asian Games that were held in Beijing in 1990.

Throughout the congress there were clear signs of the significance China attached to the ICM. One example was the opening ceremonies, held in the Great Hall of the People in Tiananmen Square; were Washington, DC, the host city, this would be equivalent to holding the opening ceremonies in the Capitol building. A convoy of about one hundred buses ferried participants and accompanying guests from the convention center to the Great Hall. Hundreds of police officers stationed on streets and highways, sometimes in locations that put their personal safety at risk, held back the city's teeming traffic to let the convoy through on the approximately 30-minute drive to the Great Hall.

Security in the Great Hall was tight, and all visitors had to pass through metal detectors; items like pocket knives were discovered and confiscated, to be returned at the end of the ceremonies. Participants were given assigned seats in the auditorium, which can hold 10,000 people. In the balcony the crowd was filled out by a horde of Chinese school kids in T-shirts bearing the words "I want to be a mathematician". On the stage in the auditorium were various IMU dignitaries, a number of Fields Medalists, Nobel laureate John Nash, and members of the local organizing committees, as well as the congress president, Wenjun Wu of the Chinese Academy of Sciences, and honorary president, Shiing Shen Chern of the Nankai Institute of Mathematics. The crowd erupted in applause when Jiang Zemin, president of China, came

Left to right: Fields Medalist Vladimir Voevodsky, President of China Jiang Zemin, IMU President Jacob Palis, and Fields Medalist Laurent Lafforgue.

onto the stage and took his seat between Chern and Palis.

Jiang was originally trained as an electrical engineer and is said to have a keen appreciation of mathematics. Unlike what one might expect from a politician, he did not rush in to give a speech and rush out again. Rather, he sat and listened for ninety minutes. He stirred from his seat only to present the Fields Medals to Laurent Lafforgue of the Institut des Hautes Études Scientifiques and Vladimir Voevodsky of the Institute for Advanced Study in Princeton. At that moment, triumphal music played on the public address system as a crowd of photographers and camera operators surrounded the Fields Medalists and the president, making it impossible for the audience to see. The Nevanlinna Prize was treated as a lesser honor; it was presented to Madhu Sudan of the Massachusetts Institute of Technology not by the Chinese president, but by IMU secretary Phillip Griffiths without any accompanying music and without such a large phalanx of photographers.

In his speech at the opening ceremonies, Palis pointed out the significance of holding the ICM in a country that is home to one-quarter of all humanity. "This makes the ICM more inclusive, and inclusiveness is a basic principle of the IMU," he said. Others spoke of the need to improve the level of mathematics research in China as the country modernizes. In a speech on behalf of the Chinese government, vice premier Lanqing Li stated the government's aim to make the country into a world-class mathematical power in the early twenty-first century. Other speakers included the president of the China Association of Science and Technology and the mayor of Beijing. After a break, brief talks on the work of the Fields Medalists and the Nevanlinna Prize winner were presented: Gérard Laumon (Université de Paris-Sud) spoke about the work of Lafforgue, Christoph Soulé (Institut des Hautes Études Scientifiques) about the work of Voevodsky, and Shafi Goldwasser (Weizmann Institute of Science) about the work of Sudan. A "reception" after the opening ceremonies turned out to be an elaborate multicourse sit-down banquet for 5,000 people. For the bus trip back to the convention center, the police once again stopped traffic as night fell on the city.

Awash in Publicity

Because of the appearance of the president, the opening ceremonies were heavily covered by the Chinese media. But the media's interest did not stop there; according to Zhiming Ma of the Chinese Academy of Sciences, who served as chair of the ICM local organizing committee, Chinese television and newspapers began carrying mathematics-related stories when the satellite conferences began on August 10 and continued coverage throughout the congress. "They were very enthusiastic to report on the ICM," he noted. "The main purpose [of the ICM publicity effort] was to make the public aware that mathematics is important and has many applications in society. In this we were successful." There were several airings of television programs about Chern and about S.-T. Yau of Harvard University, who is the only Chinese Fields Medalist. Also appearing on television were the Chinese mathematician Gang Tian, who holds the J. Simons professorship at the Massachusetts Institute of Technology, and John Nash.

In fact, Nash's arrival at the congress headquarters hotel was a media event. Hours before, the hotel had laid down a red carpet stretching from the lobby to the elevators. To prevent it from getting dirty, the carpet was taped over with old tattered pieces of cloth, which were whisked away before Nash and his wife, Alicia, arrived. When they arrived bearing several bouquets of flowers that apparently had been presented to them at the airport, they were immediately besieged by photographers, camera operators, and technicians with klieg lights. Later on during the meeting Nash gave an evening lecture aimed at the general public, for which students began lining up an hour early in order to get good seats.

The esteem in which mathematicians were held was extraordinary. One ICM speaker, Gregory Lawler of Cornell University, did some tourism in Wuhan before arriving in Beijing. The tour guide had heard about the congress, and when she found out Lawler was one of the speakers, he recalled, "She apologized to me for not having treated me with more respect." Stephen Hawking, who came to China for a satellite conference, gave a public lecture in Beijing before the ICM and also met with President Jiang. News of Hawking's lecture spread widely: When he was in Taiyuan before the ICM, Tian chatted with a

car driver hired by the university there. The driver said he had given his son 1,000 yuan to travel to Beijing to hear Hawking's lecture. One thousand yuan, about US$125, could be a month's wages for this driver. "That kind of thing is not organized," Tian noted, but rather is a spontaneous reaction on the part of ordinary people. But are people simply dazzled by the fame and celebrity of someone like Hawking? "That is not the basic reason," Tian replied. "The basic reason is that people here pay a lot of respect" to those who have made great achievements in science.

As Tian pointed out, the Cultural Revolution of the 1960s and 1970s sought to destroy the Confucian tradition but did not succeed in eliminating it. The Confucian view that "study is above all else" remains strong in China today and is the source of the country's profound respect for intellectuals. Also, China has come to recognize that building its science and technology base is crucial for the country's future development. The government has selected a number of scientific areas to emphasize, one of them being mathematics. Part of the reason for choosing mathematics is the low cost of funding mathematics research, and part is the enabling role mathematics plays in science and technology. One sign the government is serious about this goal is the recent doubling of funding for mathematics research by the main Chinese science funding agency.

There are other indications in China of this new emphasis on mathematics. One is the governmental support for the ICM, which came to US$1.2 million, more than the organizers were originally promised (an ICM host country is expected to raise about $1 million). Through a program organized by the education ministry, Chinese scientists who work abroad are brought back to China for a few months a year to organize courses and to stimulate research; Tian participates in this program through Peking University. International mathematics institutes are growing: in addition to the Morningside Institute for Mathematics, which is part of the Chinese Academy of Sciences in Beijing, there is the Nankai Institute in Tianjin, where a new building is under construction and will be completed in fall 2004.

But the level of mathematics research in China is "still far from the top," Tian said. "We need a lot of time to catch up." One of the reasons is that many good young mathematicians have gone abroad to work. Indeed, it is still common for good Chinese students in mathematics to leave the country to get Ph.D.'s, because the opportunities abroad are so much better. Nevertheless, the outlook is improving, and the ICM is a bright spot. "The ICM will have a very positive impact on Chinese mathematics," Tian said. "For example, it will attract a lot more young people into mathematics. Then the problem is how we make them into first-rate mathematicians."

Speech by Shing Shen Chern

At the opening ceremonies of ICM 2002, Shiing Shen Chern presented the following speech.

It is my great pleasure to welcome you to this gathering. We are in an ancient country that is very different from Western Europe, where modern mathematics started. In 2000 we had a mathematics year, an effort to attract more people to math. We now have a vast field and a large number of professional mathematicians whose major work is mathematics. Mathematics used to be individual work. But now we have a public. In such a situation a prime duty seems to be to make our progress available to the people. There is clearly considerable room for popular expositions. I also wonder if it is possible for research articles to be preceded by a historical and popular introduction.

The net phenomenon could be described as a globalization. It is more than geographical. In recent studies different fields were not only found to have contacts but were merging. We might even foresee a unification of mathematics, including both pure and applied, and even the possibility of the emergence of a new Gauss.

China has a long way to go in modern mathematics. In recent contests of the international mathematical Olympiad, China has consistently done very well. Thus China has begun from the roots and China has the advantage of "number" (of people). Hopefully this congress will be a critical point in the development of modern math in China.

The great Confucius guided China spiritually for over 2,000 years. The main doctrine is "仁"pronounced "ren", meaning two people, i.e., human relationship. Modern science has been highly competitive. I think an injection of the human element will make our subject more healthy and enjoyable. Let us wish that this congress will open a new era in the future development of math.

Human Rights Issues

The human rights record of the Chinese government drew some attention before and during the ICM. Joel Lebowitz of Rutgers University is chair of the AMS Committee on Human Rights of Mathematicians and a cochair of the Committee of Concerned Scientists (CCS), which addresses issues of human rights and scientific freedom. Before the congress Lebowitz sent an email message to all ICM speakers suggesting ways of registering human rights protests, such as putting up a transparency listing names of Chinese scientists whom the CCS believes have been unfairly imprisoned. This email was also signed by Joan Birman of Columbia University and Louis Nirenberg of the Courant Institute at New York University.

Closing Remarks by Edward Witten

Edward Witten of the Institute for Advanced Study presented the last lecture of ICM 2002. At the end of his lecture he made the following remarks.

All of us here at ICM 2002 love mathematics and science for their beauty and because we love to understand things. Mathematics and science are also important in society for many reasons. They are the basis for the technology that is so important in the modern world. Mathematics and science also require and help to develop the sort of independent, critical thinking without which the emergence of the modern world would scarcely have been possible.

As the largest country and the most rapidly developing country in the world, China can play a very important role in the development of mathematics and science. Thus, it is fitting that ICM 2002 was held here. All of us foreign guests at ICM 2002 are grateful to our Chinese hosts for arranging this wonderful conference and for giving us the opportunity to visit this wonderful country, to see so many of the historic monuments, and to witness some of the rapid development and progress occurring in this country, which even for those who have read about it before is extremely eye-opening to see. Many of us leave with a feeling of regret that our visits are coming to a close and a hope that we have a chance to come back soon and to witness further progress in this country. I'm sure you will all want to join me in wishing our Chinese hosts and all guests from around the world all health, prosperity, and success in science and a future of peace, democracy, and freedom.

When asked whether they planned to follow these suggestions, some speakers indicated they would not, partly out of a desire not to be rude to their Chinese hosts and partly because they did not believe they knew enough about the human rights cases. One speaker in the differential geometry section, Hubert Bray of the Massachusetts Institute of Technology, explained why he opted not to register a human rights protest: "The situation in China is very complex, so I defer to my Chinese mathematician friends as to what should be done regarding the peaceful promotion of democracy and human rights."

Paul Biran of Tel Aviv University, who also spoke in the differential geometry section, said that he had seriously considered whether to make a protest and spent some time looking into the human rights cases the CCS had identified. In the end he decided not to make a protest because he thought it would be ineffectual and could end up causing difficulties for the ICM organizers, who are not at fault. Still, he was uncomfortable. "My concern is that [the Chinese government] might be using us for propaganda," he said. By playing host to a large mathematics conference, China may be hoping to burnish its image abroad. "Why should we play into this?" Biran asked.

From what could be gleaned by querying speakers and participants, it appears that the only speaker to make a direct protest in a lecture was Harry Kesten of Cornell University, who gave a plenary talk. At the end of his lecture he put up a transparency listing the names of some Chinese people who are either scientists or associated with science (one, for example, was identified as a webmaster) and whom he said had "received long jail sentences for peaceful activities." Later Kesten said that he had encountered little reaction to his statement, though he heard secondhand that a Chinese friend had confessed to being shocked. "Of course it is a bit rude," Kesten said, "But I wanted to say it, for myself."

Edward Witten of the Institute for Advanced Study made remarks at the end of his plenary lecture that some saw as an indirect statement about human rights in China. Mixed in with gracious thanks for the hospitality of the Chinese, he pointed to the "independent, critical thinking" that is needed in mathematics and science. He ended his remarks by asking the audience to join him in wishing everyone "a future of peace, democracy, and freedom." (The complete text of Witten's remarks appears in a sidebar.) Witten's lecture was the last of the congress, and his closing statement was greeted by great applause. One participant called the diplomacy and elegance of the statement "very Chinese."

A different kind of protest was presented by Lafforgue, who gave the first plenary lecture of the congress. He began his lecture by saying that he would prefer to speak in French, his "beloved language," which has played a great role in all fields of human culture, including mathematics. "The present domination of the whole world by a single country—whatever its merits—by a single culture and by a single language can be very destructive of diversity of thought," he said. But because most Chinese mathematicians do not understand French, Lafforgue struck a compromise: he spoke in English, with two sets of transparencies, one in French and one in Chinese. He then went on to present, in terms accessible to a general mathematical audience, the quite technical work that won him his Fields Medal, namely, the solution of the global Langlands correspondence for function fields.

Connections in Mathematics

By and large the plenary lecturers at the ICM succeeded in their efforts to communicate to an audience of nonspecialists. As is to be expected, the level in the section lectures was much more variable. Although they were admonished by the ICM organizers to present talks for a general audience, the section lecturers faced a dilemma. Part of the

audience for a section talk is made up of nonspecialists, but part consists of other section speakers in closely related areas—in other words, some of the top mathematicians in the world in that particular branch of mathematics. Devising a talk suitable for both components of the audience is a formidable task, and many of the talks appealed only to specialists. But there were exceptions. For example, Stephen Bigelow of the University of Melbourne in Australia (now at the University of California, Santa Barbara) presented a very clear explanation of his elementary proof that braid groups are linear. In his doctoral thesis two years ago, Bigelow gave a proof of this result using homological topology. Now he has boiled the proof down to one that uses only basic combinatorial arguments in topology. That such an elementary proof was not found earlier is surprising, for it had been suspected for a long time that braid groups are linear.

In keeping with ICM tradition, the prizewinners who had not been invited to speak on the regular program—in this case Voevodsky and Sudan—were asked to speak in sessions arranged on-site. Both had spoken at the 1998 ICM in Berlin: Voevodsky as a plenary lecturer and Sudan as a section speaker. At the Beijing congress, the room for Voevodsky's talk was overflowing with people who were treated to an exceptionally clear account of his highly technical work on cohomology theories. That Sudan's Nevanlinna Prize-winning work stands at the center of theoretical computer science could be seen in the topics of the talks in the section on mathematical aspects of computer science, where probabilistically checkable proofs, combinatorial optimization problems, and the question of whether P equals NP were prominent themes.

Kesten's lecture on critical points in percolation theory was among the most accessible of the plenary talks. Given a graph on which vertices are colored black or white with a certain probability, percolation theory studies connected clusters of same-colored vertices. This kind of model has been used to simulate, for example, the spread of disease, but the most important uses have come in statistical physics. Percolation models are the simplest ones to exhibit phase transitions, which have been intensively studied for a long time. Kesten commented that the hunt for the so-called critical probability, which marks the exact point of the phase transition for a percolation model, slowed the field down for twenty years and yielded few results, mostly pertaining to symmetric graphs. Kesten surveyed some of most important work in the field, leading up to the recent ground-breaking results in 2001 by Stanislav Smirnov, who proved what physicists had surmised through nonrigorous arguments: that the scaling limit of critical percolation on the triangular lattice is conformally invariant (and, in particular, limits of crossing probabilities are conformally invariant). Other recent work by Gregory Lawler (who spoke in the probability and statistics section), Oded Schramm, and Wendelin Werner has led to important new insights.

Noga Alon of Tel Aviv University gave an exceptionally clear lecture surveying some results in discrete mathematics. Many early results in this area were found by ingenuity and clever tricks, but as the area has matured, more sophisticated tools have come into play. Alon described two of these: namely, algebraic techniques and probabilistic methods. He also discussed the close connections between discrete mathematics and computer science and the use of computers to solve mathematical problems, such as the four-color theorem. He predicted that computers will be used more and more in proving results in discrete mathematics and said that care is needed to integrate the use of computers so that this area of mathematics does not lose its "special beauty."

Connections between different areas of mathematics formed a theme running through many of the talks at the congress. Michael J. Hopkins of the Massachusetts Institute of Technology presented new results on "topological" modular forms, which are a topological version of the usual notion of modular forms and which bring closer together ideas from topology and algebra. Hopkins discussed how topological modular forms have provided new insights into the homotopy groups of spheres. Douglas Arnold, director of the Institute for Mathematics and its Applications at the University of Minnesota, described how the use of differential complexes, such as the de Rham complex, has unexpectedly provided new insights into the stability of numerical methods for solving partial differential equations. It turns out that differential complexes provide hints about the geometric structures underlying these methods. As the closing talk of the congress, Witten's plenary lecture described some of the exciting connections between physics and mathematics that have stimulated so much research in recent decades. He discussed singularities in string theory, combining a broad-brush conceptual picture that everyone could appreciate with more technical asides aimed at specialists.

In addition to Nash's evening lecture, there was another lecture for the general public, given by Mary Poovey, Samuel Rudin University Professor of the Humanities and director, Institute for the History of the Production of Knowledge, New York University. In her talk "Can Numbers Ensure Honesty? Unrealistic Expectations and the U.S. Accounting Scandal" she described ways in which mathematics, through accounting schemes and financial modeling, has been used to lend an aura of

objectivity and precision to representations of financial instruments. Her lecture, containing as it did some cautionary tales for the developing financial markets of China, was greeted with great interest and enthusiasm. (Poovey's lecture appears in this issue of the *Notices*, pages 27–35.)

The scientific program of the congress ran from 8:30 a.m. until 6:00 p.m. for eight days. When brain cells gave out, there were plenty of other things to do. Many participated in tours to sites in and around Beijing, such as the Forbidden City and the Great Wall. An excursion to the Peking Opera was arranged for one night, and on another night there was a variety show featuring acrobats. For the ICM party, held midway through the congress, a huge buffet of Chinese specialties was set up on a couple of acres of lawn across the street from the convention center. Other events at the congress included an international symposium on the history of Chinese mathematics, held at the China Science and Technology Museum. The museum also hosted a special exhibit of ancient Chinese mathematical toys. A panel discussion on electronic publishing, sponsored by the IMU Committee on Electronic Information and Communication, drew some lively exchanges, reflecting the struggles within the international mathematical community to come to grips with how new technologies are influencing the archiving and distribution of the mathematics literature. An event called the Juvenile Mathematics Forum was organized by the Chinese Mathematical Society, the Chinese Education Society, and the China Juvenile Science Academy. The forum brought about three hundred middle and high school students from all over China to the ICM for the opening ceremonies and three days of activities.

Two ICM volunteers, Chen Dawei and Yu Pin, undergraduate students at Peking University.

ICM Student Volunteers

One aspect of the congress organization that contributed greatly to the special warmth and hospitality of the Beijing ICM was the contingent of approximately three hundred student volunteers. They fulfilled myriad roles. For three days preceding the congress they were stationed at the Beijing airport to greet arriving participants and bring the participants to special buses going to the convention center. They worked at the registration desk and administered the couple of hundred workstations set up to provide ICM participants with access to email. And throughout the congress they were at hand to answer any kind of question and to provide translations between Chinese and English.

The majority of the student volunteers were undergraduate mathematics students from Peking University, and some also came from outside of Beijing. For many of the students the congress provided a good chance to practice speaking and understanding English, as well as an opportunity to attend talks and to meet mathematicians from all over the world. Chen Dawei and Yu Pin, both undergraduates at Peking University, were two typical volunteers. Dawei said that it was hard for him to understand most of the mathematics talks, but he liked to "feel the atmosphere" of a big international mathematics meeting. "I listened to some talks and couldn't understand them," Pin agreed. "But after this I really have a desire to study more math." This year he will begin graduate work in Paris, at the École Polytechnique. Dawei said he plans to apply to universities in the United States.

The volunteers realize that attending the ICM "will influence their future," Ma remarked. "They are very proud" to work at the congress. The volunteers' heartfelt enthusiasm and respectfulness provided a window on some of the contrasts between Chinese young people and young people in the West. Jean-Michel Bismut of Université Paris-Sud, who is a member of the IMU executive committee, commented that China knows its future depends on developing its knowledge base. "They have real needs," he said. "We in the West are trying to create needs." As a result, young Chinese have a drive and ambition that young people in the West seem to lack. What does this mean for the future of mathematics? Referring to China, Bismut said, "Maybe our future is here."

—Allyn Jackson

AAS-AMS-APS Public Service Awards

Neal Lane.

AMS President Hyman Bass (left) and Congressman Vernon Ehlers.

Left to right, Senator Barbara Mikulski, Congressman James T. Walsh, and AMS President elect David Eisenbud.

For the past three years the American Astronomical Society (AAS), the AMS, and the American Physical Society (APS) have presented Public Service Awards to recognize committed and sustained efforts in support of science.

The 2001 AAS-AMS-APS Public Service Awards were presented to CONGRESSMAN VERNON EHLERS (R-MI) and to NEAL LANE.

Ehlers's passion for science research and education shows in his tireless work to achieve a higher priority for science and science education in Congress. Ehlers, who holds a Ph.D. in physics, currently chairs the House Science Committee's Subcommittee on Environment, Technology and Standards.

Lane served for five years as the director of the National Science Foundation (NSF) before being appointed in 1998 as President Clinton's assistant for science and technology and director of the Office of Science and Technology Policy. A physicist by training, Lane is currently University Professor and Senior Fellow at the James A. Baker III Institute for Public Policy at Rice University.

The 2002 AAS-AMS-APS Public Service Awards were presented to SENATOR BARBARA MIKULSKI (D-MD) and CONGRESSMAN JAMES T. WALSH (R-NY).

At the time of the award, Mikulski chaired the Senate Appropriations Subcommittee on Veterans Affairs, Housing and Urban Development, and Independent Agencies. Walsh chairs the counterpart subcommittee in the House.

Mikulski and Walsh were honored for their committed and sustained efforts to ensure adequate federal support for science research and education. Both have worked tirelessly to build bipartisan consensus within their respective appropriations committees for funding for the NSF and for NASA, which are two of the federal agencies falling under the aegis of their subcommittees.

—Allyn Jackson

Mathematics People

Manin Receives Cantor Medal

The Deutsche Mathematiker Vereinigung (DMV, German Mathematical Society) has awarded the 2002 Georg Cantor Medal to YURI MANIN of the Max-Planck-Institut für Mathematik, Bonn. The citation notes Manin's "outstanding findings in algebra, algebraic geometry, number theory, and mathematical physics" and says that his work "is highly influential, inspiring mathematicians all over the world."

Previous recipients of the Cantor Medal are Karl Stein (1990), Jürgen Moser (1992), Erhard Heinz (1994), Jacques Tits (1996), and Volker Strassen (1999).

—From a DMV announcement

Lam Lay Yong Receives May Medal

The 2001 Kenneth O. May Medal for outstanding contributions to history of mathematics was officially awarded to LAM LAY YONG of the Department of Mathematics of the National University of Singapore during the International Congress of Mathematicians in Beijing in August 2002. Lam was honored for her many books and publications on the history of Chinese mathematics. As a result of her extensive scholarship and writing, she has brought the many historic accomplishments of Chinese mathematicians to the attention of audiences around the world, especially to those who do not speak or read Chinese.

Kenneth O. May (1915–1977) was the founding chair of the International Commission on History of Mathematics and the founding editor of the international journal *Historia Mathematica*. Born in the United States, he studied mathematics at the University of California at Berkeley but spent most of his career teaching history of mathematics at the University of Toronto, Canada. When he died, the Institute for History of Science and Technology at the University of Toronto and the International Commission on History of Mathematics decided to honor his memory with an international prize to be awarded every four years to scholars who had made significant lifetime contributions to the history of mathematics. The award consists of a certificate and a medal cast in bronze.

Previous recipients of the Kenneth O. May Medal are: Dirk J. Struik and A. P. Youschkevitch (1989), Christoph J. Scriba and Hans Wussing (1993), René Taton (1997), Ubiratan D'Ambrosio (2001).

—Joseph Dauben, on behalf of the International Commission on History of Mathematics

NSF CAREER Awards

Six mathematicians have been honored by the Division of Mathematical Sciences (DMS) of the National Science Foundation (NSF) in fiscal year 2001 with Faculty Early Çareer Development (CAREER) awards. The NSF established the awards to support promising scientists, mathematicians, and engineers who are committed to the integration of research and education. The grants run from four to five years and range from $200,000 to $500,000 each.

The CAREER grant awardees and the titles of their grant projects are: ANDREW BELMONTE, Pennsylvania State University: Macromolecular Fluid Flow: Experiments, Equations, and Education; BRIAN CONRAD, University of Michigan: Galois Representations and Modular Forms; YURY GRABOVSKY, Temple University: Macroscopic Properties of Heterogeneous Media and Development of the Applied Mathematics Curriculum; MARINA VANNUCCI, Texas A&M University: Some Applications of Wavelets in Statistics; CHRISTOPHER WOODWARD, Rutgers University: Symplectic Geometry, Physics, and Algebraic Combinatorics; and YUHONG YANG, Iowa State University: Adaptive Regression for Dependent Data by Combining Different Procedures.

—From NSF announcement

ONR Young Investigators Awards Announced

The Office of Naval Research (ONR) has announced the awarding of 26 grants in the 2002 ONR Young Investigator Program competition. Two individuals in the mathematical sciences received awards. They are STEVEN M. SEITZ of the University of Washington and SCOTT D. STOLLER of the State University of New York at Stony Brook.

Seitz will do research on the plenoptic reconstruction of time-varying scenes. Stoller's research will focus on checking critical software for concurrent, distributed, open, secure systems.

The Young Investigator Program supports basic research by exceptional faculty at U.S. universities who have received Ph.D.'s or equivalent degrees within the preceding five years. Grants to their institutions provide up to $100,000 per year for three years. The funds may be applied to a variety of research costs, including salary, graduate student support, laboratory supplies, and operating costs. Young Investigators are selected on the basis of prior professional achievement, the submission of a meritorious research proposal, and evidence of strong support by their respective universities. The program supports outstanding research in a wide range of science and engineering fields that are critical to the evolution of a first-rate Navy and Marine Corps.

—From an ONR announcement

Barkhudaryan Awarded Emil Artin Junior Prize

The 2002 Emil Artin Junior Prize in Mathematics has been awarded to ARTUR BARKHUDARYAN of Yerevan State University, Armenia. Barkhudaryan was chosen for his paper, joint with Věra Trnková, "Some universal properties of the category of clones", published in *Algebra Universalis* **47** (2002), 239–66.

Established in 2001, the Emil Artin Junior Prize carries a cash award of US$500 and is presented annually to a student or former student at an Armenian university who is under the age of thirty-five for outstanding contributions to algebra, geometry, topology, and number theory—the fields in which Emil Artin made major contributions. The previous awardee was Vahagn Mikaelian (2001).

The prize committee consisted of A. Basmajian, Y. Movsisyan, and V. Pambuccian.

—Artin Prize Committee announcement

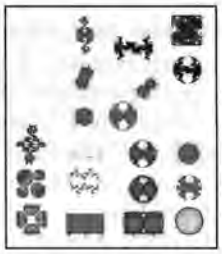
About the Cover

This month's cover has been lifted from the "road map" of two-generator groups at the end of the book *Indra's Pearls*, reviewed in this issue (see pages 38-44). It is essentially just a sample of the marvelous collection of images done for the book, a landmark in mathematical graphics, by David Wright in collaboration with David Mumford.

Roughly speaking, the correspondence between infinite words and limit points becomes more complicated in proceeding from left to right. David Wright tells us, "The Road Map isn't intended be a classification of the possible changes that happen, but mostly a summary of the journey that we take in exploring the changes that can happen to limit sets... Every image in the Road Map appears somewhere in the book except for the very first one (far left top on the cover). That is because to be able to draw a generalized dust we had to advance beyond the correspondence between limit points and infinite words (Chapter 5)and the general parametrization of free two-generator groups (Chapter 8). But by that point we had set our focus pretty much on quasifuchsian groups, and did not return to general Schottky groups. Still I thought in one picture to show how complicated the dust limit sets can be. In general it is quite difficult to prove that such a group is a generalized Schottky group (i.e., to find explicit Schottky curves) and at the same time it is difficult to prove that there is not some pair of generators for which the Schottky curves are genuinely circular."

Wright's webpage `http://klein.math.okstate.edu/kleinian/` has a copy of the original road map and other illustrations from the book.

—Bill Casselman
(`covers@ams.org`)



Mathematics Opportunities

Deadlines and Target Dates at the DMS

The Division of Mathematical Sciences (DMS) of the National Science Foundation (NSF) has a number of programs in support of mathematical sciences research and education. Listed below are some of the programs and their deadlines or target dates for the year 2003. Some dates are tentative; please refer to the program announcement or contact the program director for more information.

First week of January 2003 (target date): Mathematical Biology part of Applied Mathematics (includes all Research in Undergraduate Institutions (RUI) proposals)

January 15, 2003 (target date): Mid-Career Methodological Opportunities

January 18, 2003 (deadline): Scientific Computing Research Environments for the Mathematical Sciences (SCREMS)

Late January 2003 (deadline; see solicitation): Major Research Instrumentation (MRI) Program

February 1, 2003 (target date): Research Planning Grants and Career Advancement Awards for Minority Scientists and Engineers

Early April 2003 (target date; see soliciation): Conference Board of the Mathematical Sciences (CBMS) Regional Research Conferences in the Mathematical Sciences

July 2003 (proposal deadline; see solicitation): Grants for Vertical Integration of Research and Education in the Mathematical Sciences (VIGRE)

July 2003 (deadline; see solicitation): Faculty Early Career Development (CAREER) Program

August 15, 2003 (target date): Mid-Career Methodological Opportunities

Proposals for conferences, workshops, and special years that are submitted to the Statistics and Probability program or to the Topology and Foundations program can be sent at any time. However, proposals for these activities that are submitted to all other DMS programs (Analysis, Algebra and Number Theory, Applied Mathematics, Computational Mathematics, and Geometric Analysis) must be submitted according to the target dates for those programs. Proposals for supplements for Research Experiences for Undergraduates may be submitted at any time.

For further information consult the DMS website at `http://www.nsf.gov/mps/divisions/dms/news/c_deadlines.htm`. The mailing address is Division of Mathematical Sciences, National Science Foundation, Room 1025, 4201 Wilson Boulevard, Arlington, VA 22230. The telephone number is 703-292-5111.

—From a DMS announcement

2003 Prize Committee for Achievement in Information-Based Complexity

This annual prize is for outstanding achievement in Information-Based Complexity. It consists of $3,000 and a plaque and will be awarded at a suitable location. The prize committee will consist of Stefan Heinrich, Universitat Kaiserslautern; Sergei Pereverzev, Ukrainian Academy of Science; Joseph F. Traub, Columbia University; Grzegorz W. Wasilkowski, University of Kentucky; and Henryk Wozniakowski, Columbia University and University of Warsaw. Anyone other than current members of the prize committee is eligible. The members of the prize committee would appreciate nominations for the prize. However, a person does not have to be nominated to win the award.

The deadline for nominations is March 31, 2003. The award can be based on work done in a single year, in a number of years, or over a lifetime. It can be published in any journal, number of journals, or monographs.

—Joseph F. Traub
Columbia University

For Your Information

Departments Coordinate Job Offer Deadlines

A group of mathematical sciences departments has adopted an agreement to coordinate deadlines for acceptance of postdoctoral job offers. The purpose is to ensure that applicants do not have to make decisions about job offers before the results of the National Science Foundation (NSF) postdoctoral fellowship competition are announced. The agreement applies only to offers of postdoctoral positions, not to not tenure-track positions, and only to applicants who are less than two years past the Ph.D.

The departments have agreed not to require these applicants to decide about a job offer before Monday, February 10, 2003. The NSF has agreed to notify postdoctoral fellowship recipients no later than Friday, January 31, 2003. The list of participating departments, together with additional information, may be found on the Web at `http://www.ams.org/employment/postdoc-offers.html`.

—Allyn Jackson

Elsevier Supports Joint Meetings Speakers

Elsevier supported the travel and local expenses for five AMS Special Session speakers at the Joint Mathematics Meetings in Baltimore in January 2003. The speakers who are receiving support are all from developing countries. They were chosen to receive the support from nominations made by organizers of AMS Special Sessions at the Joint Meetings.

The names and affiliations of the supported speakers are: PETER BOYVALENKOV, Institute of Mathematics and Informatics, Bulgarian Academy of Sciences, Sofia, Bulgaria; MALGORZATA GUZOWSKA, University of Szczecin, Poland; URSULA MOLTER, Departamento de Matematica, Universidad de Buenos Aires, Argentina; MIKHAIL M. POPOV, Chernivtsi National University, Ukraine; MUKUT MANI TRIPATHI, Department of Mathematics and Astronomy, Lucknow University, India.

—Allyn Jackson

VIGRE Workshop Report Available

In May 2002 a workshop was held to share information about the Vertical Integration of Research and Education in the Mathematical Sciences (VIGRE) program of the National Science Foundation. The report of the VIGRE workshop is now available on the AMS website, `http://www.ams.org/amsmtgs/VIGRE-report.pdf`.

An article about the workshop, "VIGRE Turns Three", by Rick Durrett, appeared in the November 2002 issue of the *Notices*, pages 1237–43. An "Opinion" piece, "Whither VIGRE?", also by Durrett, appeared in the same issue, page 1221.

—Allyn Jackson

Correction

Harry Hochstadt, a doctoral student of Wilhelm Magnus and a close friend of the latter's widow, has noted an error in my account of Max Dehn's emigration ["Max Dehn, Kurt Gödel, and the Trans-Siberian Escape Route", October 2002 issue]. He points out that Magnus's one son, Alfred (not Albert, as I mistranscribed the name), was born in 1950 and so could not have helped Dehn get to the Frankfurt railroad station. My statement was based on the account in Yandell's book. Siegel's memoir, on the other hand, states that Dehn was helped by "the wife and son of Professor Alfred Magnus". According to Hochstadt, that reference is actually to Wilhelm Magnus's *father*, who was also named Alfred. It was he and his wife who came to Dehn's aid. I regret the confusion.

In the references at the end of my article, the volume and issue numbers for the English translation of Siegel's memoir that appeared in the *Mathematical Intelligencer* were switched. The correct reference is vol. 1, no. 4.

—John Dawson

Reference and Book List

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

Contacting the *Notices*

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

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

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

Upcoming Deadlines

December 16, 2002: Applications for AMS Epsilon Fund. See http://www.ams.org/careers-edu/epsilon.html, or contact Professional Services Department, AMS, 201 Charles Street, Providence, RI 02904; telephone: 800-321-4267, ext. 4105; email: prof-serv@ams.org.

December 31, 2002: Nominations for Alan T. Waterman Award. Contact Susan E. Fannoney, telephone: 703-292-8096, or email: sfannone@nsf.gov.

January 2, 2003: Applications for postdoctoral positions at The Fields Institute. See http://www.fields.utoronto.ca/proposals/postdoc.html.

January 6, 2003: Applications for National Defense Science and Engineering Graduate Fellowships. Contact the NDSEG Fellowship Program, c/o American Society for Engineering Education, 1818 N Street, N.W. #600,

Where to Find It

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

AMS Bylaws—*November 2001, p. 1205*

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

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

AMS Officers 2000 and 2001 (Council, Executive Committee, Publications Committees, Board of Trustees)—*June/July 2002, p. 705*

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

Backlog of Mathematics Research Journals—*September 2002, p. 963*

Conference Board of the Mathematical Sciences—*September 2002, p. 955*

Information for *Notices* Authors—*June/July 2002, p. 697*

Mathematics Research Institutes Contact Information—*August 2002, p. 828*

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

New Journals for 2001—*June/July 2002, p. 698*

NRC Board on Mathematical Sciences and Staff—*April 2002, p. 492*

NRC Mathematical Sciences Education Board and Staff—*May 2002, p. 583*

NSF Mathematical and Physical Sciences Advisory Committee—*March 2002, p. 345*

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

Washington, DC 20036; telephone: 202-331-3516; fax: 202-265-8504; email: ndseg@asee.org. See http://www.asee.org/ndseg/html/preface.htm.

January 8, 2003: Applications for NRC-Ford Foundation Postdoctoral Fellowship Program. See http://national-academies.org/fellowships/, or contact Ford Foundation Fellowships/TJ 2041, National Research Council, 2101 Constitution Avenue, NW, Washington, DC 20418; telephone: 202-334-2872; email: infofell@nas.edu.

January 10, 2003: Applications for AAUW Selected Professions Fellowships. See http://www.aauw.org/3000/fdnfelgra/selectprof.html or contact the AAUW Educational Foundation, 1111 Sixteenth St. N.W., Washington, DC 20036; telephone: 800-326-2289 (AAUW); fax: 202-872-1425; email: info@aauw.org.

January 15, 2003: Applications for AMS-AAAS Mass Media Fellowships. See http://ehrweb.aaas.org/massmedia.htm, or contact Katrina Malloy, Program Coordinator, AAAS Mass Media Science and Engineering Fellows Program, 1200 New York Avenue, NW, Washington, DC 20005; telephone: 202-326-6760; fax: 202-371-9849; or the AMS Washington Office, 1527 Eighteenth Street, NW, Washington, DC 20036; telephone: 202-588-1100; fax: 202-588-1853; email: amsdc@ams.org.

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

January 24, 2003: Applications for AWM Workshop for Women Graduate Students and Postdocs. See the AWM website at http://www.awm-math.org/.

January 31, 2003: Applications for postdoctoral fellowships for Institut Mittag-Leffler. See http://www.ml.kva.se/.

February 1, 2003: Applications for NSF/AWM Travel Grants for Women. See http://www.awm-math.org/travelgrants.html; telephone: 301-405-7892; email: awm@math.umd.edu.

March 1, 2003: Nominations for Third World Academy of Science Prizes. See http://www.ictp.trieste.it/~twas/twas_prizes.html.

March 3, 2003: Applications for EDGE Summer Program. See http://www.edgeforwomen.org.

March 31, 2003: Nominations for the 2003 Prize for Achievement in Information-Based Complexity. See "Mathematics Opportunities" in this issue.

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

April 18, 2003: Full proposals for NSF IGERT program. See http://www.nsf.gov/pubsys/ods/getpub.cfm?nsf02145.

May 1, 2003: Applications for NSF/AWM Travel Grants for Women. See http://www.awm-math.org/travelgrants.html; telephone: 301-405-7892; email: awm@math.umd.edu.

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

June 30, 2003: Nominations for the Fermat Prize for Mathematics Research. See http://www.ups-tlse.fr/ACTUALITES/Sciences/Prix_Fermat_2003/Areglement.html.

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

National Science Board

The National Science Board is the policymaking body of the National Science Foundation. The names and affiliations of the board members follow.

Nina V. Fedoroff
Willaman Professor of Life Sciences
Director, Life Sciences Consortium
Director, Biotechnology Institute
Pennsylvania State University
University Park, PA

Pamela A. Ferguson
Professor of Mathematics
Grinnell College
Grinnell, IA

Mary K. Gaillard (consultant)
Professor of Physics
University of California
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M. R. C. Greenwood (consultant)
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Chancellor
Washington University
Saint Louis, MO

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Rita R. Colwell (Chairman, Executive Committee)
Director
National Science Foundation
Arlington, VA

The contact information for the Board is: National Science Board, National Science Foundation, 4201 Wilson Boulevard, Suite 1225, Arlington, VA 22230; telephone: 703-292-5111; World Wide Web: `http://www.nsf.gov/nsb/`.

Book List

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

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

The Algorithmic Beauty of Seaweeds, Sponges and Corals, by Jap Kaandorp and Janet Kübler. Springer Verlag, January 2001. ISBN 3-540-67700-3.

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

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

The Bit and the Pendulum: How the New Physics of Information Is Revolutionizing Science, by Tom Siegfried. John Wiley & Sons, February 2000. ISBN 0-47132-174-5. (Reviewed August 2002.)

The Book of Nothing: Vacuums, Voids, and the Latest Ideas about the Origins of the Universe, by John D. Barrow. Pantheon Books, April 2001. ISBN 0-375-42099-1. (Reviewed June/July 2002.)

Codes and Ciphers: Julius Caesar, the Enigma, and the Internet, by Robert Churchhouse. Cambridge University Press, January 2002. ISBN 0-521-81054-X.

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

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

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

Curve Ball: Baseball, Statistics, and the Rules of Chance in the Game, by Jim Albert and Jay Bennett. Copernicus-Springer Verlag, July 2001. ISBN 0-387-98816-5.

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

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

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

The Essential John Nash, Harold Kuhn and Sylvia Nasar, editors. Princeton University Press, December 2001. ISBN 0-691-09527-2.

Euclid's Window: The Story of Geometry from Parallel Lines to Hyperspace, by Leonard Mlodinow. Free Press, April 2001. ISBN 0-684-86523-8. (Reviewed May 2002.)

Flatterland: Like Flatland, Only More So, by Ian Stewart. Perseus Publishing, May 2001. ISBN 0-7382-0442-0. (Reviewed April 2002.)

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

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

A Gardner's Workout: Training the Mind and Entertaining the Spirit, by Martin Gardner. A K Peters, June 2001. ISBN 1-56881-120-9.

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

Go To: The Story of the Math Majors, Bridge Players, Engineers, Chess Wizards, Scientists and Iconoclasts Who Were the Hero Programmers of the Software Revolution, by Steve Lohr. Basic Books, October 2001. ISBN 0-465-04225-2.

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

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

The Hilbert Challenge, by Jeremy J. Gray. Oxford University Press, December 2000. ISBN 0-198-50651-1. (Reviewed September 2002.)

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

The Honors Class, by Benjamin Yandell. A K Peters, December 2001. ISBN 1-568-81141-1. (Reviewed September 2002.)

How the Other Half Thinks: Adventures in Mathematical Reasoning, by Sherman Stein. McGraw-Hill, July 2001. ISBN 0-071-37339-X. (Reviewed September 2002.)

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

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

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

The Lady Tasting Tea: How Statistics Revolutionized Science in the Twentieth Century, by David Salsburg. W. H. Freeman & Co., April 2001. ISBN 0-716-74106-7.

Lebesgue's Theory of Integration: Its Origins and Development, by Thomas Hawkins. AMS, September 2001. ISBN 0-8218-2963-7.

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

The Mathematical Explorer, by Stan Wagon. Electronic book, Wolfram Research, Inc., 2001. (Reviewed June/July 2002.)

* *Mathematical Reflections*, by Peter Hilton, Derek Holton, and Jean Pedersen. Springer, December 1996. ISBN 0-387-94770-1.

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

A Mathematician Grappling with His Century: The Autobiography of Laurent Schwartz. Translated from the French by L. Schneps. Birkhäuser, 2001. ISBN 3-7643-6052-6.

The Mathematician Sophus Lie: It Was the Audacity of My Thinking, by Arild Stubhaug. Springer, 2002. ISBN 3-540-42137-8.

Mathematics and the Roots of Postmodern Thought, by Vladimir Tasic. Oxford University Press, 2001. ISBN 0-195-13967-4.

Mathematics Elsewhwere: An Exploration of Ideas Across Cultures, by Marcia Ascher. Princeton University Press, September 2002. ISBN 0-691-07020-2.

Mathematics Galore: Masterclasses, Workshops, and Team Projects in Mathematics and Its Applications, by C. J. Budd and C. J. Sangwin. Oxford University Press, June 2001. ISBN 0-198-50769-0 (hardcover), 0-198-50770-4 (paperback). (Reviewed September 2002.)

Mathematics in a Postmodern Age: A Christian Perspective, Russell W. Howell and W. James Bradley, editors. Wm. B. Eerdmans Publishing Company, May 2001. ISBN 0-802-84910-5.

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

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

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

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

Niels Hendrik Abel and His Times: Called Too Soon by Flames Afar, by Arild Stubhaug; translated by R. Daly. Springer, May 2000. ISBN 3-540-66834-9. (Reviewed August 2002.)

Political Numeracy: Mathematical Perspectives on Our Chaotic Constitution, by Michael Meyerson. W. W. Norton & Company, March 2002. ISBN 0-393-04172-7.

Puzzlers' Tribute: A Feast for the Mind, Tom Rodgers, David Wolfe, editors. A K Peters, December 2001. ISBN 1-56881-121-7.

The Quest for the Quantum Computer, by Julian Brown. Touchstone Books, August 2001. ISBN 0-684-87004-5.

Radical Equations: Math Literacy and Civil Rights, by Robert P. Moses and Charles E. Cobb Jr. Beacon Press,

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

The Riddle of the Compass, by Amir Aczel. Harcourt Brace, August 2001. ISBN 0-151-00506-0.

Science and an African Logic, by Helen Verran. University of Chicago Press, January 2002. ISBN 0-226-85389-6 (cloth), 0-226-85391-8 (paper).

The Science of Conjecture: Evidence and Probability before Pascal, by James Franklin. Johns Hopkins University Press, June 2001. ISBN 0-8018-6569-7.

Signs of Life: How Complexity Pervades Biology, by Richard Solé and Brian Goodwin. Basic Books, January 2001. ISBN 0-465-01927-7.

Spaceland, by Rudy Rucker. Tor Books, June 2002. ISBN 0-765-30366-3.

Statisticians of the Centuries, C. C. Heyde and E. Seneta, editors. Springer, September 2001. ISBN 0-387-953283-7.

The Story of Mathematics, by Richard Mankiewicz. Princeton University Press, February 2001. ISBN 0-691-08808-X. (Reviewed April 2002.)

Such Silver Currents: The Story of William and Lucy Clifford, 1845–1929, by M. Chisholm. Lutterworth Press, March 2002. ISBN 0-7188-3017-2.

Thinks, by David Lodge. Viking Press, May 2001. ISBN 0-670-89984-4.

Triangle of Thoughts, by Alain Connes, André Lichnerowicz, and Marcel Paul Schützenberger. AMS, July 2001. ISBN 0-8218-2614-X. (Reviewed March 2002.)

Turing and the Universal Machine: The Making of the Modern Computer, by Jon Agar. June 2001, Totem Books. ISBN 1-840-46250-7.

Understanding Mathematics for Aircraft Navigation, by James S. Wolper. McGraw-Hill, May 2001. ISBN 0-07-137572-4.

The Unfinished Revolution: Human-Centered Computers and What They Can Do for Us, by Michael L. Dertouzos. Harperbusiness, January 2001. ISBN 0-066-62067-8.

The Universe in a Nutshell, by Stephen Hawking. Bantam Doubleday Dell, November 2001. ISBN 0-553-80202-X . (Reviewed May 2002.)

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

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

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

From the AMS Secretary

Each of the five AMS policy committees, which report to the AMS Council, has one face-to-face meeting annually. Two of them meet in the spring; three in the fall. This is a report on the meetings of the Committee on Meetings and Conferences, held in Chicago on April 6, 2002, and of the Committee on Science Policy, held in Washington, D.C., April 19–20, 2002.

Committee on Meetings and Conferences

Report of the Secretariat

The Secretariat, which met the preceding evening, recommended to the Committee on Meetings and Conferences (CoMC) that the ten-year no-repeat rule for Invited Addresses at sectional and national meetings be separated into two disjoint ten-year no-repeat rules, one for sectional meetings and one for national meetings. CoMC approved the recommendation.

Report of the Subcommittee to Review Cosponsorship of Meetings and Conferences of Other Organizations and the Conference Program

As part of the review of AMS conferences, the subcommittee collected materials from the *Notices* and final conference reports turned in over the past five years. The subcommittee found that the AMS conference program is useful and should be continued and in particular found that the Summer Research Conferences (SRCs) have been quite successful in spite of the low number of proposals submitted. It also assesses cosponsored meetings and conferences as being valuable by allowing for interaction and dialogue across disciplines. They suggested that an explanation of cosponsorship be put on the cosponsored meetings Webpage.

In connection with these recommendations, CoMC took two actions:

- The committee unanimously approved a motion to encourage the SRC committee to consider varying the format of the SRCs, for example, having a two-week institute followed by a related one-week conference. The SRC committee and its advisory committee are also encouraged to actively solicit proposals.
- The committee recommended that while CoMC itself should not actively solicit cosponsorships, it should encourage others to do so. Information on how to propose a cosponsored meeting should be posted on the Web and should include a listing of AMS's expectations regarding cosponsored meetings.

Future Reviews of Selected Activities

Upon the request of the AMS Short Course Committee, CoMC decided to add a review of the Short Courses at national meetings to its planned 2004 review of Special Lectures Series and Special Projects. In 2003 it will review sectional meetings.

Report on the San Diego Focus Group

Hema Srinivasan, who moderated the 2002 CoMC Focus Group, reported that in response to the focus group question, Do you view meetings as a valuable part of your AMS membership?, the answer typically was yes and the values mentioned fell into three main categories

- Research exposure and stimulation
- Meeting new people and reunions with old friends
- Employment Center activities (at the national meeting only)

CoMC discussed various comments and suggestions that emerged during the focus group discussions.

Special Session on Current Events in Mathematics

CoMC discussed a new type of Special Session, proposed by David Eisenbud, to be presented at the national meeting, which would feature 3 to 4 prominent mathematicians talking about recent significant new work of others in their fields, as in the Bourbaki model. The committee agreed to approve the proposed special session as an

experiment for the 2003 JMM only, with a review by CoMC next year.

2003 Joint Mathematics Meeting

CoMC intends to host another focus group at the Baltimore meeting, scheduled tentatively for Thursday, January 16, 2003, 7:00–9:00 a.m.

AMS Committee on Science Policy

Since the Committee on Science Policy (CSP) traditionally meets while the appropriations process is gearing up in Washington, a large portion of its meetings are devoted to visits by congressional and administration insiders knowledgeable about the federal budget process. New this year were a visit from a representative of the National Institutes of Health and a Saturday session intended to get committee members involved in grass roots strategies for contacting their members of Congress. Several department chairs attended, in addition to science policy representatives from other mathematical organizations. For the first time, members of the Coalition for National Science Funding were invited to attend some of the briefings.

Highlights of the Visits

James Cassatt, director of the Division of Cell Biology and Biophysics, National Institute of General Medical Sciences, talked to CSP about opportunities for mathematicians at the National Institutes of Health and outlined the many funding mechanisms available in addition to investigator-initiated grants.

Jill Harper, of the office of Congressman Rush Holt, and **Ashwin Vasavada**, from Congressman Vernon J. Ehlers's office, talked with CSP about their experiences working on Capitol Hill as AAAS Science Fellows. Both work for former scientists, which is not usual for the fellows. Both felt that members of Congress get bombarded with scientific advice, sometimes bolstering two totally opposite positions; the main source of unbiased information is still the National Academies of Science.

James Turner, chief counsel, Minority Staff, House Committee on Science, described how Congress gets scientific information. He provided CSP with background on the demise and possible revival of the Office of Technology Assessment and gave a crisp analysis of the prospects for science funding in the FY 2003 appropriations process.

David Goldston, chief of staff, Majority Staff, House Committee on Science, provided a majority view of legislation affecting science and offered a different opinion from James Turner's on the question of the Office of Technology Assessment by insisting that it had been abolished, not because of politics, but for budgetary reasons and suggesting that its revival currently is a dead issue.

David Radzanowski, NSF budget examiner, Office of Management and Budget, turned CSP's attention to the Bush administration's proposed investment criteria for research and development and its management agenda for allocating resources, including a tentative "score card" which rated NSF as the only agency receiving a green (i.e., good) sticker. Three criteria are proposed for all R&D programs: (1) relevance (to presidential priorities, agency missions, fields of science and "customers"); (2) quality; and (3) performance (on schedule and cost effective). After finalizing the criteria, OMB will work with federal agencies to apply them. Amid general expressions of skepticism about the scheme, John Ewing noted that two types of evaluation were compounded in the plan—evaluation of the agencies and their management of their funds, and evaluation of the research funded—and Radzanowski not only acknowledged that this was the center of ongoing debate at OMB but also conjectured that the plan would be implemented quite differently at NSF compared to other agencies.

Joel Widder, professional staff, Senate Appropriations Subcommittee on VA, HUD and Independent Agencies, noting that CSP had heard all the positive steps the authorizers were going to take, delivered a sobering lesson about the world of appropriations in which NSF lives (i.e., vying with VA and HUD, the two elephants in that particular world), as he went over the numbers in the president's FY 2003 budget request. When asked for advice on making the voices of the science community heard, he advised against counterproductive strategies such as the recent environmentalists' broadcast fax assault on the appropriations subcommittee's fax machines.

Michael Stephens, professional staff, House Appropriations Subcommittee on VA, HUD and Independent Agencies (Joel Widder's counterpart in the House) gave a more optimistic perspective on the House appropriations for FY 2003, noting that it is the job of appropriations staff to "build down" expectations. However, he agreed with Widder that if one examines the hard numbers in the president's budget, NSF is really getting a 3% increase, rather than the published 5%. The real question this year is how much better than the president's budget the Congress can go, because there is bipartisan and bicameral support for giving more. In particular, Stephens felt there was momentum on the appropriations committee for giving NSF a 7% increase. An emerging concern Stephens had noticed among members of his subcommittee is whether NSF's focus on priority areas comes at the expense of core scientific research.

William Berry, director, Basic Research, Department of Defense Research and Engineering, described how DoD decides how to invest science and technology money, of which its mission-oriented basic research budget amounts to less than 1% of the DoD total.

Philippe Tondeur, director of the Division of Mathematical Sciences, National Science Foundation, was happy to report that recent increases in the division's budget have been dramatic and that mathematics is now funded at a level comparable with other sciences. Tondeur spoke briefly of the NSF budget request for FY 2003. He encouraged the profession to look to NIH and also the Department of Energy as important funding sources and expressed concern that the Department of Defense research budget is incomparably smaller than it was twenty years ago.

From the AMS Secretary

Hyman Bass, AMS president, thanked Tondeur on behalf of AMS and CSP for his optimism and vision as DMS director, adding that the mathematical community owed Tondeur a great deal for his leadership.

Communicating with Congress

The Saturday sessions were devoted to "nuts and bolts" CSP work. Led by CSP chair Jane Hawkins, who guided CSP members through the techniques of making effective contacts with their members of Congress, members discussed how to visit with members and their science staff and how to deliver their message. CSP members practiced making the argument for increased support for science using examples of the impact of their research and that of their colleagues, in the member's home district.

AMS Washington Office

Sam Rankin, director of the AMS Washington Office, outlined some recent events he had organized to bring mathematicians into congressional circles and described his work with other scientific societies to make the concerns of the scientific community much more visible on Capitol Hill.

2003 Joint Mathematics Meeting

CSP chose a short-list of speakers for the government speaker slot, usually cosponsored with MAA, mentioned possible topics for the CSP panel slot for further email discussion within the full committee and after the meeting agreed on the topic of Homeland Security and Mathematics.

2003 AMS Election

Nominations by Petition

Vice President or Member at Large

One position of vice president and member of the Council *ex officio* for a term of three years is to be filled in the election of 2003. The Council intends to nominate at least two candidates, among whom may be candidates nominated by petition as described in the rules and procedures.

Five positions of member at large of the Council for a term of three years are to be filled in the same election. The Council intends to nominate at least ten candidates, among whom may be candidates nominated by petition in the manner described in the rules and procedures.

Petitions are presented to the Council, which, according to Section 2 of Article VII of the bylaws, makes the nominations. The Council of 23 January 1979 stated the intent of the Council of nominating all persons on whose behalf there were valid petitions.

Prior to presentation to the Council, petitions in support of a candidate for the position of vice president or of member at large of the Council must have at least fifty valid signatures and must conform to several rules and operational considerations, which are described below.

Editorial Boards Committee

Two places on the Editorial Boards Committee will be filled by election. There will be four continuing members of the Editorial Boards Committee.

The President will name at least four candidates for these two places, among whom may be candidates nominated by petition in the manner described in the rules and procedures.

The candidate's assent and petitions bearing at least 100 valid signatures are required for a name to be placed on the ballot. In addition, several other rules and operational considerations, described below, should be followed.

Nominating Committee

Three places on the Nominating Committee will be filled by election. There will be six continuing members of the Nominating Committee.

The President will name at least six candidates for these three places, among whom may be candidates nominated by petition in the manner described in the rules and procedures.

The candidate's assent and petitions bearing at least 100 valid signatures are required for a name to be placed on the ballot. In addition, several other rules and operational considerations, described below, should be followed.

Rules and Procedures

Use separate copies of the form for each candidate for vice president, member at large, or member of the Nominating and Editorial Boards Committees.

1. To be considered, petitions must be addressed to Robert J. Daverman, Secretary, American Mathematical Society, 312 D Ayres Hall, University of Tennessee, Knoxville, TN 37996-1330, and must arrive by 28 February 2003.
2. The name of the candidate must be given as it appears in the *Combined Membership List* (`www.ams.org/cml`). If the name does not appear in the list, as in the case of a new member or by error, it must be as it appears in the mailing lists, for example on the mailing label of the *Notices*. If the name does not identify the candidate uniquely, append the member code, which may be obtained from the candidate's mailing label or the Providence office.
3. The petition for a single candidate may consist of several sheets each bearing the statement of the petition, including the name of the position, and signatures. The name of the candidate must be exactly the same on all sheets.
4. On the next page is a sample form for petitions. Copies may be obtained from the secretary; however, petitioners may make and use photocopies or reasonable facsimiles.
5. A signature is valid when it is clearly that of the member whose name and address is given in the left-hand column.
6. The signature may be in the style chosen by the signer. However, the printed name and address will be checked against the *Combined Membership List* and the mailing lists. No attempt will be made to match variants of names with the form of name in the *CML*. A name neither in the *CML* nor on the mailing lists is not that of a member. (Example: The name Robert J. Daverman is that of a member. The name R. Daverman appears not to be.)
7. When a petition meeting these various requirements appears, the secretary will ask the candidate to indicate willingness to be included on the ballot. Petitioners can facilitate the procedure by accompanying the petitions with a signed statement from the candidate giving consent.

Nomination Petition for 2003 Election

The undersigned members of the American Mathematical Society propose the name of

_____

as a candidate for the position of (check one):

- ☐ **Vice President**
- ☐ **Member at Large of the Council**
- ☐ **Member of the Nominating Committee**
- ☐ **Member of the Editorial Boards Committee**

of the American Mathematical Society for a term beginning 1 February, 2004.

Name and address (printed or typed)	
	_____ Signature
	_____ Signature
	_____ Signature
	_____ Signature
	_____ Signature
	_____ Signature

MATHEMATICAL REVIEWS

ASSOCIATE EDITOR

Applications and recommendations are invited for a full-time position as an Associate Editor of Mathematical Reviews (MR), to commence as soon as possible after September 1, 2003, and no later than January 1, 2004.

The Mathematical Reviews division of the American Mathematical Society (AMS) is located in Ann Arbor, Michigan, not far from the campus of the University of Michigan. The editors are employees of the AMS; they also enjoy many privileges at the University. At present, MR employs fourteen mathematical editors, about six consultants, and a further sixty nonmathematicians. MR's mission is to develop and maintain the AMS databases covering the published mathematical literature. The chief responsibility is the development and maintenance of the MR Database, from which all MR-related products are produced: MathSciNet, the journals *Mathematical Reviews* and *Current Mathematical Publications*, and MathSciDisc. The responsibilities of an Associate Editor fall primarily in the day-to-day operations of selecting articles and books suitable for coverage, classifying these items, determining the type of coverage, assigning those selected for review to reviewers, and editing the reviews when they are returned.

An individual is sought who has mathematical breadth and an interest in current developments and is willing to learn new topics in pure and applied mathematics; the ability to write good English is essential and the ability to read mathematics in major foreign languages is an advantage. Preference will be given to applicants with expertise in combinatorics or information and communication (MSC sections 05, 94), together with an interest in theoretical computer science. It is required that the applicant have at least two years' relevant academic (or equivalent) experience beyond the Ph.D. Persons nearing the end of a post-doctoral appointment are encouraged to apply.

The twelve-month salary will be commensurate with the experience the applicant brings to the position. Interested applicants are invited to write (or telephone) for further information.

Applications (including curriculum vitae; bibliography; and name, address, phone number, and email of at least three references) and recommendations should be sent to

Dr. Jane E. Kister
Executive Editor
Mathematical Reviews
P. O. Box 8604
Ann Arbor, MI 48107-8604

e-mail: jek@ams.org
Tel: (734) 996-5257
Fax: (734) 996-2916

The closing date for applications is March 1, 2003.

The American Mathematical Society is an Equal Opportunity Employer.

AMS
AMERICAN MATHEMATICAL SOCIETY
www.ams.org

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 visit the AMS web site for a choice of electronic versions at www.ams.org/coversheet/), 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 purpose of the cover form is to aid department staff in tracking and responding to each application for employment. Mathematics departments in Bachelor's-, Master's-, and Doctorate-granting institutions are expecting to receive the form from each applicant, along with the other application materials they require.

The AMS suggests that applicants and employers visit the Job Application Database for Mathematicians (www.mathjobs.org), a new electronic resource being offered by the AMS (in partnership with Duke University) for the second year in 2002-03. The system provides a way for applicants to produce printed coversheet forms, apply for jobs, or publicize themselves in the "Job Wanted" list. Employers can post a job listing, and once applications are made, search and sort among their applicants. Note-taking, rating, e-mail, data downloading and customizable EOE funnctions are available to employers. Also, reference writers can submit their letters online. A paperless application process is possible with this system, however; employers can choose to use any portion of the service. There will be annual employer fees beginning this year. This system was developed at the Duke University Department of Mathematics.

Please direct all questions and comments to: emp-info@ams.org.

Academic Employment in Mathematics

AMS Standard Cover Sheet

Last Name _____

First Name _____

Middle Names _____

Address *through next June* _____ **Home Phone**

_____ _____

_____ **e-mail Address**

_____ _____

Current Institutional Affiliation **Work Phone**

_____ _____

Highest Degree Held or Expected _____

Granting Institution _____ **Date (optional)** _____

Ph.D. Advisor _____

Ph.D. Thesis Title (optional) _____

Indicate *the mathematical subject area(s) in which you have done research using the Mathematics Subject Classification printed on the back of this form or on the AMS website. Use the two-digit classification which best fits your interests in the Primary Interest line and additional two-digit numbers in the Secondary Interest line.*

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 _____

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.*

☐ _____

☐ _____

☐ _____

☐ _____

This form is provided courtesy of the American Mathematical Society.

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

Please print or type. Do not send this form to the AMS.

2000 Mathematics Subject Classification

00 General
01 History and biography
03 Mathematical logic and foundations
05 Combinatorics
06 Order, lattices, ordered algebraic structures
08 General algebraic systems
11 Number theory
12 Field theory and polynomials
13 Commutative rings and algebras
14 Algebraic geometry
15 Linear and multilinear algebra, matrix theory
16 Associative rings and algebras
17 Nonassociative rings and algebras
18 Category theory, homological algebra
19 *K*-theory
20 Group theory and generalizations
22 Topological groups, Lie groups
26 Real functions
28 Measure and integration
30 Functions of a complex variable
31 Potential theory
32 Several complex variables and analytic spaces
33 Special functions
34 Ordinary differential equations
35 Partial differential equations
37 Dynamical systems and ergodic theory
39 Difference and functional equations
40 Sequences, series, summability
41 Approximations and expansions
42 Fourier analysis
43 Abstract harmonic analysis
44 Integral transforms, operational calculus
45 Integral equations
46 Functional analysis
47 Operator theory
49 Calculus of variations and optimal control, optimization
51 Geometry
52 Convex and discrete geometry
53 Differential geometry
54 General topology
55 Algebraic topology
57 Manifolds and cell complexes
58 Global analysis, analysis on manifolds
60 Probability theory and stochastic processes
62 Statistics
65 Numerical analysis
68 Computer science
70 Mechanics of particles and systems
74 Mechanics of deformable solids
76 Fluid mechanics
78 Optics, electromagnetic theory
80 Classical thermodynamics, heat transfer
81 Quantum theory
82 Statistical mechanics, structure of matter
83 Relativity and gravitational theory
85 Astronomy and astrophysics
86 Geophysics
90 Operations research, mathematical programming
91 Game theory, economics, social and behavioral sciences
92 Biology and other natural sciences
93 Systems theory, control
94 Information and communication, circuits
97 Mathematics education

Mathematics Calendar

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

January 2003

*6-7 **DIMACS Workshop on Software Security**, DIMACS Center, Rutgers University, Piscataway, New Jersey.

Short Description: The security of computer systems and networks has become increasingly limited by the quality and security of the software running on these machines. Researchers have estimated that more than half of all vulnerabilities are due to buffer overruns, an embarassingly elementary class of bugs. All too often systems are hacked by exploiting software bugs. In short, a central and critical aspect of the security problem is a software problem. How can we deal with this?

The Software Security Workshop will explore these issues. The scope of the workshop will include security engineering, architecture and implementation risks, security analysis, mobile and malicious code, education and training, and open research issues. In recent years many promising techniques have arisen from connections between computer security, programming languages, and software engineering, and one goal is to bring these communities closer together and crystalize the subfield of software security.

Sponsor: DIMACS Center.

Organizers: G. McGraw (Chair), Cigital, gem@cigital.com, E. Felten, Princeton Univ., felten@cs.princeton.edu, V. Gligor, Univ. of Maryland, gligor@umd.edu, D. Wagner, Univ. of California at Berkeley, daw@cs.berkeley.edu.

Invited Speakers: M. Howard, Microsoft, The Microsoft Trustworthy Computing Initiative from the Inside; B. Kernighan, Coding Excellence: Security as a Side Effect of Good Software; D. Geer, @stake, Software Security in the Big Picture: Repeating ourselves all over again.

Local Arrangements: J. Thiemann, DIMACS Center, jennifer@dimacs.rutgers.edu, 732-445-5928.

Information: http://dimacs.rutgers.edu/Workshops/Software/.

*8-10 **Workshop on Dynamical Stochastic Modeling in Biology**, University of Copenhagen, Denmark.

Description: The main purpose of the workshop is to discuss dynamical stochastic models for biological problems and to identify new areas where such models might be useful. The emphasis of the workshop will be on ecology, gene regulatory networks, and topics in bioinformatics.

Organizers: M. Huebner (Michigan State Univ.) and M. Sørensen (Univ. of Copenhagen).

Confirmed Speakers: B. M. Bibby (The Royal Veterinary and Agricultural Univ., Copenhagen), D. Bray (Univ. of Cambridge), M. Huebner (Michigan State Univ.), V. Isham (Univ. College London), H. de Jong (INRIA, France), C. Laredo (INRA, Paris 6-7), G. Reinert (Univ. of Oxford), M. S. Samoilov (Univ. of California, Berkeley), E. van Someren (Tech. Univ. of Delft), F. Sun (Univ. of Southern California).

Information: http://www.math.ku.dk/~michael/dynbio/.

*28-31 **Nonlinear Evolution Problems**, Rome, Italy.

Program Committee: M. Bertsch, L. Boccardo, E. Magenes (Chairman), A. Tesei.

Organizing Committee: L. Giacomelli, C. Mascia, L. Moschini, M. A. Pozio, A. Tesei.

Invited Speakers: (*) to be confirmed. L. Ambrosio, I. Athanasopoulos, H. Berestycki (*), A. Bressan, L. Caffarelli (*), M. G. Crandall (*), C. Dafermos, G. Da Prato, J. I. Diaz, M. Escobedo, A. Friedman, G. Gilardi, L. Hsiao, S. Kamin, S. Luckhaus, H. Matano (*), W.-M. Ni, F.

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

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

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

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

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

The Mathematics Calendar, as well as Meetings and Conferences of the AMS, is now available electronically through the AMS website on the World Wide Web. To access the AMS website, use the URL: http://www.ams.org/.

Otto (*), S. I. Pohozaev, G. Savare', H. M. Soner, S. Spagnolo, J. L. Vazquez, L. Veron, A. Visintin.
Information: Further information and registration forms are available at: http://www.mat.uniroma1.it/~lincei03/.

February 2003

*27-28 **DIMACS Workshop on Protein Domains: Identification, Classification and Evolution**, DIMACS Center, Rutgers University, Piscataway, New Jersey.
Short Description: The workshop is devoted to computational challenges in this new phase of understanding protein domain organization. The goal of the workshop is to bring together biological and computational/mathematical scientists to discuss the state of the art and the open questions focusing on the following aspects of protein domains: methods for identification of protein domains, protein domain comparison and classification, mechanisms of domain evolution, topological and geometrical properties of protein domains, and the relation between sequence and structure conservation.
Sponsor: DIMACS Center.
Organizers: S. Bryant, Nat. Inst. of Health, bryant@ncbi.nim.nih.gov; T. Przytycka, Johns Hopkins Univ., przytyck@grserv.med.jhmi.edu.
Contact: T. Przytycka, Johns Hopkins Univ., przytyck@grserv.med.jhmi.edu.
Local Arrangements: J. Herold, DIMACS Center, jessicah@dimacs.rutgers.edu; tel: 732-445-5928.
Information: See http://dimacs.rutgers.edu/Workshops/ProteinDomains/.

March 2003

*6-8 **Sixth New Mexico Analysis Seminar**, University of New Mexico, Albuquerque, New Mexico.
Description: This seminar is organized each spring by analysis aficionados at New Mexico State University and The University of New Mexico. The goal is to provide an opportunity for scientific exchange and cooperation among broadly defined analysts. The centerpiece of the seminar is a series of one-hour lectures given by a keynote speaker. There is time allocated for shorter contributed talks. If you would like to attend and /or give a talk, please contact one of the organizers by January 17, 2003. Doctoral students and recent Ph.D.'s are especially encouraged to apply. An online registration form can be found at: http://www.math.unm.edu/colloquia/forms/analysis.php/.
Sponsor: NSF.
Organizers: J. Alvarez (jalvarez@math.nmsu.edu), J. Lakey (jlakey@math.nmsu.edu), C. Pereyra (crisp@math.unm.edu).
Main Speaker: J. Pipher, Brown University, Lectures on "Boundary value problems for elliptic operators: A harmonic analysis approach to issues related to lack of smoothness".
Information: We will provide travel stipends for qualified graduate students. We intend to pay, at least partially, shared accommodations for all participants, and if there are funds left, we will reimburse some travel expenses to those participants who have no other sources of funding (priority given to speakers). Information about the conference will be posted at: http://www.math.unm.edu/colloquia/analysis_seminar.php/.

*12-14 **DIMACS Working Group Meeting on Mathematical and Computational Aspects Related to the Study of the Tree of Life**, DIMACS Center, Rutgers University, Piscataway, New Jersey.
Short Description: Vast quantities of molecular data are becoming available, and there is a need to provide efficient computer algorithms that will appropriately scale to accommodate the size and quality of the underlying data sets. We recognize that for many reasons viral evolution may have features not necessarily present in the evolution of organisms on a multicellular scale. Since a workshop on the role of evolution in epidemiology is in the planning stage, our intention is to not focus on such organisms. There are a number of possible topics. We just indicate some possible themes here. We intend to ask the bioconsensus community for suggestions. First of all should this Tree of Life really be a tree, or is some other data structure a more plausible model? Certainly certain local portions of evolutionary structure should be treelike, but when these local structures are assembled, should they form a supertree or some more general structure? Here we wish to compare mathematical theory with current research trends in the biological community. We hope that the biologists will suggest areas they find useful, as opposed to mathematicians just suggesting models of interest to them.
Sponsor: DIMACS Center.
Organizers: M. F. Janowitz, DIMACS, melj@dimacs.rutgers.edu; F. R. McMorris, Illinois Inst. of Tech., mcmorris@iit.ed; F.-J. Lapointe, Univ. de Montreal, lapoinf@biol.umontreal.ca.
Contact: M. F. Janowitz, DIMACS, melj@dimacs.rutgers.edu.
Local Arrangements: J. Herold, DIMACS Center, jessicah@dimacs.rutgers.edu; tel: 732-445-5928.
Information: http://dimacs.rutgers.edu/Workshops/Tree/.

*15-19 **Arizona Winter School on "Logic and Number Theory"**, University of Arizona, Tucson, Arizona.
Topics: Motivic and p-adic integration, model theory and diophantine geometry, Hilbert's tenth problem, elementary equivalence of finitely generated fields, and the history of interactions between logic and number theory.
Speakers: F. Loeser, A. Macintyre, A. Pillay, B. Poonen, F. Pop, T. Scanlon.
Organizers: M. Kim, A. Pillay, B. Poonen.
Deadline: Applications for funding or for participation in a student project should be received by mail by December 31, 2002.
Information: http://swc.math.arizona.edu/~swcenter/newaws/index.html.

*23-29 **INGO2003: Invariant Theory and Its Interactions with Related Fields**, University of Göttingen, Germany.
Theme: INGO2003 is an initiative of research groups in Aberdeen, Manchester, and Göttingen working in the areas of algebraic topology, representation theory, and commutative algebra who have found that communication across narrow specialty boundaries can bring huge scientific benefits. The conference is organized around the central theme of invariant theory and will emphasize its interactions with other areas of mathematics. It is particularly addressed to young mathematicians from diverse research areas who wish to exchange ideas and learn new techniques that may point the way for their future work.
Invited Speakers: L. Avramov (Univ. of Nebraska), J. Hartmann (Univ. of Heidelberg), R. Kane (Univ. of Western Ontario), M. D. Neusel (Texas Tech Univ.), N. Nossem (Univ. of Sheffield), A. Shepler (Texas State Univ.), W. M. Singer (Fordham Univ.), P. Symonds (Manchester Inst. of Tech.), W. Traves (U.S. Naval Academy), G. Walker (Manchester Univ.), R. Wood (Manchester Univ.).
Scientific Committee: S. Betley (Univ. of Warsaw), J. Hubbuck (Univ. of Aberdeen), N. H. V. Hu'ng (Vietnam National Univ.), K. Lesh (Union College), D. M. Meyer (Univ. of Göttingen), L. Smith (Univ. of Göttingen), T. A. Springer (Univ. of Utrecht).
Local Organizers: D. M. Meyer (Univ. of Göttingen), L. Smith (Univ. of Göttingen).
Information: email: organizers@ingo2003.de, or visit http://www.ingo2003.de/.

*24-28 **Mathematical Theory of Hyperbolic Systems of Conservation Laws**, Newton Institute of Mathematical Sciences, Cambridge, UK.
Description: Nonlinear hyperbolic systems of conservation laws govern a broad spectrum of physical phenomena in compressible fluid dynamics, nonlinear material science, etc. Such equations admit solutions that may exhibit shock waves and other nonlinear

waves (propagating phase boundaries, fluid interfaces, etc.) which play a dominant role in multiple areas of physics. Recent developments on the theory of one-dimensional systems will be covered, including: entropy conditions, L1 well-posedness, singular limits, diffusive approximations, relaxation models, kinetic relations, shock wave structure, links with thermodynamics, etc.
Sponsor: Newton Institute of Mathematical Sciences, Cambridge.
Information: http://www.cmap.polytechnique.fr/~lefloch/newton-conf.html.

*31-April 4 **Multiphase Fluid Flows and Multi-Dimensional Hyperbolic Problems**, Newton Institute of Mathematical Sciences, Cambridge, UK.
Description: This second week will focus on multidimensional aspects of hyperbolic conservation laws and on computational methods with applications to multiphase flows. A partial list of topics includes: existence theory for multidimensional hyperbolic equations, transonic flow models, mathematical modeling of liquid-vapor flows, numerical schemes for multiphase flows, nonconservative hyperbolic systems, real fluids, material interfaces, etc.
Sponsor: Newton Institute of Mathematical Sciences, Cambridge.
Information: http://www.cmap.polytechnique.fr/~lefloch/newton-conf.html.

April 2003

*5-6 **CombinaTexas: Combinatorics Conference in the South-Central U.S.**, Southwest Texas State University, San Marcos, Texas.
Description: This will be the fourth annual meeting of CombinaTexas, a conference series intended to increase communication between mathematicians in the region, promote the research of the regional combinatorics community, and bring in leading combinatorialists from elsewhere. This year the conference has a special focus on Graph Theory and Its Applications. The conference topics range over a variety of areas around the special focus, including computational graph theory; topological graph theory; random graphs; and applications to algorithms, geometry, and number theory.

The conference will be set around 7 one-hour talks delivered by internationally recognized researchers. There will be sessions of contributed papers and poster exhibitions, for which we welcome submission.
Sponsors: Southwest Texas State Univ., Texas A&M Univ.
Organizers: D. Ferrero (dferrero@swt.edu), X. Jia (jia@swt.edu), C. Yan (cyan@math.tamu.edu).
Invited Speakers: J. Bagga (Ball State Univ.); N. Dean (Rice Univ.); F. Harary (New Mexico State Univ.); E. Kubicka (Univ. of Kentucky); M. Nathanson (City Univ. of New York); V. Vu (Univ. of California at San Diego); H. Wilf (Univ. of Pennsylvania).
Call for Papers: Contributed talks of 15 minutes in length are invited, as well as posters. To contribute a talk or a poster, submit the title and abstract by March 15, 2003, to C. Yan (cyan@math.tamu.edu) or D. Ferrero (dferrero@swt.edu).
Information: http://www.math.tamu.edu/~cyan/combinatexas/2003/index.html.

May 2003

*18-21 **Second International Workshop on Computer Graphics and Geometric Modeling, CGGM'2003**, Delta Centreville Hotel, Montreal, Canada.
Description: In the last few years, computer graphics and geometric modeling have become some of the most important and challenging areas of computer science. This workshop solicits for presentation high-quality papers describing original research results in computer graphics and geometric modeling (see topics below).

All accepted papers will be published as full papers in the Springer-Verlag Lecture Notes in Computer Science (LNCS) series. In addition, all accepted papers will be scheduled for oral presentation. Submission implies the willingness of at least one of the authors to register and present the paper.
Topics: Geometric modeling; solid modeling; physically based modeling; surface reconstruction; volume visualization; autonomous agents; computer animation; computer graphics in art, education, engineering, entertainment and medicine; rendering techniques; multimedia; non-photo-realistic rendering; virtual reality; virtual environments; illumination models; texture models; computer graphics and the Internet (VRML, Java, etc.); artificial intelligence for computer graphics; computer graphics software; computer graphics applications; computer graphics education; industrial applications of computer graphics.
Language: English.
Deadlines: January 7, 2003: Draft papers due; February 5, 2003: Notification of acceptance; February 20, 2003: Camera-ready papers; February 28, 2003: Preregistration.
Information: The workshop allows prospective authors to send a full paper by email: iglesias@unican.es. All submissions must be written in English. Send the paper as an attachment provided that the size of the message is reasonable (less than 4 MB). Otherwise, please contact us before sending the paper. Acceptable formats are PDF and PostScript (use extension .pdf or .ps respectively). You can also send your paper by airmail to: A. Iglesias, Dept. of Applied Mathematics and Computational Sciences, University of Cantabria, E.T.S.I. de Caminos, Canales y Puertos, Avda. de los Castros, s/n, Santander, E-39005, Spain, and also send any problems to the above address. However, we strongly recommend you use email for paper submission. The style files for the LNCS can be found at the following URL: http://www.springer.de/comp/lncs/authors.html.

*19-22 **Workshop on Dynamics and Bifurcations of Patterns in Dissipative Systems**, Colorado State University, Fort Collins, Colorado.
Sponsors: National Science Foundation, Colorado State Univ.
Program: Recent experimental results have demonstrated a variety of new patterns that can be observed in macroscopic systems far from equilibrium. Understanding these patterns is a major challenge for theoretical research. The workshop will stimulate the interaction between different experts, young researchers, and advanced graduate students in identifying key ideas, new advances, and open questions in the mathematical analysis of spatiotemporal patterns in dissipative systems, including both continuous systems and coupled cells.
Description: The goal of the workshop is to discuss relations between different approaches such as center manifolds and normal forms, singular perturbation methods, modulation and phase diffusion equations; and to stimulate the interaction between experts in equivariant bifurcation theory, pattern formation and dynamical systems. Specific topics include bifurcation of periodic and quasiperiodic patterns, spiral and target waves, heteroclinic cycles, phase dynamics and phase turbulence, fronts and modulated fronts, localized structures (pulses and solitary waves), bursting, intermittent and chaotic dynamics, symmetry breaking through discretization and its numerical implications. Applications will be presented in fluid mechanics, astrophysics, nonlinear oscillators and other systems.
Main Topics: Stability, bifurcation and dynamics of patterns; reduction of the governing equations; the role of symmetry.
Invited Speakers (tentative list): D. Armbruster, Arizona State Univ., Localized structures in parametrically forced systems; E. Bodenschatz, Cornell Univ., Experiments in thermal convection and spatiotemporal chaos; C. B. Ermentrout, Univ. of Pittsburg, Patterns in neuronal networks; M. Golubitsky, Univ. of Houston, Symmetries, pattern formation, and geometric visual hallucinations; G. Gunaratne, Univ. of Houston, Characterizations of complex patterns and their applications; J. Lega, Univ. of Arizona, Phase diffusion and weak turbulence; E. Knobloch, Univ. of California, Berkeley, Bursts and intermittency in fluid mechanics; I. Melbourne, Univ. of Surrey, Mathematical foundations of Ginzburg Landau theory; M. Proc-

tor, DAMTP Cambridge, UK, Hydrodynamic instabilities; H. Riecke, Northwestern Univ., to be announced; M. Silber, Northwestern Univ., Bifurcation with symmetry and superlattices.
Organizers: G. Dangelmayr and I. Oprea, Colorado State Univ.
Information: http://www.math.colostate.edu/~juliana/DynBifPat.html.

28-31 **ACMS 14th Biennial Conference**, Point Loma Nazarene University, San Diego, California.
Description: The Association of Christians in the Mathematical Sciences will sponsor their 14th conference since 1977. Paul Zorn from St. Olaf College is the featured speaker.
Conference Chair: G. Crow, Dept. of Math., Point Loma Nazarene University, San Diego, CA 92106; email: gcrow@ptloma.edu.
Information: For information or to submit abstracts of proposed papers, contact the conference chair.

28-31 **Quantum and Reversible Computation**, State University of New York at Stony Brook.
Goal: The goal of this conference is to generate interaction between mathematicians interested in efficient quantum algorithms and quantum error-correcting codes, and physicists trying to build quantum computers. We will stimulate this interaction with lectures on the most important recent developments by world experts.
Organizers: C. N. Yang Institute for Theoretical Physics, and Inst. for Math. Sci.
Organizing Committee: D. Averin, T. Bergeman, J. Glimm, P. D. Grannis, D. Gromoll, A. Kirillov, V. Korepin (chairman), H. B. Lawson, K. Likharev, J. Lukens, H. Metcalf, J. Milnor, S. Popescu, V. Semenov, G. Sterman, S. Sutherland, and W. Weisberger.
Confirmed Speakers: D. Averin, SUNY at Stony Brook; I. Cirac, Max-Planck-Institute, Munich; M. Devoret, Yale; D. DiVincenzo, IBM; E. H. Farhi, MIT; R. Fazio, Scuola Normale Superiore, Pisa, Italy; S. Han, Univ. of Kansas; M. Hillery, Hunter College, CUNY; H. Kwong Lo, MagiQ Technologies; L. Levitin, Boston Univ.; J. Lukens, SUNY at Stony Brook; C. Monroe, Univ. of Michigan, Ann Arbor; L. A. Orozco, SUNY at Stony Brook; V. Semenov, SUNY at Stony Brook; P. Shor, AT&T; H. Yuen, North West Univ.; P. Zoller, Institute for Theoretical Physics, Univ. of Innsbruck.
Information: http://insti.physics.sunysb.edu/itp/conf/simons-qcomputation.html.

June 2003

2-4 **International Workshop on Computer Algebra Systems and Their Applications, CASA'2003**, Saint Petersburg, Russian Federation.
Description: Computer algebra (also known as symbolic computation or computational algebra) has found applications in many domains of science such as mathematics, physics, chemistry, engineering, computer science, computational biology, education, etc. The computer algebra systems (cas) such as Mathematica, Maple, MuPAD, Reduce, Axiom (and others that have been developed) are becoming more and more popular and now they are valuable tools for teaching, research, and industry. This workshop solicits for presentation high-quality papers describing original research results in computer algebra systems and their applications.

All accepted papers will be published as full papers in the Springer-Verlag Lecture Notes in Computer Science (LNCS) series. In addition, all accepted papers will be scheduled for oral presentation. Submission implies the willingness of at least one of the authors to register and present the paper.
Topics: This workshop is intended to cover recent developments (algorithms, programs, packages, extensions, new tools, etc.) developed for computer algebra systems. Emphasis will be put on the applications of these systems for solving problems in science and engineering. Thus, we accept papers describing research on actual or possible applications of computer algebra systems and techniques to other fields (such as mathematics, physics, chemistry, engineering, computer science, education, industry, etc.). Papers exploring the interaction of the symbolic, numerical, and graphical tools of the computer algebra systems to solve complex problems are also welcomed.
Language: English.
Topics: The topics to be addressed include, but are not limited to: computer algebra applications to mathematics, physics, chemistry, engineering, biology, computer science, social sciences, etc.; symbolic-numerical computations using computer algebra systems; computer algebra systems and the Internet; industrial applications of computer algebra; problem-solving environments; symbolic-numeric interface; computer algebra systems in education; computer algebra-based simulations; new computer algebra developments (packages, notebooks, etc.).
Deadlines: January 10, 2003: Draft papers due; February 5, 2003: Notification of acceptance; February 20, 2003: Camera-ready papers; February 28, 2003: Preregistration.
Information: email: iglesias@unican.es; http://personales.unican.es/iglesias/TSCG2003/.

* 2-4 **Technical Session on Computer Graphics, TSCG'2003**, Saint Petersburg, Russian Federation.
Description: Nowadays, computer graphics is recognized as one of the important and challenging areas of computer science. This technical session solicits for presentation high-quality papers describing original research results in computer graphics.

All accepted papers will be published as full papers in the Springer-Verlag Lecture Notes in Computer Science (LNCS) series. In addition, all accepted papers will be scheduled for oral presentation. Submission implies the willingness of at least one of the authors to register and present the paper.
Language: English.
Topics: This technical session will accept original papers describing research on computer graphics. Therefore there is no restriction about the paper contents, provided that the subject is computer graphics or any related area. The paper should clearly identify the computer graphics field of the paper in order to speed up the reviewing process. In addition, the paper should emphasize the problem to be solved, the procedure to do it, and the potential or actual applications of the paper.

Survey papers can be accepted on the basis that they provide an interesting new approach to some specific field or they include an organized, well-structured review with a well-documented bibliography so that the paper can be useful for beginners.

Finally, papers describing hardware and/or software systems for any computer graphics topics are also welcomed.
Deadlines: December 20, 2003: Draft papers due; February 1, 2003: Notification of acceptance; February 20, 2003: Camera-ready papers; February 28, 2003: Preregistration.
Information: email: iglesias@unican.es; http://personales.unican.es/iglesias/TSCG2003/.

* 5-8 **Call for Papers: Hawaii International Conference on Statistics and Related Fields**, Sheraton Waikiki Hotel, Honolulu, Hawaii.
Description: The conference will provide many opportunities for academicians and professionals from statistics and related fields to interact with members inside and outside their own particular areas of specialization. Cross-disciplinary submissions are welcome.
Topic Areas: (All areas of statistics and related fields are invited), agricultural statistics, applied statistics, Bayesian statistics, biostatistics, biomedical statistics, business statistics, computational statistics, computer simulations, econometrics, educational statistics, environmental statistics, epidemiology, industrial statistics, management science, mathematical statistics, medical statistics, nonparametric statistics, operations research, probability, psychological measurement and statistics, quantitative methods, statistics, statistical modeling, teaching of statistics, other areas of statistics.
Submission Deadline: January 16, 2003.
Sponsor: Univ. of Hawaii-West Oahu.

Information: Visit http://www.hicstatistics.org/, or email: statistics@hicstatistics.org.

*13-22 **Poisson Geometry, Deformation Quantisation and Group Representations (PQR2003)**, Universersité Libre de Bruxelles, Belgium.
Description: The aim of the meeting is to bring together specialists of the three themes in the title, for a Summer School and a Conference. The Summer School (June 13-17) will consist of short courses (of four or five hours each) by: A. Cattaneo (Formality and Star Products), I. Moerdijk (Lie Groupoids and Lie Algebroids), W/ Schmid (Geometric Methods in Representation Theory) and A. Weinstein (Morita Equivalence in Poisson geometry), together with a broad presentation of Deformation Quantisation by D. Sternheimer. The conference (June 18-22) will consist of lectures and informal interactions.
Invited Participants: D. Arnal, M. Bertelson, R. Brylinski, H. Bursztyn, A. Cattaneo, A. Connes, B. Fedosov, R Fernandes, C. Fronsdal, E. Getzler, Y. Karshon, M. Kontsevich, B. Kostant, Y. Kosmann-Schwarzbach, P. Lecomte, J.-H. Lu, Y. Maeda, I. Moerdijk, R. Nest, T. Ratiu, J. Rawnsley, W. Schmid, L. Schwachhoefer, C. Simpson, D. Sternheimer, D. Tamarkin, C. Torossian, K. Vilonen, S. Waldmann, A. Weinstein, P. Xu. There will be poster sessions.
Deadlines: Funding for young E. U. researchers or other financial support: apply preferably before December 15, 2002. Guaranteed special price at the conference hotel (90 euros): register before December 31, 2002.
Information: Visit http://homepages.ulb.ac.be/~pqr2003/. Registration: pqr2003@ulb.ac.be.

*23-27 **15th International Conference on Formal Power Series and Algebraic Combinatorics**, Linköping University, Vadstena, Sweden.
Organizing Committee: S. Linusson (Sweden, Chair), H. Barcelo (USA), A. Duval (USA), J. Gill (Sweden), J. Wästlund (Sweden).
Topics: All aspects of combinatorics and their relationship with other parts of mathematics, computer science, physics, and biology.
Invited Speakers: I. Bárány (Hungary), F. Chung, (USA), J. Håstad, (Sweden), O. Häggström (Sweden), A. Lascoux (France), P. Leroux (Canada), I. Novik (Israel/USA), R. Shamir (Israel), R. Stanley (USA)
Official Languages: English and French.
Deadlines: Paper and poster submission: Extended abstracts of at most twelve pages by November 24, 2002. Software submission: January 15, 2003. Registration: April 1, 2003. Open problem session: June 1, 2003.
Information: http://www.mai.liu.se/fpsac/ or email: fpsac@mai.liu.se.

*23-27 **Hyperbolic Models in Astrophysics and Cosmology**, Newton Institute of Mathematical Sciences, Cambridge, UK.
Description: Hyperbolic problems in astrophysics and cosmology (relativistic compressible fluid models, the Einstein field equations of general relativity) are particularly challenging for the applied mathematician. They are essential in order to uncover the structure and formation of the universe. Main topics: general relativity, linear and nonlinear hyperbolic equations, Riemann solvers, shock waves in general relativity, well-posedness theory for the Einstein equations, black hole geometries, interaction of gravity with other force fields, etc.
Sponsors: Newton Institute of Mathematical Sciences, Cambridge, and the European Community.
Information: http://www.cmap.polytechnique.fr/~lefloch/newton-conf.html or Philippe G. LeFloch (lefloch@cmap.polytechnique.fr).

July 2003

*1-10 **PI-Rings: Structure and Combinatorial Aspects (summer course)**, Bellaterra, Barcelona, Spain.
Aim: To introduce students to the structural and combinatorial theory of algebras satisfying polynomial identities (PI-algebras).
Lecturers: V. Drensky (Bulgarian Acad. of Sci.), E. Formanek (Penn. State Univ.).
Program: Structure theorems of Kaplansky, Posner and Artin; Ring of generic matrices; Generic division ring and its relation with the theory of central simple algebras; Structure of the center of the generic division ring; Amitsur-Levitzki theorem; Construction of central polynomials for matrices; Polynomial identities of matrices and their relation with invariant theory; Nagata-Higman theorem; Shirshov theorem; Regev theorem.
Coordinator: F. Cedó.
Scientific Committee: P. Ara, D. Herbera.
Organizing Committee: R. Camps, F. Cedó.
Deadlines: For applications for financial support, April 25; for registration and payment, May 31.
Information: email: PI-rings@crm.es, or visit http://www.crm.es/PI-rings/.

*6-12 **Journées Arithmétiques XXIII**, Universität Graz, Graz, Austria.
Topics: All branches of number theory.
Contact: email: ja03@tugraz.at.
Information: http://ja03.math.tugraz.at/.

*8-11 **Applications of Plausible, Paradoxical, and Neutrosophical Reasoning for Information Fusion (FUSION 2003)**, Radisson Hotel, Cairns, Queensland, Australia.
Topics: Applications of Neutrosophic Logic in Information Fusion, Generalization of Dempster-Shafer Theory of Evidence to DSm Theory.

*9-12 **2003 Summer Conference on Topology and Its Applications**, Howard University, Washington, DC.
Plenary Speakers: V. Bergelson (Ohio State), W. W. Comfort (Wesleyan Univ.), N. Kamran (McGill Univ.), J. van Mill (Vrije Univ.), P. Olver (Univ. of Minnesota), A. Simpson (Univ. of Edinburgh).
Workshop Leader: S. Todorčević.
Special Sessions: Session in honor of W. Comfort: S. Garcia-Ferreira (Univ. Nacional Autonoma de Mexico), J. Trigos-Arrieta (Calif. State Univ., Bakersfield), G. Woods (Univ. of Manitoba); Set Theoretic Topology: J. Kulesza (George Mason Univ.), A. Dow (Univ. of North Carolina at Charlotte); Topological Dynamics and Ergodic Theory: J. Kennedy (Univ. of Delaware), R. McCutcheon (Univ. of Memphis); Topological Groupoids and Their Applications: J. Leslie (Howard Univ.), T. Robart (Howard Univ.); Topological Groups and Semigroups: K. Hofmann (Tech. Univ. Darmstadt and Tulane Univ.), D. Strauss (Univ. of Hull); Topology and Computer Science: J. Lawson (Louisiana State Univ.), M. Mislove (Tulane Univ.).
Local Organizing Committee: N. Hindman (Howard Univ.), J. Leslie (Howard Univ.), A. Maleki (Howard Univ.), T. Robart (Howard Univ.), S. El-Helaly (Catholic Univ.), J. Kulesza (George Mason Univ.).
Information: http://members.aol.com/nhindman/sumtopo/.

*12-17 **What Comes beyond the Standard Model? Symmetries beyond the Standard Model**, Hotel Histrion, Portoroz, Slovenia.
Scope: The experimental and theoretical research in elementary particle physics and cosmology has brought a new understanding of the laws of nature. The standard models of elementary particle physics and cosmology have left many open questions unanswered. New very sophisticated and costly experiments are in preparation which should help answer the open questions and which require very precise predictions. Confrontations between all new ideas as manifested in new approaches, models and theories are therefore needed. The meeting will gather together physicists and mathematicians who have already contributed new ideas and approaches to review the accumulated knowledge and confront new ideas in elementary particle physics, cosmology, and relevant fields of mathematics.
Invited Speakers (list to be completed): R. Aleksan (CEA Saclay, DAPNIA/SPP, Gif-sur-Yvette, France); E. Alvarez (Univ. Autonoma,

Madrid, Spain); I. Antoniadis (CERN, Geneva, Switzerland); L. Bonora (SISSA, Trieste, Italy); M. Duff (Univ. of Michigan, Ann Arbor, USA); R. Jackiw (MIT, Cambridge, USA); D. Kazakov (Joint Inst. for Nuclear Research, Dubna, Russia); E. Kiritsis (Univ. of Crete, Heraklion, Greece); F. Lizzi (Univ. di Napoli Federico II, Italy); J. Madore (Univ. of Paris-Sud, Orsay, France); L. Smolin (Perimeter Inst. for Theoretical Physics, Waterloo, Canada); D. Kreimer (Boston Univ., USA); A. Wassermann (Univ. of Bayreuth, Germany).
Chairs: N. Mankoc-Borstnik (Univ. of Ljubljana, SI), chair; H. B. Nielsen (Niels Bohr Institute, Copenhagen, DK), vice chair.
Deadline: 14 April 2003.
Information: Program and application form: `http://www.esf.org/euresco/03/pc03190/`.

* 21–25 **The Władysław Orlicz Centenary Conference and Function Spaces VII**, Faculty of Mathematics and Computer Science, Adam Mickiewicz University, Poznań, Poland.
Brief Description: This international conference is dedicated to the outstanding mathematician Władysław Orlicz (1903–1990) on the occasion of his birthday centenary. This conference will be joined with the Seventh International Conference on Function Spaces, which will take place at the same time as afternoon sessions. The program of the conference in honor of Orlicz will consist only of twelve 55-minute invited plenary lectures concentrated around scientific traditions of Władysław Orlicz and his influence on contemporary mathematics. Function Spaces VII is devoted to the wide range of problems in the theory of function spaces, in particular to operators and interpolation in function spaces, geometry and topology of function spaces, decomposition of functions, approximation and related topics. The scientific program will consist of invited plenary lectures (50 minutes) and short communications (20 minutes).
Organizing Committee: Z. Palka (chairman), B. Bojarski (vice chairman), S. Janeczko (vice chairman), L. Skrzypczak (secretary).
Deadline: The deadline for abstract submission is March 2003. Further details and information will be available at `http://orlicz.amu.edu.pl/`.

September 2003

* 2–5 **Symposium for the Developments of the Cantorian Set Theory**, Paris, France.
Organizers: F. Collot, R. Saumont, F. Anceau.
Program and Call for Papers: Search of New Axioms for the Set Theory, the Browerian Conceptions Revisited, Continuum Hypothesis, Well-Ordering on the Continuum, Generalized Continuum Hypothesis, Problem of the Countable Ordinal Numbers ε, Exotic Irrational Numbers, Nonstandard Analysis, Conway's Numbers, Applications to Computer Science, Quantic Theory, Biology, Cosmology.
Submission: Extended abstracts (at most 6 pages) of papers to be presented at the conference to: F. Collot, 4 rue Mayet 75006, Paris, before June 1, 2003. Abstracts or papers will be published in the journal *Bio-Math.*
Information: email: `editions.europeenne@wanadoo.fr`.

* 2–6 **The Barcelona Conference on Asymptotic Statistics**, Bellaterra, Barcelona, Spain.
Aim: The aim of the conference is to open a new line of international events devoted to asymptotic methods in statistics.
Topics: Inference for continuous-time stochastic processes, linear and nonlinear time series, wavelets and theory of extreme values.
Main Speakers: D. Boscq (Univ. Paris 6), R. Cao (Univ. de A Coruña), A. V. Ivanov (Internat. Christian Univ., Kyïv), I. Johnstone (Stanford Univ.), R. Khasminskii (Wayne State Univ.), U. Küchler (Humboldt-Univ. zu Berlin), Y. Kutoyants (Univ. de Maine) A. Le Breton (Univ. Joseph Fourier), T. Mikosch (Univ. of Copenhagen).
Coordinator: V. Zaiats.
Scientific Committee: Y. Kutoyants, U. Küchler, F. Utzet, and V. Zaiats.
Organizing Committee: F. Utzet, P. Puig, W. González, and V. Zaiats.
Deadlines: For applications for financial support, May 23; for registration and payment, June 30.
Information: email: `bas2003@crm.es` or visit `http://www.crm.es/bas2003/`.

* 4–9 **Analytic Methods of Analysis and Differential Equations (AMADE-2003)**, Belarusian State University, Minsk, Belarus.
Description: Belarusian State University (BSU) and Institute of Mathematics of Belarusian National Academy of Sciences, together with Moscow State University, organize the 3rd International Conference "Analytic Methods of Analysis and Differential Equations (AMADE-2003)" on September 4–9, 2003, in Minsk, Belarus. The arrival and departure days are September 3 and 10. The conference will be held under the guidance of ISAAC (International Society of Analysis, Applications and Computations).
Topics: Integral Transforms and Special Functions; Differential Equations and Applications; Integral, Difference, Functional Equations and Fractional Calculus; Real and Complex Analysis.
Organizing Committee: I. V. Gaishun (Belarus, cochair), V. A. Il'in (Russia, cochair), A. V. Kozulin (cochair), A. A. Kilbas (Belarus, vice chair), M. V. Dubatovskaya (Belarus, secretary), S. V. Rogosin (Belarus, secretary), H. Begehr (Germany), V. I. Burenkov (Great Britain), V. V. Gorokhovik (Belarus), N. A. Izobov (Belarus), V. I. Korzyuk (Belarus), P. A. Mandrik (Belarus), E. I. Moiseev (Russia), S. G. Samko (Portugal), N. I. Yurchuk (Belarus).
Program Committee: P. Adler (France), M. Dzhenaliev (Kazakhstan), H.-J. Glaeske (Germany), R. Gorenflo (Germany), V. I. Gromak (Belarus), N. K. Karapetyants (Russia), V. S. Kiryakova (Bulgaria), A. I. Kozhanov (Russia), A. Kufner (Czech), Kun Soo Chang (Korea), I. Laine (Finland), O. I. Marichev (USA), V. V. Mityushev (Poland), O. A. Repin (Russia), E. A. Rovba (Belarus), V. N. Rusak (Belarus), M. Saigo (Japan), S. Saitoh (Japan), A. A. Sen'ko (Belarus), A. P. Soldatov (Russia), J. J. Trujillo (Spain), N. A. Virchenko (Ukraine), L. A. Yanovich (Belarus).
Deadline: Let us know by the end of December 2002 about your intention to participate in the conference. Please send the following information: Your name, affiliation and position, mailing address and telephone (fax), email, section title, and title of report to: AMADE-2003, Dept. of Math. and Mech., Belarusian State Univ., Fr. Skaryny Ave. 4, 220050 Minsk 50, Belarus; email: `amade@im.bas-net.by` and `amade@bsu.by`; `http://amade.virtualave.net/`.

* 16–20 **The Barcelona Conference on Set Theory**, Bellaterra, Barcelona, Spain.
Aim: To present the latest developments and results in all areas of set theory and their applications to other areas of mathematics.
Topics: Descriptive set theory, inner model theory, forcing, infinite combinatorics, and applications to analysis.
Main Speakers: M. Dzamonja (Univ. of East Anglia), I. Farah (York Univ.), J. Hirschorn (Instit. für Formale Logik, Univ. Wien), R. Schindler (Instit. für Formale Logik, Univ. Wien), O. Spinas (Christian-Albrechts-Univ. zu Kiel), J. Zapletal (Univ. of Florida, Gainesville).
Coordinator: J. Bagaria.
Program Committee: A. Blass, S. Friedman, S. Todorcevic, and W. H. Woodin.
Local Organizing Committee: D. Asperó, J. Bagaria, R. Bosch, J. Llopis, and J. López-Abad.
Deadlines: For applications for financial support, May 23; for registration and payment, June 30.
Information: email: `set-theory@crm.es` and website: `http://www.crm.es/set-theory/`.

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.

New Publications Offered by the AMS

Algebra and Algebraic Geometry

A Scrapbook of Complex Curve Theory

Second Edition

C. Herbert Clemens, *Ohio State University, Columbus*

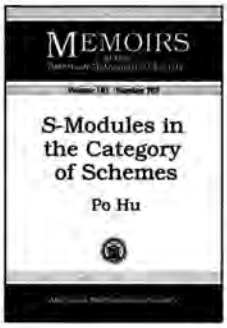
This fine book by Herb Clemens quickly became a favorite of many complex algebraic geometers when it was first published in 1980. It has been popular with novices and experts ever since. It is written as a book of "impressions" of a journey through the theory of complex algebraic curves. Many topics of compelling beauty occur along the way. A cursory glance at the subjects visited reveals an apparently eclectic selection, from conics and cubics to theta functions, Jacobians, and questions of moduli. By the end of the book, the theme of theta functions becomes clear, culminating in the Schottky problem.

The author's intent was to motivate further study and to stimulate mathematical activity. The attentive reader will learn much about complex algebraic curves and the tools used to study them. The book can be especially useful to anyone preparing a course on the topic of complex curves or anyone interested in supplementing his/her reading.

Contents: Conics; Cubics; Theta functions; The Jacobian variety; Quartics and quintics; The Schottky relation; References; Additional references; Index.

Graduate Studies in Mathematics, Volume 55

January 2003, 188 pages, Hardcover, ISBN 0-8218-3307-3, LC 2002033352, 2000 *Mathematics Subject Classification*: 14-01, 14H05, 14H42, 14K25, 30Fxx, 32G15, **All AMS members***, List $39, Order code GSM/55N



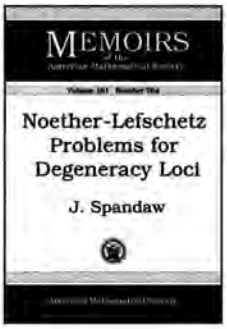
S-Modules in the Category of Schemes

Po Hu, *University of Chicago, IL*

Contents: Introduction; Preliminaries; Coordinate-free spectra; Coordinatized prespectra; Comparison with coordinatized spectra; The stable simplicial model structure; The $\mathbb{A}^1$-local model structure; Characterization of $\mathbb{A}^1$-weak equivalences; Change of universe; The space of linear injections preserving finite subspaces; Twisted half-smash products and twisted function spectra; The category of $\mathbb{L}$-spectra; Unital properties of $\mathbb{L}$-spectra; The category of S-modules; S-algebras and their modules; Proofs of the model structure theorems; Technical results on the extended injections operad; Appendix: Small objects in the category of simplicial sheaves; Bibliography.

Memoirs of the American Mathematical Society, Volume 161, Number 767

January 2003, 125 pages, Softcover, ISBN 0-8218-2956-4, LC 2002033244, 2000 *Mathematics Subject Classification*: 55P42, 55P48; 14F42, **Individual member***, List $53, Institutional member*, Order code MEMO/161/767N



Noether-Lefschetz Problems for Degeneracy Loci

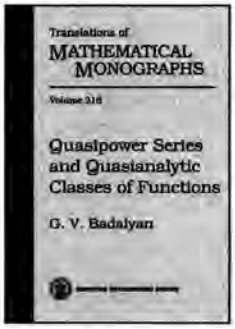
J. Spandaw, *Institut für Mathematik, Universität Hannover, Germany*

Contents: Introduction; The Monodromy theorem; Degeneracy loci of corank one; Degeneracy loci of arbitrary corank; Degeneracy loci in projective space; Examples; A: On the cohomology of $\mathbb{G}(s,F)$; Frequently used notations; Bibliography.

Memoirs of the American Mathematical Society, Volume 161, Number 764

January 2003, 136 pages, Softcover, ISBN 0-8218-3183-6, LC 2002033241, 2000 *Mathematics Subject Classification*: 14F05, 14C30; 14F17, **Individual member***, List $55, Institutional member*, Order code MEMO/161/764N

Analysis



Quasipower Series and Quasianalytic Classes of Functions

G. V. Badalyan, *Armenian Academy of Sciences, Yerevan*

In this book, G. V. Badalyan addresses the fundamental problems of the theory of infinitely-differentiable functions using the theory of functions of quasianalytic classes.

A certain class of functions C on an interval is called quasianalytic if any function in C is uniquely determined by the values of its derivatives at any point. The obvious question, then, is how to reconstruct such a function from the sequence of values of its derivatives at a certain point. In order to answer that question, Badalyan combines a study of expanding functions in generalized factorial series with a study of quasipower series.

The theory of quasipower series and its application to the reconstruction problem are explained in detail in this research monograph. Along the way other, related problems are solved, such as Borel's hypothesis that no quasianalytic function can have all positive derivatives at a point.

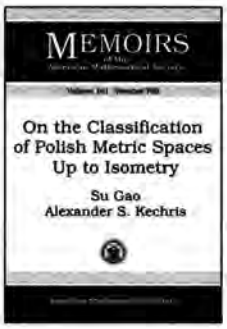
Originally published in Russian, this English translation contains additional material that treats the problems of classification of infinitely-differentiable functions, conditions for absolute convergence of quasipower series in terms of the functions that generate them, and the possibility of representing analytic functions by quasipower series in non-circular domains.

While the treatment is technical, the theory is developed chapter by chapter in detail, and the first chapter is of an introductory nature. The quasipower series technique explained here provides the means to extend the previously known results and elucidates their nature in the most relevant manner. This method also allows for thorough investigation of numerous problems of the theory of functions of quasianalytic classes by graduate students and research mathematicians.

Contents: Quasianalytic classes of functions; Generalizations of the Taylor formula. Quasipower series; Functions of Carleman's classes: Expansion in quasipower series; Criteria for the possibility of expanding functions in quasipower and factorial series; Generalized completely monotone functions and the condition for absolute convergence of a quasipower series (in the basic interval); On the use of quasipower series for representation of analytic functions in non-circular domains; Some applications of quasipower series to the theory of functions of quasianalytic classes; Bibliography.

Translations of Mathematical Monographs, Volume 216

December 2002, 183 pages, Hardcover, ISBN 0-8218-2943-2, LC 2002034246, 2000 *Mathematics Subject Classification*: 30Bxx, 30D60, **Individual member***, List $79, Institutional member* Order code MMONO/216N



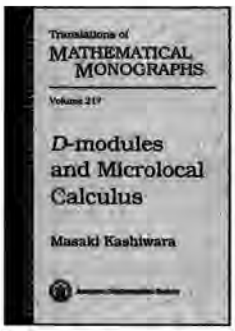
On the Classification of Polish Metric Spaces Up to Isometry

Su Gao, *University of North Texas, Denton*, and **Alexander S. Kechris**, *California Institute of Technology, Pasadena*

Contents: Introduction; Preliminaries; Isometric classification of Polish metric spaces; Characterizing the isometry groups of Polish metric spaces; Some special cases; Isometries of locally compact spaces, *I*: The pseudo-connected case; Isometries of locally compact spaces, *II*: The general case; Isometric classification of locally compact spaces; Locally compact ultrametric spaces; Some analogies with the model theory of countable structures; Open problems.

Memoirs of the American Mathematical Society, Volume 161, Number 766

January 2003, 78 pages, Softcover, ISBN 0-8218-3190-9, LC 2002033243, 2000 *Mathematics Subject Classification*: 03E15, 54E35; 54H05, 03E75, **Individual member***, List $49, Institutional member*, Order code MEMO/161/766N



D-modules and Microlocal Calculus

Masaki Kashiwara, *Research Institute for Mathematical Sciences, Kyoto University, Japan*

Masaki Kashiwara is undoubtedly one of the masters of the theory of D-modules, and he has created a good, accessible entry point to the subject. The theory of D-modules is a very powerful point of view, bringing ideas from algebra and algebraic geometry to the analysis of systems of differential equations. It is often used in conjunction with microlocal analysis, as some of the important theorems are best stated or proved using these techniques. The theory has been used very successfully in applications to representation theory.

Here, there is an emphasis on b-functions. These show up in various contexts: number theory, analysis, representation theory, and the geometry and invariants of prehomogeneous vector spaces. Some of the most important results on b-functions were obtained by Kashiwara.

A hot topic from the mid '70s to mid '80s, it has now moved a bit more into the mainstream. Graduate students and research mathematicians will find that working on the subject in the two-decade interval has given Kashiwara a very good perspective for presenting the topic to the general mathematical public.

This item will also be of interest to those working in algebra and algebraic geometry.

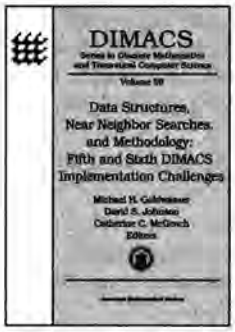
Contents: Basic properties of D-modules; Characteristic varieties; Construction of D-modules; Functorial properties of

D-modules; Regular holonomic systems; b-functions; Ring of formal microdifferential operators; Microlocal analysis of holonomic systems; Microlocal calculus of b-functions; Appendix; Bibliography; Index; Index of notations.

Translations of Mathematical Monographs (*Iwanami Series in Modern Mathematics*), Volume 217

January 2003, 254 pages, Softcover, ISBN 0-8218-2766-9, LC 2002027793, 2000 *Mathematics Subject Classification*: 32A37, 32C38, 58J15, **All AMS members***, List $49, Order code MMONO/217N

Applications



Data Structures, Near Neighbor Searches, and Methodology: Fifth and Sixth DIMACS Implementation Challenges

Michael H. Goldwasser, *Loyola University of Chicago, IL*, **David S. Johnson**, *AT&T Bell Laboratories, Florham Park, NJ*, and **Catherine C. McGeoch**, *Amherst College, MA*, Editors

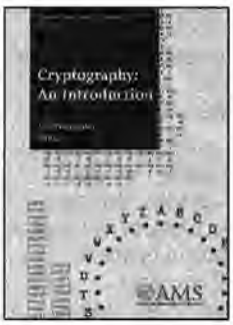
This book presents reviewed and revised papers from the fifth and sixth DIMACS Implementation Challenge workshops. These workshops, held approximately annually, aim at encouraging high-quality work in experimental analysis of data structures and algorithms. The papers published in this volume are the results of year-long coordinated research projects and contain new findings and insights. Three papers address the performance evaluation of implementations for two fundamental data structures, dictionaries and priority queues, as used in the context of real applications. Another four papers consider the still evolving topic of methodologies for experimental algorithmics. Five papers are concerned with implementations of algorithms for nearest neighbor search in high dimensional spaces, an area with applications in information retrieval and data mining on collections of Web documents, DNA sequences, images and various other data types.

Contents: **R. Battiti**, Partially persistent dynamic sets for history-sensitive heuristics; **C. Silverstein**, A practical perfect hashing algorithm; **A. V. Goldberg** and **C. Silverstein**, Computational evaluation of hot queues; **K. Zatloukal**, **M. H. Johnson**, and **R. E. Ladner**, Nearest neighbor search for data compression; **N. Katayama** and **S. Satoh**, Experimental evaluation of disk-based data structures for nearest neighbor searching; **S. Maneewongvatana** and **D. M. Mount**, Analysis of approximate nearest neighbor searching with clustered point sets; **J.-C. Perez-Cortes** and **E. Vidal**, Approximate nearest neighbor search using the extended general space-filling curves heuristic; **P. N. Yianilos**, Locally lifting the curse of dimensionality for nearest neighbor search; **R. J. Anderson**, The role of experiment in the theory of algorithms; **B. M. E. Moret**, Towards a discipline of experimental algorithmics; **D. S. Johnson**, A theoretician's guide to the experimental analysis of algorithms; **C. C. McGeoch**, A bibliography of algorithm experimentation.

DIMACS: Series in Discrete Mathematics and Theoretical Computer Science, Volume 59

January 2003, 256 pages, Hardcover, ISBN 0-8218-2892-4, LC 2002038557, 2000 *Mathematics Subject Classification*: 68-06, 68P05, 68P10, 68U05, 68W01, **All AMS members***, List $79, Order code DIMACS/59N

Recommended Text



Cryptography: An Introduction

V. V. Yaschenko, *Moscow Center for Continuous Mathematics Education, Russia*, Editor

Learning about cryptography requires examining fundamental issues about information security. Questions abound, ranging from "Whom are we protecting ourselves from?" and "How can we measure levels of security?" to "What are our opponent's capabilities?" and "What are their goals?" Answering these questions requires an understanding of basic cryptography. This book, written by Russian cryptographers, explains those basics.

Chapters are independent and can be read in any order. The introduction gives a general description of all the main notions of modern cryptography: a cipher, a key, security, an electronic digital signature, a cryptographic protocol, etc. Other chapters delve more deeply into this material. The final chapter presents problems and selected solutions from "Cryptography Olympiads for (Russian) High School Students".

This is an English translation of a Russian textbook. It is suitable for advanced high school students and undergraduates studying information security. It is also appropriate for a general mathematical audience interested in cryptography.

Also on cryptography and available from the AMS is *Codebreakers: Arne Beurling and the Swedish Crypto Program during World War II*, SWCRY.

This item will also be of interest to those working in number theory.

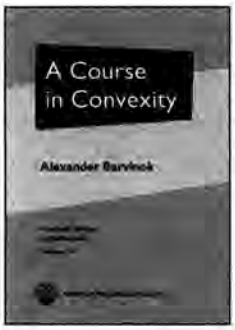
Contents: Main notions; Cryptograpy and complexity theory; Cryptographic protocols; Algorithmic problems of number theory; Mathematics of secret sharing; Cryptography olympiads for high school students; Bibliography.

Student Mathematical Library, Volume 18

December 2002, 229 pages, Softcover, ISBN 0-8218-2986-6, LC 2002027740, 2000 *Mathematics Subject Classification*: 94-01, 94A60; 11T71, 68P25, **All AMS members***, List $39, Order code STML/18N

Discrete Mathematics and Combinatorics

Recommended Text



A Course in Convexity

Alexander Barvinok, *University of Michigan, Ann Arbor*

Convexity is a simple idea that manifests itself in a surprising variety of places. This fertile field has an immensely rich structure and numerous applications. Barvinok demonstrates that simplicity, intuitive appeal, and the universality of applications make teaching (and learning) convexity a gratifying experience. The book will benefit both teacher and student: It is easy to understand, entertaining to the reader, and includes many exercises that vary in degree of difficulty. Overall, the author demonstrates the power of a few simple unifying principles in a variety of pure and applied problems.

The notion of convexity comes from geometry. Barvinok describes here its geometric aspects, yet he focuses on applications of convexity rather than on convexity for its own sake. Mathematical applications range from analysis and probability to algebra to combinatorics to number theory. Several important areas are covered, including topological vector spaces, linear programming, ellipsoids, and lattices. Specific topics of note are optimal control, sphere packings, rational approximations, numerical integration, graph theory, and more. And of course, there is much to say about applying convexity theory to the study of faces of polytopes, lattices and polyhedra, and lattices and convex bodies.

The prerequisites are minimal amounts of linear algebra, analysis, and elementary topology, plus basic computational skills. Portions of the book could be used by advanced undergraduates. As a whole, it is designed for graduate students interested in mathematical methods, computer science, electrical engineering, and operations research. The book will also be of interest to research mathematicians, who will find some results that are recent, some that are new, and many known results that are discussed from a new perspective.

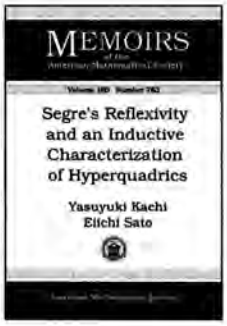
This item will also be of interest to those working in analysis and geometry and topology.

Contents: Convex sets at large; Faces and extreme points; Convex sets in topological vector spaces; Polarity, duality and linear programming; Convex bodies and ellipsoids; Faces of polytopes; Lattices and convex bodies; Lattice points and polyhedra; Bibliography; Index.

Graduate Studies in Mathematics, Volume 54

December 2002, 366 pages, Hardcover, ISBN 0-8218-2968-8, LC 2002028208, 2000 *Mathematics Subject Classification*: 52-01, 52-02, 52B45, 52C07, 46A20, 46N10, 90C05, 90C08, 90C22, 49N15, **All AMS members***, List $59, Order code GSM/54N

Geometry and Topology



Connectivity Properties of Group Actions on Non-Positively Curved Spaces

Robert Bieri, *University of Frankfurt, Germany*, and **Ross Geoghegan**, *Binghamton University, NY*

Contents: Introduction; *Part 1. Controlled Connectivity and Openness Results:* Outline, main results and examples; Technicalities concerning the CC^{n-1} property; Finitary maps and sheaves of maps; Sheaves and finitary maps over a control space; Construction of sheaves with positive shift; Controlled connectivity as an open condition; Completion of the proofs of Theorems A and A′; The invariance theorem; *Part 2. The Geometric Invariants:* Short summary of Part 2; Outline, main results and examples; Further technicalities on CAT(0) spaces; CC^{n-1} over endpoints; Finitary contractions towards endpoints; From CC^{n-1} over endpoints to contractions; Proofs of Theorems E-H; appendix A: Alternative formulations of CC^{n-1}; Appendix B: Further formulations of CC^{n-1}; Bibliography.

Memoirs of the American Mathematical Society, Volume 161, Number 765

January 2003, 83 pages, Softcover, ISBN 0-8218-3184-4, LC 2002033241, 2000 *Mathematics Subject Classification*: 20F65, 53C23, 20C99, 20F69, 57N16; 20E08, 20J05, 20G25, **Individual member***, List $51, Institutional member*, Order code MEMO/161/765N

Lusternik-Schnirelmann Category and Related Topics

O. Cornea, *Universite de Lille, France*, **G. Lupton** and **J. Oprea**, *Cleveland State University, OH*, and **D. Tanré**, *Université de Lille, France*, Editors

This collection is the proceedings volume for the AMS-IMS-SIAM Joint Summer Research Conference, Lusternik-Schnirelmann Category, held in 2001 at Mount Holyoke College in Massachusetts. The conference attracted an international group of 37 participants that included many leading experts. The contributions included here represent some of the field's most able practitioners.

With a surge of recent activity, exciting advances have been made in this field, including the resolution of several long-standing conjectures. Lusternik-Schnirelmann category is a numerical homotopy invariant that also provides a lower bound for the number of critical points of a smooth function

on a manifold. The study of this invariant, together with related notions, forms a subject lying on the boundary between homotopy theory and critical point theory.

These articles cover a wide range of topics: from a focus on concrete computations and applications to more abstract extensions of the fundamental ideas. The volume includes a survey article by P. Hilton that discusses earlier results from homotopy theory that form the basis for more recent work in this area.

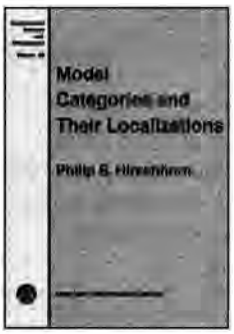
In this volume, professional mathematicians in topology and dynamical systems as well as graduate students will catch glimpses of the most recent views of the subject.

This item will also be of interest to those working in analysis.

Contents: P. Hilton, Lusternik-Schnirelmann category in homotopy theory; **M. Arkowitz, D. Stanley**, and **J. Strom**, The $\mathcal{A}$-category and $\mathcal{A}$-cone length of a map; **H. Colman**, Equivariant LS-category for finite group actions; **H. Colman** and **S. Hurder**, Tangential LS category and cohomology for foliations; **M. C. Costoya-Ramos**, Spaces in the Mislin genus of a finite, simply connected co-H_0-space; **M. Cuvilliez** and **Y. Félix**, Approximations to the $\mathcal{F}$-killing length of a space; **G. Dula**, Pseudo-comultiplications, their Hopf-type invariant and Lusternik-Schnirelmann category of conic spaces; **M. Farber**, Lusternik–Schnirelman theory and dynamics; **C. Gavrila**, The Lusternik-Schnirelmann theorem for the ball category; **P. Ghienne**, The Lusternik-Schnirelmann category of spaces in the Mislin genus of $Sp(3)$; **J. R. Hubbuck** and **N. Iwase**, A p-complete version of the Ganea conjecture for co-H-spaces; **G. Lupton**, The rational Toomer invariant and certain elliptic spaces; **H. J. Marcum**, On the Hopf invariant of the Hopf construction; **J. Oprea**, Bochner-type theorems for the Gottlieb group and injective toral actions; **J. Oprea** and **Y. Rudyak**, Detecting elements and Lusternik-Schnirelmann category of 3-manifolds; **J. Strom**, Generalizations of category weight.

Contemporary Mathematics, Volume 316

January 2003, 203 pages, Softcover, ISBN 0-8218-2800-2, LC 2002038243, 2000 *Mathematics Subject Classification*: 55M30, 55P45, 55P60, 55P62, 55P91, 55Q25, 57M99, 57R30, 58E05, **Individual member***, List $59, Institutional member*, Order code CONM/316N



Model Categories and Their Localizations

Philip S. Hirschhorn, *Wellesley College, MA*

The aim of this book is to explain modern homotopy theory in a manner accessible to graduate students yet structured so that experts can skip over numerous linear developments to quickly reach the topics of their interest. Homotopy theory arises from choosing a class of maps, called weak equivalences, and then passing to the homotopy category by localizing with respect to the weak equivalences, i.e., by creating a new category in which the weak equivalences are isomorphisms. Quillen defined a model category to be a category together with a class of weak equivalences and additional structure useful for describing the homotopy category in terms of the original category. This allows you to make constructions analogous to those used to study the homotopy theory of topological spaces.

A model category has a class of maps called weak equivalences plus two other classes of maps, called cofibrations and fibrations. Quillen's axioms ensure that the homotopy category exists and that the cofibrations and fibrations have extension and lifting properties similar to those of cofibration and fibration maps of topological spaces. During the past several decades the language of model categories has become standard in many areas of algebraic topology, and it is increasingly being used in other fields where homotopy theoretic ideas are becoming important, including modern algebraic K-theory and algebraic geometry.

All these subjects and more are discussed in the book, beginning with the basic definitions and giving complete arguments in order to make the motivations and proofs accessible to the novice. The book is intended for graduate students and research mathematicians working in homotopy theory and related areas.

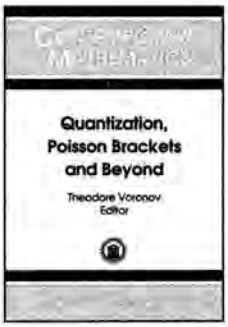
This item will also be of interest to those working in algebra and algebraic geometry.

Contents: *Localization of model category structures:* Summary of part 1; Local spaces and localization; The localization model category for spaces; Localization of model categories; Existence of left Bousfield localizations; Existence of right Bousfield localizations; Fiberwise localization; *Homotopy theory in model categories:* Summary of part 2; Model categories; Fibrant and cofibrant approximations; Simplicial model categories; Ordinals, cardinals, and transfinite composition; Cofibrantly generated model categories; Cellular model categories; Proper model categories; The classifying space of a small category; The Reedy model category structure; Cosimplicial and simplicial resolutions; Homotopy function complexes; Homotopy limits in simplicial model categories; Homotopy limits in general model categories; Index; Bibliography.

Mathematical Surveys and Monographs, Volume 99

January 2003, 457 pages, Hardcover, ISBN 0-8218-3279-4, LC 2002027794, 2000 *Mathematics Subject Classification*: 18G55, 55P60, 55U35; 18G30, **Individual member***, List $95, Institutional member*, Order code SURV/99N

Mathematical Physics



Quantization, Poisson Brackets and Beyond

Theodore Voronov, *University of Manchester Institute of Science and Technology (UMIST), England*, Editor

The papers in this volume are based on talks given at the 2001 Manchester Meeting of the London Mathematical Society, which was followed by an international workshop on "Quantization, Deformations, and New Homological and Categorical Methods in Mathematical Physics".

Focus is on the topics suggested by the title: Quantization in its various aspects, Poisson brackets and generalizations, and

structures "beyond", including symplectic supermanifolds, operads, Lie groupoids and Lie (bi)algebroids and algebras with n-ary operations. This book offers accounts of new results as well as accessible expositions useful to a broad reading audience of researchers in differential geometry, algebraic topology and mathematical physics.

This item will also be of interest to those working in algebra and algebraic geometry and geometry and topology.

Contents: **B. Fedosov**, Deformation quantization: Pro and contra; **N. P. Landsman**, Quantization as a functor; **H. Omori**, **Y. Maeda**, **N. Miyazaki**, and **A. Yoshioka**, Star exponential functions for quadratic forms and polar elements; **J. Rawnsley**, On traces for differential star products on symplectic manifolds; **J. Donin**, Quantum G-manifolds; **J. Donin** and **A. Mudrov**, $\mathcal{U}_q(sl(n))$-covariant quantization of symmetric coadjoint orbits via reflection equation algebra; **O. Radko**, Toward a classification of Poisson structures on surfaces; **J. D. S. Jones**, Lectures on operads; **T. Voronov**, Graded manifolds and Drinfeld doubles for Lie bialgebroids; **D. Roytenberg**, On the structure of graded symplectic supermanifolds and Courant algebroids; **K. C. H. Mackenzie**, On certain canonical diffeomorphisms in symplectic and Poisson geometry; **H. M. Khudaverdian**, Laplacians in odd symplectic geometry; **Y. Kosmann-Schwarzbach** and **K. C. H. Mackenzie**, Differential operators and actions of Lie algebroids; **L.-g. He**, **Z.-J. Liu**, and **D.-S. Zhong**, Poisson actions and Lie bialgebroid morphisms; **A. S. Dzhumadil'daev**, Identities and derivations for Jacobian algebras.

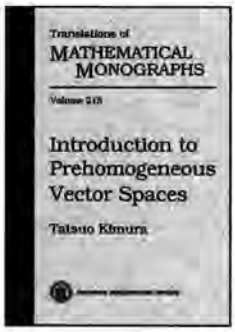
Contemporary Mathematics, Volume 315

January 2003, approximately 288 pages, Softcover, ISBN 0-8218-3201-8, LC 2002040772, 2000 *Mathematics Subject Classification*: 53D55, 46L65, 17B37, 53D17, 18D50, 58A50, 53D05, 58H05, 53D20, 17B66, **Individual member***, List $69, Institutional member* Order code CONM/315N

Number Theory

Recommended Text

Independent Study



Introduction to Prehomogeneous Vector Spaces

Tatsuo Kimura, *Institute of Mathematics, University of Tsukuba, Japan*

This is the first introductory book on the theory of prehomogeneous vector spaces, introduced in the 1970s by Mikio Sato. The author was an early and important developer of the theory and continues to be active in the field.

The subject combines elements of several areas of mathematics, such as algebraic geometry, Lie groups, analysis, number theory, and invariant theory. An important objective is to create applications to number theory. For example, one of the key topics is that of zeta functions attached to prehomogeneous vector spaces; these are generalizations of the Riemann zeta function, a cornerstone of analytic number theory. Prehomogeneous vector spaces are also of use in representation theory, algebraic geometry and invariant theory.

This book explains the basic concepts of prehomogeneous vector spaces, the fundamental theorem, the zeta functions associated with prehomogeneous vector spaces, and a classification theory of irreducible prehomogeneous vector spaces. It strives, and to a large extent succeeds, in making this content, which is by its nature fairly technical, self-contained and accessible. The first section of the book, "Overview of the theory and contents of this book," is particularly noteworthy as an excellent introduction to the subject.

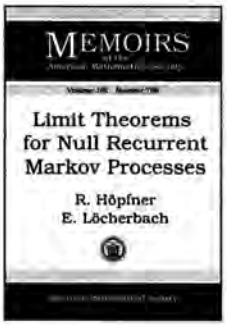
This item will also be of interest to those working in algebra and algebraic geometry.

Contents: Algebraic preliminaries; Relative invariants of prehomogeneous vector spaces; Analytic preliminaries; The fundamental theorem of prehomogeneous vector spaces; The zeta functions of prehomogeneous vector spaces; Convergence of zeta functions of prehomogeneous vector spaces; Classification of prehomogeneous vector spaces; Appendix: Table of irreducible reduced prehomogeneous vector spaces; Bibliography; Index of symbols; Index.

Translations of Mathematical Monographs, Volume 215

January 2003, 288 pages, Hardcover, ISBN 0-8218-2767-7, LC 2002032634, 2000 *Mathematics Subject Classification*: 11S90; 11-01, 11M41, 20G05, **Individual member***, List $99, Institutional member*, Order code MMONO/215N

Probability



Limit Theorems for Null Recurrent Markov Processes

R. Höpfner, *University of Mainz, Germany*, and **E. Löcherbach**, *UFR des Sciences et Technologie, Creteil, France*

Contents: Introduction; Harris recurrence; Stable increasing processes and Mittag Leffler processes; The main theorem; Proofs for subsection 3.1 - sufficient condition; Proofs for subsection 3.1 - necessary condition; Nummelin splitting in discrete time; Nummelin-like splitting for general continuous time Harris processes and proofs for subsection 3.3; Overview: assumptions (H1) - (H6); References.

Memoirs of the American Mathematical Society, Volume 161, Number 768

January 2003, 92 pages, Softcover, ISBN 0-8218-3231-X, LC 2002033245, 2000 *Mathematics Subject Classification*: 60J25, 60G44, 60F17, **Individual member***, List $51, Institutional member*, Order code MEMO/161/768N

* Discounted pricing is available to AMS members. Call 1-800-321-4AMS (4267), in the US and Canada, or 1-401-455-4000 (worldwide); fax:1-401-455-4046; email: cust-serv@ams.org. American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294, USA

Classified Advertisements

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

ALABAMA

AUBURN UNIVERSITY
Department of Mathematics

000191

The Department of Mathematics at Auburn University is seeking to broaden the scope of its expertise by developing and enhancing innovative research and educational programs with a multidisciplinary approach. In pursuit of this objective, the department expects to fill at least one tenure-track position at the assistant professor level with a starting date of August 2003. Applicants must hold a Ph.D. degree in mathematical sciences at the time of initial appointment. Moreover, they must be committed to interdisciplinary activity and excellence in teaching and research. The candidate's research interests should complement those of the present faculty. Preference will be given to candidates whose interests lie in actuarial or in computational mathematics.

Auburn University has over 50 mathematicians engaged in research in a wide variety of disciplines, including algebra, analysis, linear algebra, numerical analysis, probability, topology, geometry, and dynamical systems. In addition to an expanding undergraduate program, there is an active graduate program with approximately 60 graduate students studying in various areas of mathematical science. The mathematics department is part of the College of Science and Mathematics, which includes strong research departments in biology, chemistry, geology, and physics; additionally, the Colleges of Engineering and of Business have research programs in disciplines that require the use of the mathematical sciences.

An application, transcript(s), a curriculum vitae, and a description of the candidate's research interests and teaching philosophy should be sent to the address below. In addition, applicants should arrange for four letters of recommendation (at least one of which should address teaching) to be sent to the same address. Review of applications will begin February 1, 2003, and will continue until the position is filled.

Send information in care of:
Dr. Michel Smith
Professor and Chair
Department of Mathematics
Auburn University
Auburn, AL 36849
phone: 334-844-4290
fax: 334-844-6555

For more information visit our website: `http://www.auburn.edu/~smith01/position.html` or call.

The candidate selected for this position must be able to meet eligibility requirements for work in the United States.

Auburn University is an Equal Opportunity Employer.

Women and minorities are encouraged to apply.

THE UNIVERSITY OF ALABAMA IN HUNTSVILLE
Department of Mathematical Sciences
Faculty Position

000007

The Department of Mathematical Sciences at the University of Alabama in Huntsville invites applications for one or more tenure-track positions at the rank of assistant professor or associate professor, beginning August 2003. Applicants must possess a Ph.D. degree in mathematics or applied mathematics and show evidence of excellence in teaching and research. Preference will be given to applicants with research areas that match those of the department and particularly the areas of probability/stochastic processes and numerical analysis.

Applicants should send a curriculum vitae with the AMS Standard Cover Sheet, transcripts, and three letters of recommendation (with at least one letter addressing teaching) to:

Chairman
Department of Mathematical Sciences
University of Alabama in Huntsville,
Huntsville, AL 35899

For more information about the department, visit our website at `http://www.math.uah.edu/`.

Review of applicants will begin January 8, 2003, and will continue until the position is filled. Women and minorities are encouraged to apply. The University of Alabama in Huntsville is an Affirmative Action/Equal Opportunity Institution.

Suggested uses for classified advertising are positions available, books or lecture notes for sale, books being sought, exchange or rental of houses, and typing services.

The 2003 rate is $100 per inch or fraction thereof on a single column (one-inch minimum), calculated from top of headline. Any fractional text of 1/2 inch or more will be charged at the next inch rate. No discounts for multiple ads or the same ad in consecutive issues. For an additional $10 charge, announcements can be placed anonymously. Correspondence will be forwarded.

Advertisements in the "Positions Available" classified section will be set with a minimum one-line headline, consisting of the institution name above body copy, unless additional headline copy is specified by the advertiser. Headlines will be centered in boldface at no extra charge. Ads will appear in the language in which they are submitted.

There are no member discounts for classified ads. Dictation over the telephone will not be accepted for classified advertising.

Upcoming deadlines for classified advertising are as follows: February 2003 issue–November 22, 2002; March 2003 issue–January 8, 2003; April 2003 issue–January 28, 2003; May 2003 issue–February 27, 2003; June/July issue–April 29, 2003; August 2003 issue–May 28, 2003.

U.S. laws prohibit discrimination in employment on the basis of color, age, sex, race, religion, or national origin. "Positions Available" advertisements from institutions outside the U.S. cannot be published unless they are accompanied by a statement that the institution does not discriminate on these grounds whether or not it is subject to U.S. laws. Details and specific wording may be found on page 1373 (vol. 44).

Situations wanted advertisements from involuntarily unemployed mathematicians are accepted under certain conditions for free publication. Call toll-free 800-321-4AMS (321-4267) in the U.S. and Canada or 401-455-4084 worldwide for further information.

Submission: Promotions Department, AMS, P. O. Box 6248, Providence, Rhode Island 02940; or via fax: 401-331-3842; or send email to `classads@ams.org`. AMS location for express delivery packages is 201 Charles Street, Providence, Rhode Island 02904. Advertisers will be billed upon publication.

CALIFORNIA

CALIFORNIA STATE UNIVERSITY, LOS ANGELES
Department of Mathematics

000014

Applications are invited for a tenure-track position in mathematics at the level of assistant/associate professor, starting June or September 2003. Ph.D. in mathematics with a strong background in algebra is required. Doctorate degrees must be from an accredited institution of higher education. Successful candidate should be able to teach a range of undergraduate mathematics classes. Publications in peer-reviewed journals and/or grant activity is required. CSULA is on the quarter system. Review of applications will start January 22, 2003, and will continue until position is filled. Send a letter of application and vita to: Dr. P. K. Subramanian, Chair, Department of Mathematics, California State University at Los Angeles, 5151 State University Drive, Los Angeles, CA 90032. An Equal Opportunity/Title IX/Disabled/Employer. All qualified applicants are encouraged to apply.

COLORADO

UNIVERSITY OF COLORADO AT BOULDER
Department of Applied Mathematics

000016

Assistant, associate, or full professor, to begin in August 2003. Applicants at all levels will be considered. Preference given to candidates with demonstrated research expertise in applied analysis. Information about the department can be found at: `http://amath.colorado.edu/`. Excellence in teaching is also expected. Send a letter of application, a current curriculum vitae, a statement of research interests, and an AMS cover sheet (see `http://www.ams.org/employment/cover-template.doc/`) to: Chair of Search Committee, Department of Applied Mathematics, University of Colorado, Boulder, CO, 80309-0526. Three letters of recommendation should also be sent to this address. The University of Colorado at Boulder is an Equal Opportunity/Nondiscrimination Institution.

DELAWARE

UNIVERSITY OF DELAWARE
Department of Mathematical Sciences
Assistant Professor

000011

Tenure-track assistant professor in discrete mathematics beginning September 2003. Preference given to applicants whose research is compatible with current faculty (designs, extremal/algebraic combinatorics, finite geometry, probabilistic method). Highly desirable: (1) demonstrated interest in applications (e.g. cryptography, coding theory, scheduling, genetics); (2) use of computing in teaching/research. Send curriculum vitae and 3 letters of reference by December 31, 2002, to:

Dr. Gary Ebert, Chair
Search Committee
Mathematical Sciences Department
University of Delaware
Newark, DE 19716-2553

The curriculum vitae and letters of reference shall be shared with departmental faculty.

The University of Delaware is an Equal Opportunity Employer that encourages applications from minority group members and women.

GEORGIA

GEORGIA STATE UNIVERSITY
Department of Risk Management and Insurance
Actuarial Science Program

000008

JOB QUALIFICATIONS:

The Department of Risk Management and Insurance invites applications for the position of director of the Actuarial Science Program. This is a tenure-track position with the rank of associate or full professor of actuarial science. The department expects to fill the position for the fall 2003 semester. Applicants should have enthusiasm and demonstrated ability to lead one of the country's outstanding actuarial science programs. The position requires excellence in scholarship and teaching as well as actuarial credentials.

Scholarship: An established record of high-quality research is required. A doctorate in actuarial science, finance, mathematics, statistics, or related field is strongly preferred. This is a tenure-track position and requires maintaining a successful research program in actuarial science or a closely related area such as mathematical finance.

Teaching: The department is consistently ranked among the best teaching departments in the university. The applicant must be able to teach master's-level and undergraduate courses that are oriented to the examination syllabus of the actuarial societies while maintaining or exceeding the department's standards.

Actuarial Credentials: Membership in a professional actuarial organization is required. These may include Fellows of the Casualty Actuarial Society, the Society of Actuaries, the Institute of Actuaries, the Faculty of Actuaries, or Australian Institute of Actuaries. Associates of these societies or members of other actuarial societies may also meet this requirement if they have exceptional strength in scholarship, teaching, and leadership.

ABOUT THE ENVIRONMENT:

From its founding in 1958, the GSU Actuarial Science Program has been one of the leading programs in North America. It has a distinguished history of serving students, alumni, and the actuarial profession. Hundreds of our graduates become Fellows or Associates of the Society of Actuaries and/or the Casualty Actuarial Society. Many graduates have become leaders in the actuarial profession and related businesses. As a program in the J. Mack Robinson College of Business, the program strives to produce well-rounded business professionals with substantial actuarial and mathematical skills. This goal is a hallmark of our student recruitment and academic approach as well as representation of our graduates to the actuarial profession and the public.

The Risk Management and Insurance Department, housed in the Robinson College of Business, maintains strong ties with the risk management profession, is well supported financially, and is regarded as one of the best departments of its type internationally.

The Department of Risk Management and Insurance has recently expanded its research and educational mission to include a Mathematical Risk Management Program. The Mathematical Risk Management and Actuarial Science Programs work closely in recruiting and placing students. Some courses are cross-listed, and many actuarial students take mathematical risk management courses, such as financial engineering, as electives.

FURTHER INFORMATION AND APPLICATION PROCEDURE:

Preference will be given to applications received by February 1, 2003. Applicants should send a current curriculum vitae, three letters of recommendation, and recent publications or working papers to:

Samuel H. Cox, Chair
Search Committee
Department of Risk Management and Insurance
Robinson College of Business
Georgia State University
P. O. Box 4036
Atlanta, GA 30302-4036
tel: 404-651-4854

Applications may be submitted electronically via email at: `samcox@gsu.edu`. For further information contact the chair of the search committee.

An interview can be scheduled for the 2002 annual meeting of the Society of Actuaries, 2003 annual meeting of the American Mathematical Society, and other meetings. Contact Professor Cox or check the website for an update.

Georgia State University is an Equal Opportunity Educational Institution/ Affirmative Action Employer and encour-

ages applications from qualified minorities.

SOUTHERN POLYTECHNIC STATE UNIVERSITY
Mathematics Program

000015

The Mathematics Program of SPSU invites applications for a tenure-track assistant professor to begin August 2003. Ph.D. in mathematics or a closely related field required, plus a commitment to teaching a wide range of mathematics courses. Responsibilities include 12 hours of teaching, scholarly activity, and service. SPSU offers day and evening courses and degrees in technology-related fields, including mathematics. Applicants from all areas of mathematics are invited to apply. Review of applications will begin on January 20, 2003. For more details, see http://www2.SPSU.edu/math/jobs/. Send letter of application, vita, and three letters of recommendation to: Alan Gabrielli, Dean of Arts & Sciences, Southern Polytechnic State University, Marietta, GA 30060-2896. SPSU is an AA/ADA/EEO Employer.

INDIANA

INDIANA UNIVERSITY PURDUE UNIVERSITY INDIANAPOLIS (IUPUI)
Department of Mathematical Sciences
Tenure-Track Positions

000013

Indiana University Purdue University Indianapolis (IUPUI) invites applications for three tenure-track positions in the Department of Mathematical Sciences beginning in August 2003. Ranks and salaries will be commensurate with qualifications. The university also offers excellent fringe benefits.

IUPUI is an urban doctoral/research-intensive university with 29,000 students. The department, with a current faculty of 32 members, offers programs of study leading to Purdue University B.S, M.S., and Ph.D. degrees and an excellent environment for collaborative and interdisciplinary research. Current research areas within the department include integrable systems, mathematical physics, dynamical systems, noncommutative geometry, operator algebras, differential geometry, PDE, functional analysis, statistics and probability, applied mathematics, and scientific computing.

Applicants should have a Ph.D. in the mathematical sciences and are expected to have developed or be able to develop significant research programs in their fields of expertise. A strong commitment to quality undergraduate and graduate teaching is also required. While all applications will be considered, at least one position will be filled from applicants in applied mathematics and scientific computing, and one position will be filled from applicants in statistics.

A complete application must include: the AMS application cover sheet; letter of application; curriculum vitae; statements on research and teaching philosophy; four letters of recommendation, one of which must address the candidate's teaching ability and experience.

Screening of completed applications will begin on December 1, 2002, and will continue until the positions are filled. All applications should be mailed to:

Search and Screen Committee
Department of Mathematical Sciences
Indiana University Purdue
University Indianapolis
402 N. Blackford St., LD Suite 270
Indianapolis, IN 46202-3216

IUPUI is an Equal Opportunity/Affirmative Action Employer and strongly encourages applications from women and underrepresented minorities. Additional information about IUPUI and the department is available at http://www.iupui.edu/ and http://www.math.iupui.edu/.

IOWA

GRINNELL COLLEGE
Department of Mathematics and Computer Science
2 Tenure-Track Positions in Mathematics

000129

Two tenure-track positions as assistant professor of mathematics starting fall 2003. Ph.D. in mathematics expected. For one of these positions, we seek applicants whose specialty is an area of analysis; for the other position, all specialties will be considered. Grinnell College is a highly selective liberal arts college that seeks outstanding teacher-scholars for its faculty, rewards excellence in teaching, and is generous in its support of scholarship. For more information see http://www.math.grinnell.edu/2002-math.html. Please include a statement describing your interests in teaching and research in an undergraduate liberal arts environment that emphasizes close student-faculty interaction and values diversity. Send AMS cover sheet, curriculum vitae, undergraduate and graduate transcripts (copies acceptable), and three letters of recommendation to: Mathematics Search Committee, Department of Mathematics and Computer Science, 1116 8th Avenue, Grinnell College, Grinnell, IA 50112. Review of applications will continue until positions are filled.

Grinnell College is an Equal Opportunity/Affirmative Action Employer committed to attracting and retaining highly qualified individuals who collectively reflect the diversity of the nation. No applicant shall be discriminated against on the basis of race, national or ethnic origin, age, gender, sexual orientation, marital status, religion, creed, or disability.

KANSAS

UNIVERSITY OF KANSAS
Department of Mathematics

000012

Applications are invited for a temporary position at the assistant professor level beginning August 18, 2003; January 1, 2004; or as negotiated. (This position is contingent on final budgetary approval.) This position is normally renewable for a second and third year. Preference will be given to candidates in complex dynamics, dynamical systems, commutative algebra, probabilistic analysis, or topology/set theory. Candidates must have a Ph.D. in math or related field or its requirements completed by August 18, 2003.

Letter of application, detailed résumé with description of research, completed AMS application form, and at least three recommendation letters should be mailed to: Jack Porter, Chair, Department of Mathematics, 1460 Jayhawk Boulevard, University of Kansas, Lawrence, KS 66045-7567 (or faxed to 785-864-5255). For more details see http://www.math.ukans.edu/jobs/ or contact kumath@math.ukans.edu.

Deadlines: Review of applications will begin on January 1, 2003, and will continue until the position is filled.

EO/AA Employer.

KENTUCKY

WESTERN KENTUCKY UNIVERSITY
Department of Mathematics

000021

The Department of Mathematics invites applications for a tenure-track position at the level of assistant professor to begin in the fall of 2003. Preference will be given to fields that best fit the department's interests. Candidates must have a Ph.D. in mathematics by August 31, 2003. A description of a research program and a statement of teaching experience and philosophy are required. At least three letters of recommendation, a vita, transcripts, and the AMS cover letter should be sent to:

Search Committee
Department of Mathematics
Western Kentucky University
Bowling Green, KY 42101

Applications will be reviewed as received and will be considered until the position is filled.

Western Kentucky University is an EO/AA Employer. All qualified individuals are encouraged to apply, including women, minorities, persons with disabilities, and disabled veterans. Information about the department is available at http://www.wku.edu/Mathematics/.

MASSACHUSETTS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Mathematics
Applied Mathematics

000132

Applications are invited for a limited number of positions in applied mathematics, including numerical analysis, scientific computation, and physical applied mathematics, starting fall 2003. Available positions include instructorships, lectureships, assistant professorships, and possibly higher levels. Appointments will be made mainly on the basis of demonstrated research accomplishments and potential. Complete applications must be received by January 6. To apply, please send a vita with a description of your recent research and research plans, and arrange to have three letters of reference sent to: Committee on Applied Mathematics, Massachusetts Institute of Technology, Room 2-345, 77 Massachusetts Ave., Cambridge, MA 02139-4307. M.I.T. is an Equal Opportunity/Affirmative Action Employer. (For more information about the position and institution: `http://www-math.mit.edu/`.)

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Mathematics
C. L. E. Moore Instructorships in Mathematics

000131

These positions are open to mathematicians with doctorates who show definite promise in research. The teaching load will be nine hours for the academic year. Applications should be complete by January 6. Applicants should arrange to have sent (a) a vita, (b) three letters of reference, (c) a description of the research in their thesis, and (d) a research plan for the next year to: Pure Mathematics Committee, Massachusetts Institute of Technology, Room 2-263, 77 Massachusetts Ave., Cambridge, MA 02139-4307. M.I.T. is an Equal Opportunity/Affirmative Action Employer. (For more information about the position or institution: `http://www-math.mit.edu/`.)

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Mathematics

000130

The Department of Mathematics may make appointments at the level of lecturer and assistant professor or higher in pure mathematics for the year 2003–2004. The teaching load will be nine hours for the academic year (eight hours for assistant professor appointments). These positions are open to mathematicians with doctorates who show definite promise in research. Applications should be complete by January 6. Applicants should arrange to have sent (a) a vitae, (b) three letters of reference, (c) a description of their most recent research, and (d) a research plan for the immediate future to: Pure Mathematics Committee, Massachusetts Institute of Technology, Room 2-263, 77 Massachusetts Ave., Cambridge, MA 02139-4307. M.I.T. is an Equal Opportunity/Affirmative Action Employer. (For more information about the position or institution: `http://www-math.mit.edu/`.)

UMASS BOSTON
College of Arts and Sciences
Mathematics Department
Assistant Professor
Search 615

000019

The mathematics department at the University of Massachusetts Boston seeks to hire a tenure-track Assistant Professor beginning September 1, 2003. Qualifications include a Ph.D. in mathematics. The successful candidate will be expected to assist the department in developing a proposal and offering a Master of Arts in Teaching degree and to establish an active research program in mathematics. The mathematics department currently offers a bachelor's degree in mathematics.

College of Arts and Sciences
Mathematics Department
Assistant Professor
Search 620

The mathematics department at the University of Massachusetts Boston seeks to hire a tenure-track assistant professor beginning September 1, 2003. Qualifications include a Ph.D. in applied mathematics or statistics with research experience in the application of mathematics to biology, along with a strong commitment to undergraduate teaching. We expect the successful candidate to pursue external funding and to collaborate with members of the biology department or other science departments. Teaching responsibilities include undergraduate mathematics courses, with the possibility of team-teaching undergraduate and graduate biology courses. The mathematics department offers a bachelor's degree, and the biology department offers bachelor's, master's, and Ph.D. degrees.

The University of Massachusetts is an Equal Opportunity/Affirmative Action Employer and strongly encourages applications from women and minorities. Please send a letter of application to University of Massachusetts Boston, Office of Human Resources, Search #, 100 Morrissey Blvd., Boston, MA 02125-3393. UMass Boston is an Affirmative Action/Equal Opportunity/Title IX Employer.

Please visit our website at `http://www.math.umb.edu/` for other positions.

WILLIAMS COLLEGE
Department of Mathematics and Statistics

000089

The department invites applications for two positions in mathematics and one position in statistics, beginning fall 2003, all at the rank of assistant professor (in exceptional cases, more advanced appointments may be considered). We are seeking highly qualified candidates who have demonstrated excellence in teaching and research and who will have a Ph.D. by the time of appointment.

Williams College is a private, residential, highly selective liberal arts college with an undergraduate enrollment of approximately 2,000 students. The teaching load is two courses per 12-week semester and a winter-term course every other January. In addition to excellence in teaching, an active and successful research program is expected.

To apply, please send a vita and have three letters of recommendation on teaching and research sent to the Hiring Committee, Department of Mathematics and Statistics, Williams College, Williamstown, MA 01267. Teaching and research statements are also welcome. Evaluations of applications will begin on or after November 25 and will continue until the positions are filled. Williams College is dedicated to providing a welcoming intellectual environment for all of its faculty, staff, and students; as an EEO/AA Employer, Williams especially encourages applications from women and underrepresented minorities. For more information on the Department of Mathematics and Statistics, visit `http://www.williams.edu/Mathematics/`.

MICHIGAN

HILLSDALE COLLEGE
Mathematics and Computer Science
Two positions available: (1) Applied Mathematics and (2) Mathematics

000098

Applications are invited for positions in applied mathematics and in mathematics. Entry-level, tenure-track positions with initial appointments made at the assistant professor level beginning in August 2003.

1. Candidates for applied mathematics position required to have a Ph.D. in mathematics with specialty in applied mathematics and to be willing to teach especially mathematical modeling, differential equations, numerical analysis, and vector analysis, in addition to other undergraduate mathematics courses.

2. Candidates for mathematics position required to have a Ph.D. in mathematics and to be willing to teach various undergraduate mathematics courses.

Candidates for either position must have a strong commitment to excellence in

teaching undergraduate mathematics. Duties for each position include a 12-hour (3 course) teaching load per semester, which will include teaching all levels of undergraduate mathematics, academic advising, college service, and continued mathematical activity.

Hillsdale College, founded in 1844, is an independent, coeducational, four-year liberal arts college of 1,200 students. Hillsdale has traditionally upheld two concepts: academic excellence and institutional independence. For additional college information check our website: http://www.hillsdale.edu/.

Send a letter of application, which should include a personal statement addressing the applicant's teaching philosophy and qualifications for the position; curriculum vitae; graduate transcript; a short summary of teaching evaluations; and at least three letters of recommendation to: Professor Mark J. Watson, Chair, Department of Mathematics and Computer Science, Hillsdale College, Hillsdale, MI 49242. Review of applications will begin November 1, 2002, and will continue until the positions are filled. EOE.

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000001

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UNIVERSITY OF MICHIGAN
Department of Mathematics
Ann Arbor, MI

000022

The Department expects to have a position beginning September 2003 at the advanced assistant professor or tenure level for a specialist in mathematics education. Duties will include teaching a range of courses for students seeking a teaching certificate in either elementary or secondary mathematics education, providing counseling for these students, and working with the mathematics specialists in the School of Education to develop and maintain this joint program. Outreach to schools is strongly encouraged. Candidates should have a Ph.D. in either mathematics (preferred) or mathematics education and a record of publication in some area related to mathematics education. Salaries are competitive and are based on credentials. Applicants should send a CV, bibliography, descriptions of research and teaching experience, and have three or four letters of recommendation, at least one of which addresses the candidate's teaching experience and capabilities, sent to: Personnel Committee, University of Michigan, Department of Mathematics, 2074 East Hall, Ann Arbor MI 48109-1109. Applications are considered on a continuing basis but candidates are urged to apply by December 15, 2002. Women and minorities are encouraged to apply; the University is responsive to the needs of dual career couples. Inquiries may be made by email to: math-fac-search@umich.edu. More detailed information regarding the Department may be found on our web page: http://www.math.lsa.umich.edu/ . The University of Michigan is an Equal Opportunity, Affirmative Action Employer.

NEBRASKA

UNIVERSITY OF NEBRASKA-LINCOLN
Department of Mathematics
and Statistics

000005

Applications are invited for a tenure-track assistant professor position in mathematical biology beginning August 2003. The successful candidate must have a Ph.D. in mathematics or related area, outstanding potential as a research scholar who will complement the department's research faculty and their life science collaborators, and a commitment to teaching excellence. Preference will be given to candidates with expertise in mathematical modeling and analysis of biological problems, especially in ecological dynamics or a related area.

Applicants should send a letter of application, a CV, research and teaching statements, and three letters of reference to: Mathematical Biology Search Committee, Department of Mathematics and Statistics, University of Nebraska-Lincoln, Lincoln, NE 68588-0323. Use of the AMS application cover sheet is encouraged. Review of applications will begin January 31, 2003, and will continue until suitable candidates are found. For more information see the department's website at http://www.math.unl.edu/. The University of Nebraska is committed to a pluralistic campus community through affirmative action and equal opportunity and is responsive to the needs of dual-career couples. We assure reasonable accommodation under the Americans with Disabilities Act; contact Marilyn Johnson at (402) 472-3731 for assistance.

UNIVERSITY OF NEBRASKA-LINCOLN
Department of Mathematics
and Statistics

000006

Applications are invited for a 3-year, nontenure-track postdoctoral position starting August 2003. Preference to applicants within three years of having received the Ph.D. who show strong research promise in one of the areas in which UNL's mathematics faculty is currently active. Excellence in teaching is also expected. Applicants should send a letter of application, a CV, statements addressing the candidate's research and teaching, and three letters of reference to: Postdoctoral Search Committee, Department of Mathematics and Statistics, University of Nebraska-Lincoln, Lincoln, NE 68588-0323. Use of the AMS application cover sheet is encouraged. Review of applications will begin January 31, 2003, and will continue until suitable candidates are found. For more information see the department's website at http://www.math.unl.edu/. The University of Nebraska is committed to a pluralistic campus community through affirmative action and equal opportunity. We assure reasonable accommodation under the Americans with Disabilities Act; contact Marilyn Johnson at (402) 472-3731 for assistance.

NEW JERSEY

THE RUTGERS UNIVERSITY
Department of Mathematics

000023

The Rutgers University Mathematics Department invites applications for the following positions which may be available September 2003.

TENURE-TRACK OR TENURED POSITION: The Department anticipates at least one appointment at the level of Assistant Professor or above. Strong candidates in all fields are encouraged to apply. Candidates must have the Ph.D., outstanding research accomplishments in pure or applied mathematics, and concern for teaching.

HILL ASSISTANT PROFESSORSHIPS (nontenure track): These three-year nonrenewable positions include reduced teaching load for research. Candidates should have received the Ph.D., show outstanding promise of research ability in pure or applied mathematics, and have concern for teaching.

NON-TENURE-TRACK ASSISTANT PROFESSORSHIPS: These are three-year nonrenewable positions. Candidates should have a Ph.D., show evidence of superior teaching accomplishments, and show promise of research ability.

Applicants should send a printed resume, with the AMS Application Cover Sheet attached, and have four letters of recommendation (one of which evaluates teaching) sent to: Search Committee, Dept. of Math-Hill Center, Rutgers University, 110 Frelinghuysen Road, Piscataway, NJ 08854-8019. In addition, an electronic version of the AMS Application Cover Sheet should also be submitted at the website http://www.mathjobs.org/jobs/. It is essential to fill out this cover sheet completely, including specific position(s) applied for and the AMS Subject Classification number of your area(s) of specialization. Rutgers is an Affirmative Action/Equal Opportunity Employer and encourages applications from women and minority-group members.

The Department will begin reviewing applications December 1, 2002, and will continue its review until the positions are filled. Updated details of these positions will appear on the Rutgers Mathematics Department web page at http://www.math.rutgers.edu/.

NEW YORK

ST. JOHN'S UNIVERSITY
Department of Mathematics and Computer Science

000017

St. John's University, with campuses in the Hillcrest-Jamaica and Staten Island sections of New York City, is an independent Catholic co-educational institution in the Vincentian tradition.

The Department of Mathematics and Computer Science, St. John's College, is seeking applications for a tenure-track position at the assistant or associate professor rank in mathematics on the Queens campus for September 2003. Applicants should possess a Ph.D. in mathematics. A commitment to teaching and research is essential.

Send letter of application, résumé, three letters of recommendation, and undergraduate and graduate transcripts to: Search Committee, Dept. of Mathematics & Computer Science SJH 334, St. John's University, 8000 Utopia Parkway, Jamaica, NY 11439, or email: trainac@stjohns.edu.

St. John's University is an Equal Opportunity Employer and encourages applications from women and minorities.

STATE UNIVERSITY OF NEW YORK AT NEW PALTZ
Department of Mathematics

000020

SUNY at New Paltz seeks to fill a tenure-track position in the Department of Mathematics at the assistant professor level for fall 2003. Candidates must have a Ph.D. degree in the mathematical sciences. Preference will be given to candidates with expertise in the general area of analysis (especially probability). However, candidates who work in other research areas already represented in the department (universal algebra, lattice theory, logic, combinatorics, PDE) may also apply. Applicants must show significant evidence of research potential and outstanding teaching ability; preference will be given to candidates who will contribute to the department's General Education mathematics program. Duties include teaching a spectrum of mathematics courses for majors and nonmajors, advising students, developing curriculum, and sustaining research.

Review of applications will begin immediately and will continue until the position is filled. Please affix the number F02/05 (Mathematics) to all materials related to this search. To apply, send a letter describing research and teaching philosophy, a current curriculum vitae, and three letters of recommendation to: Search Committee Chair, Mathematics Department Search #F02/05 (Mathematics), FOB E-2, SUNY at New Paltz, 75 South Manheim Blvd., New Paltz, NY 12561. Expected date of appointment is 9/1/03 pending budgetary approval. Webpage: http://www.newpaltz.edu/hr/. AA/EOE/ADA Employer.

OHIO

CASE WESTERN RESERVE UNIVERSITY
Department of Mathematics

000010

Contingent on funding and staffing needs, the Department of Mathematics anticipates one or more one-year visiting faculty positions for the academic year 2003-04. The rank is open. The research interests of a candidate should complement those of the department members. The position includes a 2/2 teaching responsibility. Required: Ph.D. in mathematics with experience in teaching and research commensurate with the position. Please submit a letter of application (including email address and fax number) and curriculum vitae, along with names of three people who can write letters of evaluation. Mail all materials to: James Alexander, Chair, Department of Mathematics, Case Western Reserve University, Cleveland, OH 44106-7058. No email or fax applications will be accepted. Screening of applications will begin February 1; however, applications will be accepted until positions are filled. CWRU is an Equal Opportunity/Affirmative Action Employer. Women and minorities are strongly encouraged to apply.

PENNSYLVANIA

MILLERSVILLE UNIVERSITY OF PENNSYLVANIA
Department of Mathematics

000009

Full-time, tenure-track assistant professorship to begin August 2003 in a department of 20 faculty and approximately 175 majors in mathematics and mathematics education. Area of expertise in applied mathematics with experience using mathematics in the context of industry, government, or an interdisciplinary program is required. Ph.D. (or completion by second-year reappointment) in mathematics is required. Must exhibit evidence of strong commitment to excellence in teaching and continued scholarly activity. Must be prepared to teach a broad spectrum of undergraduate mathematics courses, including numerical analysis and differential equations. Candidates must be interested in connecting undergraduate students with real-world problems originating in business, industry, or government. Must provide evidence of teaching effectiveness and must complete a successful interview and teaching demonstration. Duties include an annual 24-hour teaching load, scholarly activity, student advisement, supervision of student research, curriculum development, and committee work. Salary/benefits are competitive. Research support is available locally through released-time grants on a competitive basis. Full consideration given to applications received by January 31, 2003. Email applications will not be accepted. Send letter of application addressing qualifications, curriculum vita, copies of undergraduate and graduate transcripts, and three current letters of reference (at least two of which attest to recent teaching effectiveness) to: Dr. Zhoude Shao, Search Chair/AMS0103, Department of Mathematics, Millersville University of Pennsylvania, P. O. Box 1002, Millersville, PA 17551-0302. An AA/EO Institution.

TENNESSEE

VANDERBILT UNIVERSITY
Department of Mathematics
1326 Stevenson Center
Nashville, TN 37240

000201

We invite applications for a non-tenure-track position in algebra and combinatorics beginning in fall 2003. This is a two-year appointment at the assistant professor level, normally renewable for a third year, with 2:1 teaching load. It is intended for a recent Ph.D. with demonstrated research potential and a strong commitment to excellence in teaching. Research areas of interest include, but are not limited to, geometric group theory, universal algebra, algebraic/geometric combinatorics, and graph theory. To apply, send the following materials to Algebra and Combinatorics Search: a letter of application (including email and fax number), the AMS standardized application form fully completed, a curriculum vitae and research summary, and at least 3 letters of recommendation (one of which should specifically address teaching effectiveness). Evaluation of applications will commence on January 7, 2003, and will continue until the position is filled.

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TEXAS

R. L. MOORE INSTITUTE
Austin, TX
Executive Director

000018

The Educational Advancement Foundation, a nonprofit organization supporting math-

ematical education through inquiry-based learning, seeks a full-time executive director for the R. L. Moore Institute (our new multiprogram office situated near The University of Texas campus, which will be headquarters for the Legacy of R. L. Moore Project).

Applicants should have a strong mathematics background (preferably a current or former faculty member), including recent administrative or leadership experience in academic societies or professional associations. In addition, a history of "entrepreneurial" (i.e., sole proprietorship or small business) type management accomplishment is desirable.

Duties: Strong "hands-on" managerial leadership and personal involvement carrying out nonroutine activities is essential. The executive director will coordinate workflow and assign "priority" while working actively with a small staff and a large, diverse group of consultants/volunteers/constituency members and outsiders. The candidate shall have exceptional communication, organizational, and executive skills as well as an ability to articulate a mission-focused vision to diverse constituencies. It is essential that the executive director be able to manage actively and conclude multiple nonroutine projects on a timely basis.

Requirements: Advanced degree in mathematics or science desirable, with over 10 years' educational/administrative experience. The prospective executive director must demonstrate accomplishment in combining leadership with administrative controls and support while sustaining entrepreneurial initiatives. Applicants must be adaptable and flexible to rapidly changing priorities; a self-starter and self-responsible individual with a successful history working with both small groups and larger organizations/associations.

Excellent benefits (health, life, and long-term disability insurance, retirement, etc.) and stimulating cross-discipline working environment with demanding workload. Compensation includes an early merit bonus for exceptional performance.

R. L. Moore Institute is an Equal Opportunity Employer. Email cover letter and résumé to: personnel@edu-adv-foundation.org.

THE UNIVERSITY OF TEXAS AT ARLINGTON
Department of Mathematics
000004

The Department of Mathematics at The University of Texas at Arlington invites applications for a tenure-track or tenured position at the level of assistant/associate/or full professor beginning fall 2003. The position is open to all fields of mathematics. Candidates in numerical analysis, particularly finite elements, preferred. Applicants should have a Ph.D. in mathematics, a strong commitment to teaching at all levels, and an internationally recognized record of research with a strong history of external funding and/or strong potential for future external funding.

Applications should include a résumé detailing research interests and funding record, and three recommendation letters. Use of the standard AMS application cover sheet is recommended. Screening of applicants will begin January 15, 2003. Applications will be accepted until the position is filled. Applications should be sent to:

G. Liao, Chair
Faculty Search Committee
Department of Mathematics
The University of Texas at Arlington
Box 19408
Arlington, TX 76019-0408

For more information about the department, see http://www.uta.edu/math/.

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

WISCONSIN

UNIVERSITY OF WISCONSIN-MADISON
Department of Mathematics
000003

The Department of Mathematics invites applications for possible Van Vleck Visiting Assistant Professorships to begin August 25, 2003. Appointments are for a fixed term of two or three years. The usual teaching load is two courses per semester. Ordinarily only those applicants who have received their doctorate since 2000 will be considered. Promise of excellence in research and teaching is important. Preference will be given to candidates who are likely to interact well with other members of the department. The department also expects to have available one or more VIGRE Van Vleck Assistant Professorships, partially funded by an NSF VIGRE grant, with a reduced teaching load. VIGRE awards are restricted to U.S. citizens and permanent residents who have received the Ph.D. within 18 months of the start of the award.

Applicants should send a completed AMS Standard Cover Sheet, a curriculum vitae which includes a publication list, and a brief statement of research plans to:

Hiring Committee
Dept. of Mathematics, Van Vleck Hall
University of Wisconsin-Madison
480 Lincoln Drive
Madison, WI 53706-1388

Applicants should also arrange to have sent to the above address three to four letters of recommendation, at least one of which must discuss the applicant's teaching experiences and capabilities. Other evidence of good teaching will be helpful. The deadline for applications is December 15, 2002, although applications will continue to be considered until all available positions are filled.

The Department of Mathematics is committed to increasing the number of women and minority faculty. The University of Wisconsin is an Affirmative Action/Equal Opportunity Employer and encourages applications from women and minorities. Unless confidentiality is requested in writing, information regarding the applicants must be released upon request. Finalists cannot be guaranteed confidentiality.

For more information about the position, please consult http://www.math.wisc.edu/.

TAIWAN

NATIONAL CHIAO TUNG UNIVERSITY
Department of Applied Mathematics
000002

Applications are invited for the assistant, associate, or full professor positions beginning fall 2003. All areas of pure and applied mathematics will be considered. The successful applicant should hold the Ph.D. degree in mathematics or a related field (earned by August 2003) and demonstrate strong research potential. The language of instruction is Mandarin.

Applicants must send a letter of application, a curriculum vitae, a copy of transcript, a summary of research plans, and three letters of recommendation to:

Hiring Committee
Department of Applied Mathematics
National Chiao Tung University
Hsinchu 300, Taiwan

For full consideration the application should be received by February 15, 2003.

The department is one of the leading mathematics centers in Taiwan, featuring 21 faculty members in the areas of combinatorics, differential equations, differential geometry, dynamical systems, financial mathematics, functional analysis, Lie theory, numerical analysis, operator theory, probability theory. Visit the department's home page at http://www.math.nctu.edu.tw/ for more information.

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MSRI

Mathematical Sciences Research Institute

POSITION AVAILABLE:

Associate Director/Deputy Director

The Mathematical Sciences Research Institute (MSRI), in Berkeley, seeks a person to serve for two or three years beginning in August 2003, first as Associate Director and then, beginning August 2004, as Deputy Director.

MSRI was founded in 1981 as an independent nonprofit corporation located high in the hills above the campus of the University of California at Berkeley. Its fundamental purpose is to further research in the mathematical sciences through major programs of a semester or a year, through workshops, and through postdoctoral training.

MSRI also engages in outreach to other sciences, to the public, and to various efforts in education, and it is active in encouraging diversity in the research population. MSRI has more than 1,200 visitors to its programs during the year, and has an average of about 20 postdocs and 60 more senior mathematicians in residence at any time.

The Associate Director works alongside the Director and Deputy Director on all phases of Institute activity, and is directly involved in formulation of Institute policy. He or she shares responsibility for the administration of present and future programs. This includes recruiting and hiring postdocs and members, assisting in interactions between program committees and MSRI governance committees, and working with program committees to facilitate smooth organization of program activities. In addition, there are a number of special projects (workshops, journalist-in-residence activities) that the Associate Director helps to arrange. He or she serves on the Scientific Advisory Committee and Human Resource Advisory Committee. The Associate Director helps to coordinate the work of the Board as well as the committees of Academic Sponsors and Corporate Affiliates (currently 69 universities and 12 corporations). In the 2003-04 academic year the Associate Director will serve alongside David Eisenbud, Director, and Robert Megginson, Deputy Director.

Applicants should have a broad understanding of mathematical culture, have an established research record in mathematics, and have substantial administrative experience.

Applications are welcome, and consideration of candidates will begin in January 2003. Applicants should include a statement of their vision for MSRI, and names of possible references; they may also wish to solicit letters of recommendation. Please send materials to:

Search Committee
Mathematical Sciences Research Institute
17 Gauss Way, Berkeley, CA, 94720-5070

HAIL COMMUNITY COLLEGE
Hail, Saudi Arabia

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

Division of Supporting Courses
(Ref. SC 015)

Applications are invited for faculty positions in the Division of Supporting Courses at Hail Community College. Applicants should be well qualified, committed, experienced, flexible, enthusiastic and adaptable with suitable lecturing and/or industrial experience. Candidates should possess either a relevant Ph.D. or Master's Degree and have experience of lecturing either Physics or Chemistry courses at College or University level. Successful applicants will be offered positions at Associate/Assistant Professor or Lecturer level and will be expected to lecture at Undergraduate/Associate Degree level and to undertake other duties as required by the College. The medium of instruction at the College is English.

All contracts: Two-year renewable, competitive salaries depending on qualifications and experience; monthly local transportation allowance and an end-of-service gratuity.

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To apply: Mail, fax or e-mail cover letter, detailed CV/resume to:

Dean, Faculty & Personnel Affairs
King Fahd University of Petroleum & Minerals
DEPT: HCC-2308
Dhahran 31261, Saudi Arabia
Fax: (+966-3) 860-2429
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Payment by check must be drawn on U.S. bank if paid in U.S. dollars.

Send checks, money orders, UNESCO coupons to American Mathematical Society, P.O. Box 845904, Boston, MA 02284-5904.

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For Foreign Bank Transfers: Citizens Bank, 1 Citizens Drive, Riverside, RI 02915, ABA #011-500-120, for American Mathematical Society, Acct #1107802021.

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M03NO

Membership Categories

Please read the following to determine what membership category you are eligible for, and then indicate below the category for which you are applying.

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

Introductory ordinary member rate applies to the first five ***consecutive*** years of ordinary membership. Eligibility begins with the first year of membership in any category other than student and nominee. Dues are $54.

For ***ordinary members*** whose annual professional income is below $75,000, the dues are $108; for those whose annual professional income is $75,000 or more, the dues are $144.

Minimum dues for ***contributing members*** are $216. The amount paid which exceeds the higher ordinary dues level and is purely voluntary may be treated as a charitable contribution.

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.)

The annual dues for ***reciprocity members*** who reside outside the U.S. are $72. To be eligible for this classification, members must belong to one of those foreign societies with which the AMS has established a reciprocity agreement. Annual verification is required. Reciprocity members who reside in the U.S. must pay ordinary member dues ($108 or $144).

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

For either ***students*** or ***unemployed individuals,*** dues are $36, and annual verification is required.

2003 Dues Schedule (January through December)

Ordinary member, introductory rate			☐$54
Ordinary member	☐$108		☐$144
Joint family member (full rate)	☐$108		☐$144
Joint family member (reduced rate)	☐$88		☐$124
Contributing member (minimum $216)			☐
Student member (please verify)[1]			☐$36
Unemployed member (please verify)[2]			☐$36
Reciprocity member (please verify)[3]	☐$72	☐$108	☐$144
Category-S member [4]			☐$16

Multi-year membership .....$.....for.....years

[1] ***Student Verification*** (sign below)
I am a full-time student at _____

_____ currently working toward a degree.

[2] ***Unemployed Verification*** (sign below) I am currently unemployed and actively seeking employment.

[3] ***Reciprocity Membership Verification*** (sign below) I am currently a member of the society indicated on the right and am therefore eligible for reciprocity membership.

_____
Signature

[4] ☐ ***send*** **NOTICES** ☐ ***send*** **BULLETIN**

Reciprocating Societies

- ☐ Allahabad Mathematical Society
- ☐ Australian Mathematical Society
- ☐ Azerbaijan Mathematical Society
- ☐ Balkan Society of Geometers
- ☐ Belgian Mathematical Society
- ☐ Berliner Mathematische Gesellschaft
- ☐ Calcutta Mathematical Society
- ☐ Canadian Mathematical Society
- ☐ Croatian Mathematical Society
- ☐ Cyprus Mathematical Society
- ☐ Danish Mathematical Society
- ☐ Deutsche Mathematiker-Vereinigung
- ☐ Edinburgh Mathematical Society
- ☐ Egyptian Mathematical Society
- ☐ European Mathematical Society
- ☐ Gesellschaft für Angewandte Mathematik und Mechanik
- ☐ Glasgow Mathematical Association
- ☐ Hellenic Mathematical Society
- ☐ Icelandic Mathematical Society
- ☐ Indian Mathematical Society
- ☐ Iranian Mathematical Society
- ☐ Irish Mathematical Society
- ☐ Israel Mathematical Union
- ☐ János Bolyai Mathematical Society
- ☐ The Korean Mathematical Society
- ☐ London Mathematical Society
- ☐ Malaysian Mathematical Society
- ☐ Mathematical Society of Japan
- ☐ Mathematical Society of Serbia
- ☐ Mathematical Society of the Philippines
- ☐ Mathematical Society of the Republic of China
- ☐ Mongolian Mathematical Society
- ☐ Nepal Mathematical Society
- ☐ New Zealand Mathematical Society
- ☐ Nigerian Mathematical Society
- ☐ Norsk Matematisk Forening
- ☐ Österreichische Mathematische Gesellschaft
- ☐ Palestine Society for Mathematical Sciences
- ☐ Polskie Towarzystwo Matematyczne
- ☐ Punjab Mathematical Society
- ☐ Ramanujan Mathematical Society
- ☐ Real Sociedad Matemática Española
- ☐ Saudi Association for Mathematical Sciences
- ☐ Singapore Mathematical Society
- ☐ Sociedad Colombiana de Matemáticas
- ☐ Sociedad Española de Matemática Aplicada
- ☐ Sociedad de Matemática de Chile
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- ☐ Sociedad Matemática Mexicana
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- ☐ Sociedade Brasileira Matemática
- ☐ Sociedade Brasileira de Matemática Aplicada e Computacional
- ☐ Sociedade Paranaense de Matemática
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- ☐ Societatea de Ştiinţe Matematice din România
- ☐ Societatea Matematicienilor din Romania
- ☐ Société Mathématique de France
- ☐ Société Mathématique du Luxembourg
- ☐ Société Mathématique Suisse
- ☐ Société Mathématiques Appliquées et Industrielles
- ☐ Society of Associations of Mathematicians & Computer Science of Macedonia
- ☐ Society of Mathematicians, Physicists, and Astronomers of Slovenia
- ☐ South African Mathematical Society
- ☐ Southeast Asian Mathematical Society
- ☐ Suomen Matemaattinen Yhdistys
- ☐ Svenska Matematikersamfundet
- ☐ Ukrainian Mathematical Society
- ☐ Union Mathemática Argentina
- ☐ Union of Bulgarian Mathematicians
- ☐ Union of Czech Mathematicians and Physicists
- ☐ Union of Slovak Mathematicians and Physicists
- ☐ Unione Matematica Italiana
- ☐ Vijnana Parishad of India
- ☐ Wiskundig Genootschap

Change of Address

Members of the Society who move or change positions are urged to notify the Providence Office as soon as possible.

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

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

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

If your address has changed or will change within the next two or three months, please fill out this form, supply any other information appropriate for the AMS records, and mail it to:

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02940-6248 USA

or send the information on the form by e-mail to:
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New position _____

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Location of employer (city, state, zip code, country)

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Telephone/home: _____ **office:** _____

Fax: _____

e-mail _____

Recent honors and awards

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Baltimore, Maryland, January 15–18, 2003

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Recent titles by authors speaking at the Joint Mathematics Meetings

FREE AMS briefcase with purchase of $75 or more at the AMS booth!

Ramanujan: Essays and Surveys

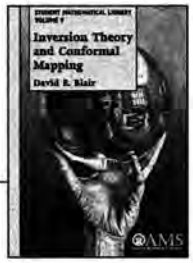
Bruce C. Berndt, *University of Illinois, Urbana-Champaign,* and **Robert A. Rankin**, *University of Glasgow, Scotland,* Editors

Copublished with the London Mathematical Society. Members of the LMS may order directly from the AMS at the AMS member price. The LMS is registered with the Charity Commissioners.

History of Mathematics, Volume 22; 2001; 347 pages; Hardcover; ISBN 0-8218-2624-7; List $79; All AMS members*; Order code HMATH/22CT301

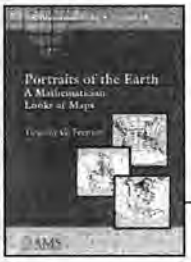
Inversion Theory and Conformal Mapping

David E. Blair, *Michigan State University, East Lansing*



M. C. Escher's Hand with Reflecting Sphere ©2000 Cordon Art B.V. - Baarn - Holland. All rights reserved.

Student Mathematical Library, Volume 9; 2000; 118 pages; Softcover; ISBN 0-8218-2636-0; List $19; All AMS members*; Order code STML/9CT301



Portraits of the Earth

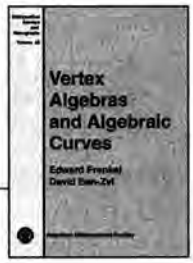
A Mathematician Looks at Maps

Timothy G. Feeman, *Villanova University, PA*

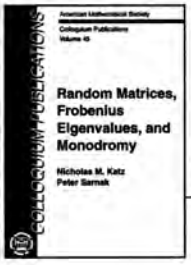
Mathematical World, Volume 18; 2002; 123 pages; Softcover; List $26; All AMS members*; Order code MAWRLD/18CT301

Vertex Algebras and Algebraic Curves

Edward Frenkel, *University of California, Berkeley,* and **David Ben-Zvi**, *University of Chicago, IL*



Mathematical Surveys and Monographs, Volume 88; 2001; 348 pages; Hardcover; ISBN 0-8218-2894-0; List $55; All AMS members*; Order code SURV/88CT301



Random Matrices, Frobenius Eigenvalues, and Monodromy

Nicholas M. Katz and **Peter Sarnak**, *Princeton University, NJ*

Colloquium Publications, Volume 45; 1999; 419 pages; Hardcover; ISBN 0-8218-1017-0; List $72; Individual member*; Order code COLL/45CT301

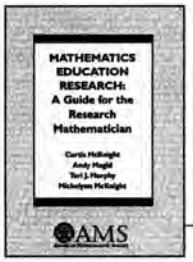
Classical and Quantum Computation

A. Yu. Kitaev, *California Institute of Technology, Pasadena,* and **A. H. Shen** and **M. N. Vyalyi**, *Independent University of Moscow, Russia*

Available in Hardcover and Softcover

Graduate Studies in Mathematics, Volume 47; 2002; 257 pages;
Hardcover; ISBN 0-8218-2161-X; List $59; All AMS members*; Order code GSM/47CT301
Softcover; ISBN 0-8218-3229-8; List $36; All AMS members*; Order code GSM/47.SCT301

* Discounted pricing is available for AMS members, visit www.amsbookstore.org, email cust-serv@ams.org, or call 1-401-455-4000 (worldwide) for your membership price.

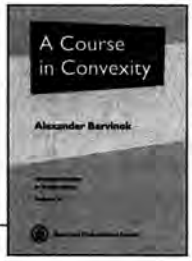


Mathematics Education Research: A Guide for the Research Mathematician

Curtis McKnight, **Andy Magid**, and **Teri J. Murphy**, *University of Oklahoma, Norman*, and **Michelynn McKnight**, *Norman, OK*

2000; 106 pages; Softcover; ISBN 0-8218-2016-8; List $20;
All AMS members*; Order code MERCT301

These recent publications will also be available at the AMS booth.



A Course in Convexity

Alexander Barvinok, *University of Michigan, Ann Arbor*

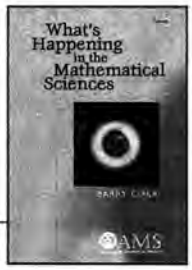
Graduate Studies in Mathematics, Volume 54;
2002; 366 pages; Hardcover; ISBN 0-8218-2968-8; List $59; All AMS members*; Order code GSM/54CT301

Codebreakers

Arne Beurling and the Swedish Crypto Program during World War II

Bengt Beckman

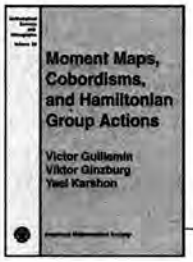
2003; 259 pages; Hardcover; ISBN 0-8218-2889-4;
List $39; All AMS members*; Order code SWCRYCT301



What's Happening in the Mathematical Sciences

Barry Cipra

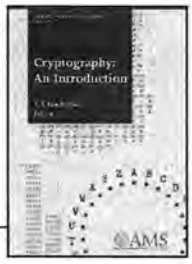
What's Happening in the Mathematical Sciences, Volume 5;
2002; 95 pages; Softcover; ISBN 0-8218-2904-1; List $19;
All AMS members*; Order code HAPPENING/5CT301



Moment Maps, Cobordisms, and Hamiltonian Group Actions

Victor Guillemin, *Massachusetts Institute of Technology, Cambridge*, **Viktor Ginzburg**, *University of California, Santa Cruz*, and **Yael Karshon**, *The Hebrew University of Jerusalem, Israel*

Mathematical Surveys and Monographs, Volume 98; 2002; 350 pages; Hardcover; ISBN 0-8218-0502-9;
List $79; Individual member*; Order code SURV/98CT301



Cryptography: An Introduction

V. V. Yaschenko, *Moscow Center for Continuous Mathematics Education, Russia*, Editor

Student Mathematical Library, Volume 18;
2002; approximately 234 pages; Softcover; ISBN 0-8218-2986-6;
List $39; All AMS members*; Order code STML/18CT301

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11/02

General Information Regarding Meetings & Conferences of the AMS

Speakers and Organizers: The Council has decreed that no paper, whether invited or contributed, may be listed in the program of a meeting of the Society unless an abstract of the paper has been received in Providence prior to the deadline.

Although an individual may present only one ten-minute contributed paper at a meeting, any combination of joint authorship may be accepted, provided no individual speaks more than once. An author can speak by invitation in more than one Special Session at the same meeting.

Special Sessions: The number of Special Sessions at an Annual Meeting is limited. Special Sessions at Annual Meetings are held under the supervision of the Program Committee for National Meetings and, for Sectional Meetings, under the supervision of each Section Program Committee. They are administered by the Associate Secretary in charge of that meeting with staff assistance from the Meetings and Conferences Department in Providence. (See the list of Associate Secretaries on the last page of this issue.)

Each person selected to give an Invited Address is also invited to generate a Special Session, either by personally organizing one or by having it organized by others. Proposals to organize a Special Session are sometimes solicited either by a program committee or by the Associate Secretary. Other proposals should be submitted to the Associate Secretary in charge of that meeting (who is an ex officio member of the program committee) at the address listed below. These proposals must be in the hands of the Associate Secretary at least seven months (for sectional meetings) or nine months (for national meetings) prior to the meeting at which the Special Session is to be held in order that the committee may consider all the proposals for Special Sessions simultaneously. Special Sessions must be announced in the *Notices* in a timely fashion so that any Society member who so wishes may submit an abstract for consideration for presentation in the Special Session.

Talks in Special Sessions are usually limited to twenty minutes; however, organizers who wish to allocate more time to individual speakers may do so within certain limits. A great many of the papers presented in Special Sessions at meetings of the Society are invited papers, but any member of the Society who wishes to do so may submit an abstract for consideration for presentation in a Special Session, provided it is submitted to the AMS prior to the special early deadline for consideration. Contributors should know that there is a limit to the size of a single Special Session, so sometimes all places are filled by invitation. Papers submitted for consideration for inclusion in Special Sessions but not accepted will receive consideration for a contributed paper session, unless specific instructions to the contrary are given.

The Society reserves the right of first refusal for the publication of proceedings of any Special Session. If published by the AMS, these proceedings appear in the book series *Contemporary Mathematics*. For more detailed information on organizing a Special Session, see `www.ams.org/meetings/specialsessionmanual.html`.

Contributed Papers: The Society also accepts abstracts for ten-minute contributed papers. These abstracts will be grouped by related *Mathematical Reviews* subject classifications into sessions insofar as possible. The title and author of each paper accepted and the time of presentation will be listed in the program of the meeting.

Other Sessions: In accordance with policy established by the AMS Committee on Meetings and Conferences, mathematicians interested in organizing a session at an annual or sectional meeting on employment opportunities inside or outside academia for young mathematicians should contact the Associate Secretary for the meeting with a proposal by the stated deadline. Also, potential organizers for poster sessions on a topic of choice should contact the Associate Secretary before the deadline.

Abstracts: Abstracts for all papers must be received by the meeting coordinator in Providence by the stated deadline. Unfortunately, late papers cannot be accommodated.

Electronic submission procedures: Send a message to `abs-submit@ams.org` and type *help* as the subject to review your options, or visit the meetings and conferences home page on the Web at `http://www.ams.org/committee/meetings/`. **Completed electronic abstracts must be submitted to** `abs-submit@ams.org`, typing *submission* as the subject.

Submission by U. S. mail: Paper AMS abstract forms may be requested by contacting the Meeting Coordinator, AMS Meetings and Conferences Department, P. O. Box 6887, Providence, RI 02940; telephone: 401-455-4146; e-mail: `meet@ams.org`. Your completed abstract should be sent to the same address by the stated deadline. N. B. there is a $20 processing fee for paper abstracts. There is no charge for abstracts submitted electronically.

See the inside front cover of *Abstracts of Papers Presented to the American Mathematical Society* for information on abstracts published by title and not presented at a meeting.

Site Selection for Sectional Meetings

Sectional meeting sites are recommended by the Associate Secretary for the section and approved by the Secretariat. Recommendations are usually made eighteen to twenty-four months in advance. Host departments supply local information, ten to fifteen rooms with overhead projectors for contributed paper sessions and Special Sessions, an auditorium with twin overhead projectors for Invited Addresses, space for registration activities and an AMS book exhibit, and registration clerks. The Society partially reimburses for the rental of facilities and equipment and for staffing the registration desk. Most host departments volunteer; to do so, or for more information, contact the Associate Secretary for the section.

Meetings & Conferences of the AMS

IMPORTANT INFORMATION REGARDING MEETINGS PROGRAMS: AMS Sectional Meeting programs do not appear in the print version of the *Notices*. However, comprehensive and continually updated meeting and program information with links to the abstract for each talk can be found on the AMS website. See `http://www.ams.org/meetings/`. Programs and abstracts will continue to be displayed on the AMS website in the Meetings and Conferences section until about three weeks after the meeting is over. Final programs for Sectional Meetings will be archived on the AMS website in an electronic issue of the *Notices* as noted below for each meeting.

Baltimore, Maryland

Baltimore Convention Center

January 15–18, 2003

Meeting #983

Joint Mathematics Meetings, including the 109th Annual Meeting of the AMS, 86th Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), the winter meeting of the Association for Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).

Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: October 2002
Program first available on AMS website: November 1, 2002
Program issue of electronic *Notices*: January 2003
Issue of *Abstracts*: Volume 24, Issue 1

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired
For summaries of papers to MAA organizers: Expired

Joint Program Updates

Math on the Web, Wednesday–Saturday, various times. The problem of communicating Math on the Web is really no different from communicating math via other media. Namely, authoring and displaying mathematical notation is difficult. On top of that, the Web is a dynamic medium, where users can interact with rich media documents in sophisticated ways. This introduces a whole new layer of challenges and possibilities for engaging, interactive communication between authors and readers. Informative presentations at the Math on the Web Pavilion (exhibit booths 719 and 818) will address many of these challenges and possibilities. Come and see what's new in the area of Math on the Web!

Topics to be presented include *Overview of MathML Markup*; *Math on the Web with Mathematica Technology*; *Creating Interactive Web Pages with MathML*; *Displaying MathML in Browsers*; *MathML, OpenMath, and Web Services*; *Creating Mathematical Documents for the Web With Scientific WorkPlace*; *TEX to Web Conversion*; *MathML in the Digital Library of Mathematical Functions*; *Maple on the Web: New Technologies, Products, and Applications*; and *The Case for Structured Documents in Math and Science*. See the "Program of the Sessions" section for details on days and times. This session is cosponsored by the AMS and the MAA.

AMS Program Updates

Graphic Depiction of Mathematics: Tips for Minimizing Hassles with Your Publisher, Thursday, 1:00 p.m. to 2:30 p.m., presented by **Stephen Moye** and **Tom Kacvinsky**, AMS. "Dear Author: Your paper is accepted for publication, but there are problems with your graphics." Have you ever received a note like this? Feeling discouraged? Then join the AMS experts for a session on how to prepare graphics for your publisher. Graphics, often an essential part of a document devoted to mathematics, are also the element of the publishing process most prone to headaches and hassles for authors and publishers alike. In this session we will talk about good practices for the creation of graphics and discuss commonly available software that can considerably ease the process of creating graphics. This presentation offers tips and information to avert problems before they happen, thus facilitating the publishing process for you and the publisher.

A **Town Meeting**: Friday, 2:30 p.m. to 4:00 pm., with **William Rundell**, new Director of the Division of Mathematical Sciences, National Science Foundation. This special presentation is sponsored by the Committee on Science Policy.

Successfully Recruiting Mathematics Majors, Saturday, 8:30 a.m. to 10:00 a.m. This panel discussion sponsored by the Committee on Education will address the declining number of undergraduate and graduate students. The moderator is **William G. McCallum**, University of Arizona. Panelists include **John C. Mayer**, University of Alabama at Birmingham; **Ronald Miech**, University of California Los Angeles; **Calvin C. Moore**, University of California Berkeley; and **Lisa M. Traynor**, Bryn Mawr College.

MAA Program Updates

MAA Invited Addresses:

Ivor Grattan-Guiness, Middlesex University, *History or heritage? Historians and mathematicians on the history of mathematics*, Wednesday, 3:20 p.m.

The Invited Address by **David H. Fowler** has been cancelled.

Other Organizations

Women in Mathematics: Past, Present, and Future, Thursday, 5:45 p.m. to 7:45 p.m., organized by **Antonia Bluher** and **Michelle D. Wagner**, National Security Agency. This is the tenth year anniversary of NSA's Women in Mathematics Symposium (WIMS). In 1993 the NSA invited women mathematicians from the academic community to attend WIMS to solicit their perspectives on NSA as an employer, and to discuss ways in which the NSA mathematics community could encourage young women to pursue careers in mathematics. Please join us to celebrate this milestone with technical talks, a panel discussion, and networking opportunities.

Other Events

Employment Center Exhibit: A special historical exhibit marking the fiftieth anniversary of the Employment Register is on display in the lobby outside of the Joint Meetings Registration area.

Started by the AMS and MAA in December 1953 (later joined by SIAM), the original Employment Register was conducted by J. Sutherland Frame, who managed it with the help of other volunteers (the Joint Committee on Employment Opportunities, JCEO) until 1959. At that time it consisted of four looseleaf binders filled with job announcements that were passed from meeting to meeting. The idea of an interview scheduling process came up in the 1960s, and the original computer programming was done by a JCEO member, D. R. Morrison. In the job crunch of the early 1970s the print publication *Employment Information in the Mathematical Sciences* (EIMS) was created to help broadcast job openings. The Employment Register evolved from its beginnings as an actual paper register to become an on-site meeting place for employers and applicants at the Joint Meetings, which it is today, under its new name, the Employment Center.

Over the years, applicants and employers have had some complaints about each other and about the room, the noise, the bells, the lighting, the chairs, the schedule, and yes, at times, the smell. But for fifty years they have sat through numerous useful and less useful chats, always with the idea in mind that the right colleague may appear on the other side of the table at any moment and a connection be formed that will be productive for decades. This exhibit chronicles the ups and downs of an always difficult process, and even includes snapshots of the careers of some individuals as they happened in the years following their Employment Register experience.

Social Events

Fun Run, Thursday, 7:00 a.m. to 8:00 a.m. All meeting participants are invited on a 5K fun run sponsored by Elsevier Science. Upon finishing the route, runners are invited to a complimentary continental breakfast. Join your colleagues for this healthy eye-opener on Thursday morning. Further details will be published in the daily newsletter and also be available at the Elsevier Science booth in the exhibit hall.

MAA Two-Year College Reception, Thursday, 5:45 p.m. to 7:00 p.m., is open to all meeting participants, particularly two-year faculty members. This is a great opportunity to meet old friends and make some new ones. There will be hot and cold refreshments and a cash bar. Sponsored by Addison Wesley Longman.

Purdue Mathematics Department Alumni Reception, Monday, 6:00 p.m. to 7:00 p.m.

Registration at the Meetings

Individuals who registered by November 15 and who so elected will have their badge and the final program mailed to them before the Meetings. All other registrants will receive the final program at the Meetings. The additional information below is to assist those who will register at the Meetings and those who registered in advance but elected not to receive their badges and final programs by mail.

Advance and on-site meeting registration fees only partially cover expenses of holding meetings. All mathematicians who wish to attend sessions are expected to register and should be prepared to show the Meetings badge, if so requested. Badges are required to obtain discounts at the AMS and MAA Book Sales and to cash a check with the Meetings cashier. If advance registrants should arrive too late in the day to pick up their badges, they may show the acknowledgment received from the Mathematics Meetings Service Bureau (MMSB) as proof of registration.

Registration fees may be paid at the Meetings in cash, by personal or traveler's check, or by VISA, MasterCard, American Express, or Discover. Letters verifying attendance at the Meetings may be obtained from the cashier or at the Registration Assistance section of the Registration Desk.

Participants wishing to attend sessions for one day only may take advantage of a one-day fee. These special fees are effective daily, January 15 through 18, and are available at the Meetings to both members and nonmembers. These one-day fees are not applicable to librarians, high school teachers, unemployed or emeritus participants, or high school, undergraduate, or graduate students.

Joint Mathematics Meetings

Member of AMS, ASL, Canadian Mathematical Society (CMS), MAA, SIAM	$247
Emeritus Member of AMS, MAA/ Graduate Student/Unemployed/ Librarians/High School Teachers/ Developing Country Participant	$45
Undergraduate Students	$26
Nonmember	$383
Temporarily Employed	$172
High School Students	$5
Nonmathematician Guest	$5

Joint Mathematics Meetings One Day

Member of AMS, ASL, CMS, MAA, SIAM	$136
Nonmember	$211

MAA Minicourses (if openings available)

Minicourses #1-6	$90
Minicourses #7-16	$60

Employment Center

Employer (First Table)	$300
Employer (Each Additional Table)	$100
Applicant (All Services)	$75
Applicant (Message Center Only)	$20

AMS Short Course

Student/Unemployed	$50
Emeritus Member of AMS, MAA	$50
Member of AMS or MAA	$100
All Other Participants	$130

MAA Short Course

MAA member	$140
Nonmember	$190
Student/Unemployed/Emeritus	$60

Accommodations and Travel

Participants who did not reserve a room during advance registration but who would like to obtain a room at one of the hotels listed on pages 1184-1185 in the October issue of the *Notices* should call the hotels directly after **December 23**. However, we regret that after that date the MMSB can no longer guarantee availability of rooms or of the special convention rates.

Please see the October issue for special discount fare information on USAirways and Southwest Airlines.

Registration Dates, Times, and Locations

AMS and MAA Short Courses
outside Room 301, Baltimore Convention Center
Monday, January 13 8:00 a.m. to 2:00 p.m.

Joint Mathematics Meetings and MAA Minicourses
Hall A, Baltimore Convention Center
Tuesday, January 14 3:00 p.m. to 7:00 p.m.
Wednesday-Friday, Jan. 15-17 7:30 a.m. to 4:00 p.m.
Saturday, January 18 7:30 a.m. to 2:00 p.m.

Employment Center
Hall C, Baltimore Convention Center
Wednesday, January 15
Registration for scheduled interviews, materials pickup 7:30 a.m. to 4:00 p.m.
Interview Center 9:30 a.m. to 6:00 p.m.
Thursday, January 16
Schedule distribution, interviews 7:00 a.m. to 4:40 p.m.
Interview Center 8:00 a.m. to 7:30 p.m.
Friday, January 17
Scheduled interviews 8:15 a.m. to 4:40 p.m.
Interview Center 8:00 a.m. to 7:30 p.m.
Saturday, January 9
Interview Center only 9:00 a.m. to noon

Employment Center registrants who are participating in the computer-scheduled interviews must register and fill out interview request forms on **Wednesday, January 15.** There will be no registration on Thursday and Friday; only interviews will take place on these days.

Baton Rouge, Louisiana

Louisiana State University

March 14–16, 2003

Meeting #984

Southeastern Section
Associate secretary: John L. Bryant
Announcement issue of *Notices*: January 2003
Program first available on AMS website: January 30, 2003
Program issue of electronic *Notices*: March 2003
Issue of *Abstracts*: Volume 24, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: January 22, 2003

Invited Addresses

Bruce K. Driver, University of California San Diego, *Heat Equations on Loop Groups.*

Gunter Lumer, Université de Mons-Hainout, *Stability analysis, Paley-Wiener criteria, and related problems in material science/ecology.*

Barry M. McCoy, SUNY at Stony Brook, *Title to be announced.*

Stephen C. Milne, Ohio State University, *A new look at sums of squares, Jacobi elliptic functions, and Ramanujan's tau function.*

Special Sessions

Algebraic Number Theory and K-Theory (Code: AMS SS A1), **Jurgen Hurrelbrink** and **Jorge F. Morales**, Louisiana State University, and **Robert Osburn**, McMaster University.

Applied Mathematics and Materials Science (Code: AMS SS B1), **Robert Lipton**, **Stephen Shipman**, **Blaise Bourdin**, and **Yuri Antipov**, Louisiana State University.

Arrangements in Topology and Algebraic Geometry (Code: AMS SS C1), **Daniel C. Cohen**, Louisiana State University, and **Alexander I. Suciu**, Northeastern University.

Asymptotic Analysis, Stability, and Generalized Functions. (Code: AMS SS M1), **Ricardo Estrada** and **Frank Neubrander**, Louisiana State University, and **Gunter Lumer**, University of Mons-Hainaut.

Commutative Ring Theory (Code: AMS SS D1), **James B. Coykendall**, North Dakota State University, and **Bernadette Mullins**, Birmingham State College.

Frames, Wavelets, and Tomography (Code: AMS SS E1), **Gestur Olafsson**, Louisiana State University.

Graphs and Matroids (Code: AMS SS F1), **Bogdan S. Oporowski** and **James G. Oxley**, Louisiana State University.

Induced Representations: Connections to Graphs, Number Theory, Geometry (Code: AMS SS G1), **J. William Hoffman**, **Robert V. Perlis**, and **Neal W. Stoltzfus**, Louisiana State University.

Low Dimensional Topology (Code: AMS SS H1), **Oliver T. Dasbach**, **Patrick M. Gilmer**, and **Richard A. Litherland**, Louisiana State University.

Mathematical Techniques in Musical Analysis (Code: AMS SS J1), **Judith L. Baxter**, University of Illinois at Chicago, and **Robert Peck**, Louisiana State University.

Q-Series in Number Theory and Combinatorics (Code: AMS SS N1), **Mourad E. H. Ismail**, University of South Florida, and **Stephen C. Milne**, The Ohio State University.

Stochastic Analysis and Applications (Code: AMS SS K1), **H.-H. Kuo** and **P. Sundar**, Louisiana State University.

Stochastics, Quantization, and Segal-Bargmann Analysis (Code: AMS SS L1), **Bruce K. Driver**, University of California San Diego, **Brian C. Hall**, University of Notre Dame, and **Jeffrey J. Mitchell**, Baylor University.

The Role of Mathematics Departments in Secondary Education (Code: AMS SS P1), **James J. Madden** and **Frank Neubrander**, Louisiana State University.

Accommodations

Participants should make their own arrangements directly with a hotel of their choice. Special rates for the meeting are available at the properties shown below for the nights of Thursday, Friday, and Saturday, March 13–15. Room rates do not include the tax of 13%. Please cite the group name **LSU Math** or **American Mathematical Society** when making a reservation. Hotels have varying cancellation or early checkout penalties; be sure to ask details when making your reservation. The AMS is not responsible for rate changes or for the quality of the accommodations.

Lod and Carole Cook Conference Center & Hotel, 3848 West Lakeshore Drive, Baton Rouge, LA 70808; 225-383-2665; 225-383-4200 (fax); 866-610-2665 (toll free); standard rooms are $75/single or double, $85/triple, $95/quad; suites are $95/single or double, $105/triple, $115/quad; mega suites are $135/single or double, $145/triple, $155/quad; rates include complimentary breakfast for up to two people per room; fitness center on site; property is on campus, about a 20-minute walk (just under a mile) to the sessions. **Deadline for reservations is January 31, 2003.** See `http://www.cookconferencecenter.org/`.

Sheraton Baton Rouge Convention Center Hotel, 102 France Street, Baton Rouge, LA 70802, 225-242-2600; 225-242-2601 (fax); $75/single or double for deluxe room and $95/single or double for the concierge level; full service restaurant, complimentary guest parking and airport shuttle (to/from Baton Rouge Metro/Ryan Field Airport), heated outdoor pool, fitness facility; property is about five miles from campus. **Deadline for reservations is January 31, 2003.**

Additionally, a very limited number of bed and breakfast type accommodations are available at the **LSU Faculty Club**, Corner of Highland Road & Raphael Semmes Drive on campus; $55/single, $60/double (only one bed unless twin beds are requested), $75/single suite. Rates include continental breakfast and free parking. Call 225-578-2356 for reservations and information or send email to `facclub@eatel.net`.

Food Service

There is a cafeteria with an all-you-can-eat buffet, two coffee shops, and a food court available in the LSU Union, a leisurely walk of about eight minutes from the sessions. There are a variety of restaurants about a 12-minute walk from the meeting. The list will be published in the program.

Local Information

The Math Department's Web page is located at `http://www.math.lsu.edu`; the University's home page is `http://www.lsu.edu`. There is a campus map at `http://www.lsu.edu/campus/`.

Other Activities

Book Sales: Examine the newest titles from the AMS! Many of the AMS books will be available at a special 50% discount available only at the meeting. Complimentary coffee will be served courtesy of AMS Membership Services.

AMS Editorial Activity: An acquisitions editor from the AMS Book program will be present to speak with prospective authors. If you have a book project that you would like to discuss with the AMS, please stop by the book exhibit.

Parking

Parking is available in the LSU Union parking lot (the cost is $1/hour on Friday, but free on Saturday and Sunday), and along curbside during the weekends.

Registration and Meeting Information

The meeting is on the main campus of Louisiana State University in Baton Rouge, Louisiana. Sessions will take place in Tureaud Hall; Invited Addresses will be in Dodson Auditorium.

The registration desk will be in Tureaud Hall and will be open Friday, March 14, noon–4:30 p.m. and Saturday, March 15, 7:30 a.m.–4:00 p.m. Fees are $40 for AMS or CMS members, $60 for nonmembers; and $5 for students/unemployed/emeritus, payable on site by cash, check or credit card.

Travel

The nearest airport is Baton Rouge Metro/Ryan Field Airport (BTR) (8 miles away). Some travelers may find it convenient to use the New Orleans International Airport (MSY) (75 miles away) or the Lafayette Regional Airport (LFT) (50 miles away). To find your way around campus, it is recommended that you first go to the Visitor Information Center to obtain detailed campus directions, a parking permit, and parking instructions. The Visitors Information Center is located at the corner of Highland Road and Dalrymple Drive. There are three possible routes of access from I-10:

1. Exit at Nicholson Dr./Highland Rd. (Exit 155A). Take Highland Rd. to Dalrymple Dr. (about 1.4 miles).

2. Exit at Dalrymple Dr. (Exit 156B). Both eastbound and westbound traffic will take a right onto Dalrymple Dr. from the off-ramp. Take Dalrymple Dr. to Highland Rd. (about 0.5 mile).

3. Exit at Acadian Thruway (Exit 157B). If exiting from the eastbound off-ramp you will take a right onto Acadian Thruway; if exiting from the westbound off-ramp you will take a left onto Acadian Thruway. Take Acadian Thruway (which turns into Stanford Avenue and then into LSU Avenue) to Highland Rd. Take a right onto Highland Rd. Take Highland Rd. to Dalrymple Dr. (about 1.8 miles).

Car rental: Special rates have been negotiated with Avis Rent A Car for the period March 7 to March 23, 2003, beginning at $23.99/day for a subcompact car at the weekend rate (the weekend rate is available from noon Thursday until midnight Monday) All rates include unlimited free mileage. Rates do not include state or local surcharges, tax, optional coverages, or gas refueling charges. Renter must meet Avis' age, driver, and credit requirements, and return to the same renting location. Make reservations by calling 800-331-1600 or online at `www.avis.com`. Please quote **Avis Discount Number B159266** when making reservations.

Weather

Weather conditions in March in Baton Rouge are usually pleasant. Temperatures are between 50 and 70 degrees, and the average rainfall is five inches for the month.

Bloomington, Indiana

Indiana University

April 4–6, 2003

Meeting #985

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: February 2003
Program first available on AMS website: February 20, 2003
Program issue of electronic *Notices*: April 2003
Issue of *Abstracts*: Volume 24, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: December 17, 2002
For abstracts: February 11, 2003

Invited Addresses

Daniel J. Allcock, University of Texas, *Title to be announced.*

Brian D. Conrad, University of Michigan, *Title to be announced.*

Robin A. Pemantle, Ohio State University, *Title to be announced.*

Sijue Wu, University of Maryland, *Title to be announced.*

Special Sessions

Algebraic Topology (Code: AMS SS W1), **Randy McCarthy**, University of Illinois, Urban-Champaign, and **Ayelet Lindenstrauss**, Indiana University.

Applications of Teichmueller Theory to Dynamics and Geometry (Code: AMS SS K1), **Christopher M. Judge** and **Matthias Weber**, Indiana University.

Codimension One Splittings of Manifolds (Code: AMS SS U1), **James F. Davis**, Indiana University, and **Andrew A. Ranicki**, University of Edinburgh.

Cryptography and Computational and Algorithmic Number Theory (Code: AMS SS S1), **Joshua Holden** and **John Rickert**, Rose-Hulman Institute of Technology, **Jonathan Sorenson**, Butler University, and **Andreas Stein**, University of Illinois at Urbana-Champaign.

Differential Geometry (Code: AMS SS L1), **Jiri Dadok, Bruce Solomon**, and **Ji-Ping Sha**, Indiana University.

Ergodic Theory and Dynamical Systems (Code: AMS SS A1), **Roger L. Jones** and **Ayse A. Sahin**, DePaul University.

Extremal Combinatorics (Code: AMS SS R1), **Dhruv Mubayi**, University of Illinois at Chicago, and **Jozef Skokan**, University of Illinois at Urbana-Champaign.

Geometric Topology (Code: AMS SS D1), **Paul A. Kirk** and **Charles Livingston**, Indiana University.

Graph Theory (Code: AMS SS Q1), **Tao Jiang, Zevi Miller**, and **Dan Pritikin**, Miami University.

Graph and Design Theory (Code: AMS SS N1), **Atif A. Abueida**, University of Dayton, and **Mike Daven**, Mount Saint Mary College.

Harmonic Analysis in the 21st Century (Code: AMS SS E1), **Winston C. Ou** and **Alberto Torchinsky**, Indiana University.

Holomorphic Dynamics (Code: AMS SS B1), **Eric D. Bedford** and **Kevin M. Pilgrim**, Indiana University.

Mathematical and Computational Problems in Fluid Dynamics and Geophysical Fluid Dynamics (Code: AMS SS

H1), **Roger Temam** and **Shouhong Wang**, Indiana University.

Operator Algebras and Free Probability (Code: AMS SS J1), **Hari Bercovici**, Indiana University, and **Marius Dadarlat**, Purdue University.

Operator Algebras and Their Applications (Code: AMS SS T1), **Jerry Kaminker** and **Ronghui Ji**, Indiana University-Purdue University Indianapolis.

Particle Models and their Fluid Limits (Code: AMS SS F1), **Robert T. Glassey** and **David C. Hoff**, Indiana University.

Probability (Code: AMS SS G1), **Russell D. Lyons**, Indiana University, and **Robin A. Pemantle**, Ohio State University.

Recent Trend in the Analysis and Computations of Functional Differential Equations (Code: AMS SS M1), **Paul W. Eloe** and **Qin Sheng**, University of Dayton.

Representations of Infinite Dimensional Lie Algebras and Mathematical Physics (Code: AMS SS P1), **Katrina Deane Barron**, University of Notre Dame, and **Rinat Kedem**, University of Illinois, Urbana-Champaign.

Stochastic Analysis with Applications (Code: AMS SS V1), **Jin Ma** and **Frederi Viens**, Purdue University.

Weak Dependence in Probability and Statistics (Code: AMS SS C1), **Richard C. Bradley** and **Lanh T. Tran**, Indiana University.

New York, New York

Courant Institute

April 12–13, 2003

Meeting #986

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: February 2003
Program first available on AMS website: February 27, 2003
Program issue of electronic *Notices*: April 2003
Issue of *Abstracts*: Volume 24, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: December 24, 2002
For abstracts: February 18, 2003

Invited Addresses

Matthias Aschenbrenner, University of California Berkeley, *Title to be announced.*

John Etnyre, University of Pennsylvania, *Title to be announced.*

Hans Foellmer, Humboldt University Berlin, *Title to be announced.*

Wilfrid Gangbo, Georgia Institute of Technology, *Title to be announced.*

Special Sessions

Algebraic Geometry, Integrable Systems, and Gauge Theory (Code: AMS SS C1), **Marcos Jardim** and **Eyal Markman**, University of Massachusetts, Amherst.

Algebraic and Topological Combinatorics (Code: AMS SS E1), **Eva-Maria Feichtner**, ETH, Zurich, Switzerland, and **Dmitry N. Kozlov**, University of Bern, Switzerland and KTH, Stockholm, Sweden.

Analytical and Computational Methods in Electromagnetics (Code: AMS SS G1), **Alexander P. Stone**, University of New Mexico, and **Peter A. McCoy**, U. S. Naval Academy.

Combinatorial and Statistical Group Theory (Code: AMS SS B1), **Alexei Myasnikov** and **Vladimir Shpilrain**, City College, New York.

Contact and Symplectic Geometry (Code: AMS SS K1), **John B. Etnyre** and **Joshua M. Sabloff**, University of Pennsylvania.

Galois Module Theory and Hopf Algebras (Code: AMS SS F1), **Daniel R. Replogle**, College of Saint Elizabeth, and **Robert G. Underwood**, Auburn University.

Hopf Algebras and Quantum Groups (Code: AMS SS A1), **M. Susan Montgomery**, University of Southern California, **Earl J. Taft**, Rutgers University, and **Sarah J. Witherspoon**, Amherst College.

Low-Dimensional Topology (Code: AMS SS M1), **James Conant**, Cornell University, **Slava Krushkal**, University of Virginia, and **Rob Schneiderman**, NYU-Courant Institute.

Nonlinear Partial Differential Equations in Differential Geometry (Code: AMS SS L1), **John C. Loftin** and **Mu-Tao Wang**, Columbia University.

Rigidity in Dynamics, Geometry, and Group Theory (Code: AMS SS J1), **David Fisher**, CUNY, Herbert H. Lehman College, and **Steven E. Hurder** and **Kevin M. Whyte**, University of Illinois at Chicago.

The History of Mathematics (Code: AMS SS D1), **Patricia R. Allaire**, Queensborough Community College, CUNY, and **Robert E. Bradley**, Adelphi University.

Topological Aspects of Complex Singularities (Code: AMS SS H1), **Sylvain E. Cappell**, NYU, Courant Institute, and **Walter D. Neumann** and **Agnes Szilard**, Barnard College, Columbia University.

San Francisco, California

San Francisco State University

May 3–4, 2003

Meeting #987

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: March 2003
Program first available on AMS website: March 20, 2003

Program issue of electronic *Notices*: May 2003
Issue of *Abstracts*: Volume 24, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: January 14, 2003
For abstracts: March 11, 2003

Invited Addresses

Joe P. Buhler, Reed College, *A problem in symmetric functions arising from phase determination in crystallography.*

Raymond C. Heitmann, University of Texas at Austin, *Title to be announced.*

Alexei Y. Kitaev, California Institute of Technology, *Title to be announced.*

Arkady Vaintrob, University of Oregon, *Title to be announced.*

Special Sessions

Beyond Classical Boundaries of Computability (Code: AMS SS E1), **Mark Burgin**, University of California Los Angeles, and **Peter Wegner**, Brown University.

Combinatorial Commutative Algebra and Algebraic Geometry (Code: AMS SS C1), **Serkan Hosten**, San Francisco State University, and **Ezra Miller**, Mathematical Sciences Research Institute.

Commutative Algebra (Code: AMS SS L1), **Raymond C. Heitmann**, University of Texas at Austin, and **Irena Swanson**, New Mexico State University.

Efficient Arrangements of Convex Bodies (Code: AMS SS H1), **Dan P. Ismailescu**, Hofstra University, and **Wlodzimierz Kuperberg**, Auburn University.

Geometry and Arithmetic over Finite Fields (Code: AMS SS G1), **Bjorn Poonen**, University of California Berkeley, and **Joe P. Buhler**, Reed College.

Numerical Methods, Calculations and Simulations in Knot Theory and its Applications (Code: AMS SS J1), **Jorge Alberto Calvo**, North Dakota State University, **Kenneth C. Millett**, University of California Santa Barbara, and **Eric J. Rawdon**, Duquesne University.

PDEs and Applications in Geometry (Code: AMS SS K1), **Qi S. Zhang**, University of California Riverside.

Q-series and Partitions (Code: AMS SS B1), **Neville Robbins**, San Francisco State University.

Qualitative Properties and Applications of Functional Equations (Code: AMS SS F1), **Theodore A. Burton**, Southern Illinois University at Carbondale.

The History of Nineteenth and Twentieth Century Mathematics (Code: AMS SS A1), **Shawnee McMurran**, California State University, San Bernardino, and **James A. Tattersall**, Providence College.

Topological Quantum Computation (Code: AMS SS D1), **Alexei Kitaev**, California Institute of Technology, and **Samuel J. Lomonaco**, University of Maryland, Baltimore County.

Seville, Spain

June 18–21, 2003

Meeting #988

First Joint International Meeting between the AMS and the Real Sociedad Matematica Española (RSME).
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: February 2003
Program first available on AMS website: Not applicable
Program issue of electronic *Notices*: Not applicable
Issue of *Abstracts*: Not applicable

Deadlines

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

Invited Addresses

Xavier Cabre, Universidad Politécnica de Cataluña, Barcelona, *Title to be announced.*

Charles Fefferman, Princeton University, *Title to be announced.*

Michael Hopkins, Massachusetts Institute of Technology, *Title to be announced.*

Ignacio Sols, Universidad Complutense, Madrid, *Title to be announced.*

Luis Vega, Universidad del Pais Vasco, Bilbao, *Title to be announced.*

Efim Zelmanov, Yale University, *Title to be announced.*

Special Sessions

Affine Algebraic Geometry, **Jaime Gutierrez**, University of Cantabria, **Vladimir Shpilrain**, City College of New York, and **Jie-Tai Yu**, University of Hong Kong.

Algebraic Geometry, **Felix Delgado**, Universidad de Valladolid, and **Andrey N. Todorov**, University of California Santa Cruz.

Algebraic Toplogy, **Alejandro Adem**, University of Wisconsin, **J. Aguade**, Universitat Autónoma de Barcelona, and **Eric M. Friedlander**, Northwestern University.

Banach Spaces of Analytic Functions, **Daniel Girela**, University of Malaga, and **Michael Stessin**, SUNY at Albany.

Biomolecular Mathematics, **Thomas J. Head** and **Fernando Guzman**, SUNY at Binghamton, **Mario Perez**, Universidad de Sevilla, and **Carlos Martin-Vide**, Rovira i Virgili University.

Classical and Harmonic Analysis, **Nets Katz**, Washington University, **Carlos Perez**, Universidad de Sevilla, and **Ana Vargas**, Universidad Autonoma de Madrid.

Combinatorics, **Joseph E. Bonin**, George Washington University, and **Marc Noy**, Universitat Politecnica de Catalunya.

Commutative Algebra: Geometric, Homological, Combinatorial and Computational Aspects, **Alberto Corso**, University of Kentucky, **Philippe Gimenez**, Universidad de Valladolid, and **Santiago Zarzuela**, Universitat de Barcelona.

Computational Methods in Algebra and Analysis, **Eduardo Cattani**, University of Massachusetts, Amherst, and **Francisco Jesus Castro-Jimenez**, Universidad de Sevilla.

Constructive Approximation Theory, **Antonio Duran**, University de Sevilla, and **Edward B. Saff**, Vanderbilt University.

Control and Geometric Mechanics, **Manuel de Leon**, Instituto de Matemáticas y Física Fundamental, **Alberto Ibort**, Universidad Carlos III, and **Francesco Bullo**, University of Illinois, Urbana-Champaign.

Differential Galois Theory, **Teresa Crespo** and **Zbigniew Hajto**, Universitat de Barcelona, and **Andy R. Magid**, University of Oklahoma.

Differential Structures and Homological Methods in Commutative Algebra and Algebraic Geometry, **Gennady Lyubeznik**, University of Minnesota, and **Luis Narvaez-Macarro**, Universidad de Sevilla.

Discrete and Computational Geometry, **Ferran Hertado**, Universitat Politècnica de Catalunya, and **William Steiger**, Rutgers University.

Dynamical Systems, **George Haller**, Massachusetts Institute of Technology, **Zbigniew H. Nitecki**, Tufts Univesity, **Enrique Ponce**, Universidad de Sevilla, **Tere M. Seara**, Universitat Politècnica de Catalunya, and **Xavier Jarque**, Universitat Autónoma de Barcelona.

Effective Analytic Geometry Over Complete Fields, **Luis-Miguel Pardos**, Universidad de Cantabria, and **J. Maurice Rojas**, Texas A&M University.

Geometric Methods in Group Theory, **José Burillo**, Universitat Politècnica de Catalunya, **Jennifer Tayback**, University of Albany, and **Enric Ventura**, Universitat Politècnica de Catalunya.

History of Modern Mathematics—Gauss to Wiles, **Jose Ferreiros**, Universidad de Sevilla, and **David Rowe**, Universitat Mainz.

Homological Methods in Banach Space Theory, **Jesus M. F. Castillo**, Universidad de Extremadura, and **N. J. Kalton**, University of Missouri.

Homotopy Algebras, **Pedro Real**, Universidad de Sevilla, **Thomas J. Lada**, North Carolina State University, and **James Stasheff**, University of North Carolina.

Interpolation Theory, Function Spaces and Applications, **Fernando Cobos**, University Complutense de Madrid, and **Pencho Petrushev**, University of South Carolina.

Lorentzian Geometry and Mathematical Relativity, **Luis J. Alias**, Universidad de Murcia, and **Gregory James Galloway**, University of Miami.

Mathematical Aspects of Semiconductor Modeling and Nano-technology, **Irene Martinez Gamba**, University of Texas, Austin, and **Jose Antonio Carrillo**, Universidad de Granada.

Mathematical Fluid Dynamics, **Diego Cordoba**, CSIC, Madrid, and Princeton University, **Susan Friedlander**, University of Illinois, Chicago, and **Marcos Antonio Fontelos**, Universidad Rey Juan Carlos.

Mathematical Methods in Finance and Risk Management, **Santiago Carrillo Menendez**, Universidad Autonoma de Madrid, **Antonio Falcos Montesinos**, Universidad Cardenal Herrera CEU, **Antonio Sanchez-Calle**, Universidad Autonoma de Madrid, and **Luis A. Seco**, University of Toronto at Mississauga.

Moduli Spaces in Geometry and Physics, **Steven B. Bradlow**, University of Illinois, Urbana-Champaign, and **Oscar Garcia-Prada**, Universidad Autonoma de Madrid.

Nonassociative Algebras and Their Applications, **Efim I. Zelmanov**, Yale University, **Santos Gonzalez**, Universidad de Oviedo, and **Alberto Elduque**, Universidad de Zaragoza.

Nonlinear Dispersive Equations, **Gustavo Ponce**, University of California Santa Barbara, and **Luis Vega**, Universidad del Pais Vascos.

Numerical Linear Algebra, **Lothar Reichel**, Kent State University, and **Francisco Marcellan**, University Carlos III de Madrid.

Operator Theory and Spaces of Analytic Functions, **Jose Bonet**, Universidad Politecnica de Valencia, **Pedro Paul**, Universidad de Sevilla, and **Cora S. Sadosky**, Howard University.

PDE Methods in Continuum Mechanics, **Juan L. Vazquez**, Universidad Autonoma de Madrid, and **J. W. Neuberger**, University of North Texas.

Polynomials and Multilinear Analysis in Infinite Dimensions, **Richard M. Aron**, Kent State University, **J. A. Jaramillo** and **Jose G. Llavona**, Universidad Complutense de Madrid, and **Andrew M. Tonge**, Kent State University.

Quantitative Results in Real Algebra and Geometry, **Carlos Andradas** and **Antonio Diaz-Cano**, Universidad Complutense, **Victoria Powers**, Emory University, and **Frank Sottile**, University of Massachusetts, Amherst.

Recent Developments in the Mathematical Theory of Inverse Problems, **Russell Brown**, University of Kentucky, **Alberto Ruiz**, Universidad Autonoma de Madrid, Spain, and **Gunther Uhlmann**, University of Washington.

Riemannian Foliations, **Jesus Antonio Alvarez Lopez**, Universidade de Santiago de Compostela, and **Efton L. Park**, Texas Christian University.

Ring Theory and Related Topics, **Jose Gomez-Torrecillas**, University of Granada, **Pedro Antonio Guil Asensio**, University of Murcia, **Sergio R. Lopez-Permouth**, Ohio University, and **Blas Torrecillas**, University of Almeria.

The Mathematics of Electronmicroscopic Imaging, **Jose-Maria Carazo**, Centro Nacional de Biotecnologia-CSIC, and **Gabor T. Herman**, City University of New York.

Variational Problems for Submanifolds, **Frank Morgan**, Williams College, and **Antonio Ros**, Universidad de Granada.

Boulder, Colorado

University of Colorado

October 2–4, 2003

Meeting #989

Joint Central/Western Sections
Associate secretaries: Susan J. Friedlander and Michel L. Lapidus
Announcement issue of *Notices*: August 2003
Program first available on AMS website: August 21, 2003
Program issue of electronic *Notices*: October 2003
Issue of *Abstracts*: Volume 24, Issue 4

Deadlines

For organizers: March 3, 2003
For consideration of contributed papers in Special Sessions: June 6, 2003
For abstracts: August 12, 2003

Invited Addresses

J. Brian Conrey, American Institute of Mathematics, *Title to be announced.*

Giovanni Forni, Northwestern University, *Title to be announced.*

Juha M. Heinonen, University of Michigan, *Title to be announced.*

Joseph D. Lakey, New Mexico State University, *Title to be announced.*

Albert Schwarz, University of California Davis, *Title to be announced.*

Brooke E. Shipley, Purdue University, *Title to be announced.*

Avi Wigderson, Institute for Advanced Study, *Title to be announced* (Erdős Memorial Lecture).

Special Sessions

Algebras, Lattices and Varieties (Code: AMS SS A1), **Keith A. Kearnes**, University of Colorado, Boulder, **Agnes Szendrei**, Bolyai Institute, and **Walter Taylor**, University of Colorado, Boulder.

Applications of Number Theory and Algebraic Geometry to Coding (Code: AMS SS B1), **David R. Grant**, University of Colorado, Boulder, **Jose Felipe Voloch**, University of Texas at Austin, and **Judy Leavitt Walker**, University of Nebraska, Lincoln.

Geometric Methods in Partial Differential Equations (Code: AMS SS C1), **Jeanne N. Clelland**, University of Colorado, Boulder, and **George R. Wilkins**, University of Hawaii.

Groupoids in Analysis and Geometry (Code: AMS SS D1), **Lawrence Baggett**, University of Colorado, Boulder, **Jerry Kaminker**, Indiana University-Purdue University Indianapolis, and **Judith Packer**, University of Colorado, Boulder.

Binghamton, New York

SUNY-Binghamton

October 11–12, 2003

Meeting #990

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: August 2003
Program first available on AMS website: August 28, 2003
Program issue of electronic *Notices*: October 2003
Issue of *Abstracts*: Volume 24, Issue 4

Deadlines

For organizers: March 10, 2003
For consideration of contributed papers in Special Sessions: June 24, 2003
For abstracts: August 19, 2003

Invited Addresses

Peter Kuchment, Texas A&M University, *Title to be announced.*

Zlil Sela, Einstein Institute of Mathematics, *Title to be announced.*

Zoltan Szabo, Princeton University, *Title to be announced.*

Jeb F. Willenbring, Yale University, *Title to be announced.*

Special Sessions

Biomolecular Mathematics (Code: AMS SS A1), **Thomas J. Head** and **Dennis G. Pixton**, SUNY at Binghamton, **Mitsunori Ogihara**, University of Rochester, and **Carlos Martin-Vide**, Universitat Rovira i Virgili.

Geometric Group Theory (Code: AMS SS B1), **Zlil Sela**, Einstein Institute of Mathematics, and **Ross Geoghegan**, SUNY at Binghamton.

Chapel Hill, North Carolina

University of North Carolina at Chapel Hill

October 24–25, 2003

Meeting #991

Southeastern Section
Associate secretary: John L. Bryant
Announcement issue of *Notices*: August 2003
Program first available on AMS website: September 11, 2003

Program issue of electronic *Notices*: October 2003
Issue of *Abstracts*: Volume 24, Issue 4

Deadlines

For organizers: March 24, 2003
For consideration of contributed papers in Special Sessions: July 19, 2003
For abstracts: September 3, 2003

Bangalore, India

India Institute of Science

December 17–20, 2003

Meeting #992

First Joint AMS-India Mathematics Meeting
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: To be announced
Program first available on AMS website: Not applicable
Program issue of electronic *Notices*: Not applicable
Issue of *Abstracts*: Not applicable

Deadlines

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

Special Sessions

Algebraic and Geometric Methods in Multivariable Operator Theory (Code: AMS SS A1), **Ronald G. Douglas**, Texas A&M University, and **Gadadhar Misra**, Indian Statistical Institute.

Phoenix, Arizona

Phoenix Civic Plaza

January 7–10, 2004

Meeting #993

Joint Mathematics Meetings, including the 110th Annual Meeting of the AMS, 87th Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL).
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: October 2003
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2004
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 2, 2003
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

Request for Proposals from AMS Special Session Organizers

Michel L. Lapidus, Associate Secretary responsible for the AMS program in Phoenix, solicits proposals for Special Sessions for this meeting. Each proposal must include the full names, email addresses, and institutions of all members of the organizing committee, and identify the one organizer who will serve as contact for all communications about the session; the title and a brief (two or three paragraphs) description of the proposed session; and a *sample* list of speakers whom the proposed organizers plan to invite (please note that it is not at all necessary to have confirmed commitments from these speakers).

It is expected that each Special Session will be allotted 10 hours over two days of the meeting in which to schedule speakers. In order to allow the maximum movement between sessions for all participants, Special Session speakers will be scheduled for either a 20-minute talk, 5-minute discussion, and 5-minute break; or a 40-minute talk, 10-minute discussion, and 10-minute break. All talks must begin on the hour or half-hour. Any combination of 20-minute and 40-minute talks is allowed, provided the schedule conforms to beginning on the hour and half-hour (except on the first afternoon, for technical reasons).

Proposals of AMS Special Sessions must be received by the deadline for organizers, **April 2, 2003**, and submitted (preferably by email) to the AMS Associate Secretary, Michel L. Lapidus (`lapidus@math.ucr.edu`). Late proposals will not be considered.

There is limited space available for Special Sessions on the AMS program, so it is likely that not all proposals will be accepted. Please be sure to submit as detailed a proposal as possible for review by the Program Committee. All proposed organizers will be notified of acceptance or rejection no later than May 1, 2003.

Tallahassee, Florida

Florida State University

March 12–13, 2004

Meeting #994

Southeastern Section
Associate secretary: John L. Bryant
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: August 13, 2003
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Athens, Ohio

Ohio University

March 26–27, 2004

Meeting #995

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: August 26, 2003
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Los Angeles, California

University of Southern California

April 3–4, 2004

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

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

Special Sessions

Contact and Symplectic Geometry (Code: AMS SS A1), **Dragomir Dragnev**, **Ko Honda**, and **Sang Seon Kim**, University of Southern California.

Lawrenceville, New Jersey

Rider University

April 17–18, 2004

Meeting #997

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: September 17, 2003
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Houston, Texas

University of Houston

May 13–15, 2004

Sixth International Joint Meeting of the AMS and the Sociedad Matemática Mexicana (SMM).
Associate secretary: John L. Bryant
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

Pittsburgh, Pennsylvania

University of Pittsburgh

November 6–7, 2004

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 7, 2004
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Atlanta, Georgia

Atlanta Marriott Marquis and Hyatt Regency Atlanta

January 5–8, 2005

Joint Mathematics Meetings, including the 111th Annual Meeting of the AMS, 88th Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association of Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association of Symbolic Logic (ASL).
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: October 2004
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2005
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 5, 2004
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

Mainz, Germany

Second Joint AMS-Deutsche Mathematiker-Vereinigung (DMV) Meeting

June 16–19, 2005

Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

San Antonio, Texas

Henry B. Gonzalez Convention Center

January 12–15, 2006

Joint Mathematics Meetings, including the 112th Annual Meeting of the AMS, 89th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL).
Associate secretary: John L. Bryant
Announcement issue of *Notices*: October 2005
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2006
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 12, 2005
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

New Orleans, Louisiana

New Orleans Marriott and Sheraton New Orleans Hotel

January 4–7, 2007

Joint Mathematics Meetings, including the 113th Annual meeting of the AMS, 90th Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL).
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: October 2006
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2007
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 4, 2006
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

Presenters of Papers

Baltimore, Maryland; January 15–18, 2003

Numbers following the name indicate the speaker's position on the program.
*◇ AMS-MAA Invited Lecturer, • AMS Invited Lecturer, ○ MAA Invited Lecturer, □ AWM Emmy Noether Lecturer, ■ NAM Invited Lecturer, ◊ ASL Invited Lecturer, ▾ OTHER Invited Lecturer, * Special Session Speaker, ▸ Graduate Student, ◂ Undergraduate Student*

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* Pratt, L. J. 159
*▸ Predescu, M. 1343
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*◂ Rouse, J. A. 883
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*◂ Stanich, J. 721
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*▸ Stavrov, I. 192
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*◂ Svitzer, T. A. 1156
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* Takesaki, M. 212
* Takloo-Bighash, R. 757
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* Terhal, B. M. 372
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*▸ Togha, A. 59
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* Torney, D. C. 171
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* Traub, J. F. 377
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* Tripathi, M. M. 382
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* Turbek, P. 951
*▸ Uddin, Z. 391
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* Umble, R. 1194
◂ Uminsky, D. T. 478
*▸ Ushakov, A. 20
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* Vaishampayan, V. A. 175

Presenters

Program of the Sessions

Baltimore, Maryland, January 15–18, 2003

Monday, January 13

MAA Short Course on Mathematics in the Ancient World

8:45 AM – 4:45 PM

Organizer: **V. Frederick Rickey**, U. S. Military Academy

8:00AM Registration.
8:45AM Introduction, **V. Frederick Rickey**, U. S. Military Academy
9:00AM (1) *Mesopotamian mathematics.* **Eleanor Robson**, The Oriental Institute, All Souls College, Oxford University
10:15AM Break.
10:45AM (2) *Archimedes.* **Reviel Netz**, Department of Classics, Stanford University
1:45PM (3) *Mathematics in India.* **Kim Plofker**, Department of the History of Mathematics, Brown University
3:00PM Break.
3:30PM (4) *Mathematics in China.* **Joseph W. Dauben**, Herbert H. Lehman College (CUNY)

AMS Short Course on Public-Key Cryptography

10:00 AM – 5:00 PM

Organizer: **Daniel B. Lieman**, University of Georgia

8:00AM Registration.
10:00AM (5) *Public-Key and symmetric-key cryptography.* **Paul Garrett**, University of Minnesota
1:30PM (6) *Cryptography in the real world today.* **Daniel Lieman**, University of Georgia and NTRU Cryptosystems
3:30PM (7) *Towards faster cryptosystems, I.* **Nicholas Howgrave-Graham**, NTRU Cryptosystems, Inc.

Tuesday, January 14

AMS Short Course on Public-Key Cryptography

8:30 AM – 3:30 PM

Organizer: **Daniel B. Lieman**, University of Georgia

8:30AM (8) *Attacks, I.* **Igor Shparlinski**, Macquarie University
10:00AM Break.
10:30AM (9) *Attacks, II.* **William Whyte**, NTRU Cryptosystems
2:00PM (10) *Towards faster cryptosystems, II.* **William Banks**, University of Missouri

MAA Board of Governors

8:30 AM – 4:00 PM

MAA Short Course on Mathematics in the Ancient World

9:00 AM – 5:00 PM

Organizer: **V. Frederick Rickey**, U. S. Military Academy

9:00AM (11) *Islamic mathematics.* **Len Berggren**, Simon Fraser University
10:15AM Break.
10:45AM Questions and discussion with the speakers.
2:30PM (12) *The Archimedes Palimpsest and its restoration.* **Will Noel**, The Walters Art Museum

AMS Council

1:30 PM – 8:00 PM

Joint Meetings Registration

3:00 PM – 7:00 PM

The time limit for each AMS contributed paper in the sessions is ten minutes. The time limit for each MAA contributed paper varies. 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 Volume 24, Issue 1 of *Abstracts of papers presented to the American Mathematical Society*, ordered according to the numbers in parentheses following the listings.

Wednesday, January 15

Joint Meetings Registration

7:30 AM - 4:00 PM

Employment Center

7:30 AM - 5:00 PM

AMS-MAA-MER Special Session on Mathematics and Education Reform, I

8:00 AM - 10:55 AM

Organizers: **Naomi Fisher**, University of Illinois at Chicago
William H. Barker, Bowdoin College
Jerry L. Bona, University of Illinois at Chicago
Kenneth C. Millett, University of California Santa Barbara

8:00AM (13) *Seeing the Connections: Promoting Profound Understanding of Secondary Mathematics.* **Al Cuoco*** and **Steve Benson**, Education Development Center, Inc. (983-97-296)

9:00AM ► (14) *The role of mathematical content in professional development.* Preliminary report. **Carolyn R. Mahoney***, Elizabeth City State University, and **Dick Stanley**, University of California, Berkeley (983-97-1033)

9:30AM (15) *Learning Mathematics on a New Playing Field - Discrete Mathematics.* **Joseph G. Rosenstein***, Rutgers University, and **Valerie A. DeBellis**, East Carolina University (983-97-453)

10:00AM ► (16) *Integrating Mathematics and Science with Preservice K-8 Teachers.* **Philip D Wagreich**, University of Illinois at Chicago (983-97-288)

10:30AM Discussion.

AMS-ASL Special Session on Interactions Between Logic, Group Theory and Computer Science, I

8:00 AM - 10:55 AM

Organizers: **Alexandre V. Borovik**, UMIST
Alexei Myasnikov, City College of CUNY

8:00AM ► (17) *Reflections on Computability, Complexity and Group Theory.* **Paul E. Schupp**, University of Illinois (983-20-1022)

9:00AM ► (18) *Asymptotic cones in geometric group theory.* **Simon Thomas**, Rutgers University (983-20-1025)

10:00AM (19) *Genericity, Arzhantseva-Olshanskii method and one-relator groups.* Preliminary report. **Ilya Kapovich*** and **Paul Schupp**, University of Illinois at Urbana-Champaign (983-20-1117)

10:30AM ► (20) *Taboo-search algorithm for conjugacy problem for one-relator groups.* Preliminary report. **Alexander Ushakov**, CUNY (983-20-1106)

AMS Special Session on Algebras, Actions, and Algorithms, I

8:00 AM - 10:50 AM

Organizers: **Edward S. Letzter**, Temple University
Martin Lorenz, Temple University

8:00AM (21) *Quasi-Koszul Algebras and their Resolutions.* Preliminary report. **Edward L Green***, Virginia Tech, and **Yuriy Drozd**, Kiev Taras Shevchenko University (983-16-796)

8:30AM (22) *Schur indicator for abelian extensions of Hopf algebras.* **Yevgenia Kashina***, DePaul University, **Geoffrey Mason**, University of California, Santa Cruz, and **Susan Montgomery**, University of Southern California (983-16-781)

9:00AM (23) *Some Properties of DG Hopf Algebras.* **Q. -S. Wu***, Fudan University, and **J. J. Zhang**, University of Washington (983-16-649)

9:30AM (24) *Algebraic deformations arising from an orbifold with discrete torsion.* **Andrei Caldararu**, University of Pennsylvania, **Anthony Giaquinto**, Loyola University Chicago, and **Sarah Witherspoon***, Amherst College (983-16-701)

10:00AM (25) *Classical Simple Lie Superalgebras, Clifford Algebras and Induced Modules.* Preliminary report. **Ian M Musson**, University of Wisconsin-Milwaukee (983-33-702)

10:30AM (26) *Prime ideals and twisting in Hopf Galois extensions.* Preliminary report. **M Susan Montgomery**, University of Southern California (983-16-597)

AMS Special Session on Quantum Computation and Information: Mathematical Challenges, I

8:00 AM - 10:55 AM

Organizers: **Samuel J. Lomonaco, Jr.**, University of Maryland Baltimore County
Howard E. Brandt, Army Research Laboratory
Louis H. Kauffman, University of Illinois at Chicago

8:00AM (27) *Quantum and topological entanglements in view of entanglement schemes.* Preliminary report. **Fernando J. O. Souza**, University of Iowa (983-81-1482)

8:30AM ► (28) *Quantum Circuit Design for Multi-Object Search.* **Goong Chen*** and **Zijian Diao**, Math. Dept., Texas A&M University (983-68-789)

9:00AM ► (29) *Optimization Problem in Quantum Cryptography.* **Howard E. Brandt**, U.S. Army Research Laboratory (983-81-246)

9:30AM (30) *Entanglement and Invariant Theory.* Preliminary report. **Ranee Brylinski***, Penn State, and **Jean-Luc Brylinski**, Truro, Massachusetts (983-22-1374)

10:00AM ► (31) *Lattice Loading of Neutral Atoms: The Bose-Hubbard Hamiltonian undergoing a Quantum Phase Transition from a Superfluid to the Mott-Insulator Regime.* Preliminary report. **Carl J. Williams*** and **Gavin Brennen**, NIST (983-81-1237)

10:30AM ► (32) *Non-Abelian Stabilizer Codes.* Preliminary report. **Harriet S. Pollatsek**, Mt. Holyoke College, and **Mary Beth Ruskai***, Arlington, MA (983-94-884)

AMS Special Session on Recent Advances in Riemannian and Lorentzian Geometries, I

8:00 AM - 10:50 AM

Organizers: **Krishan L. Duggal**, University of Windsor

Ramesh Sharma, University of New Haven

8:00AM (33) *The Jordan normal form of natural operators associated to the curvature tensor.* **Peter B Gilkey***, University of Oregon, **Raina Ivanova**, University of Hawaii, and **Tan Zhang**, Murray State University (983-53-34)

8:30AM (34) *Geodesic Structure of Standard Static Space-times.* Preliminary report. **Dean E. Allison***, University of Northern Colorado, and **Bulent Unal**, Atilim University (983-53-44)

9:00AM (35) *Hyperbolic Twistor Spaces.* **David E. Blair***, Michigan State University, **Johann Davidov** and **Oleg Muskarov**, Bulgarian Academy of Sciences (983-53-644)

9:30AM (36) *Curvature singularities and abstract boundary singularity theorems for space-time.* **Michael J Ashley***, The Pennsylvania State University, and **Susan M Scott**, The Australian National University (983-83-1341)

10:00AM (37) *The spectral geometry of holomorphic manifolds with boundary.* **Jeong Hyeong Park**, Honam University (983-58-431)

10:30AM (38) *Linear perturbations of spatially locally homogeneous spacetimes.* **Masayuki Tanimoto**, Yale University (983-83-1041)

AMS Special Session on Primes and Knots, I

8:00 AM – 10:45 AM

Organizers: **Jack Morava**, Johns Hopkins University
Stavros Garoufalidis, Georgia Institute of Technology
Masanori Morishita, Kanazawa University

8:00AM (39) *Ideles in number theory and in topology.* Preliminary report. **Adam S. Sikora**, SUNY Buffalo (983-57-1287)

9:00AM ► (40) *Analogies between primes and knots, number fields and 3-manifolds.* **Masanori Morishita**, Kanazawa University (983-11-1271)

10:00AM (41) *Colorings of Knots and Links – Combinatorial Conjectures.* **Louis Hirsch Kauffman**, Univ of Illinois at Chicago (983-57-1053)

AMS Special Session on Computability and Models, I

8:00 AM – 10:55 AM

Organizers: **Douglas Cenzer**, University of Florida
Valentina S. Harizanov, The George Washington University

8:00AM (42) *Scott fragments and computability.* Preliminary report. **Jessica M Young**, Harvard (983-03-1461)

8:30AM (43) *Undecidability of Lattices of Ideals in $\mathcal{R}$.* **Russell G. Miller***, Cornell University, **Andre O. Nies**, University of Auckland, and **Richard A. Shore**, Cornell University (983-03-1405)

9:00AM (44) *Enumerations and structures.* Preliminary report. **S. S. Goncharov**, Novosibirsk State University, **V. S. Harizanov**, George Washington University, **J. F. Knight***, **C. McCoy**, University of Notre Dame, **R. G. Miller**, Cornell University, and **D. R. Solomon**, University of Notre Dame (983-03-1189)

9:30AM (45) *Minimal degrees which are Σ^0_2 but not Δ^0_2.* **Richard A. Shore**, Cornell University (983-03-967)

10:00AM (46) *Computable choice sets for computable linear orderings.* **Manuel Lerman***, University of Connecticut at Storrs, and **Richard M Watnick**, University of Connecticut (983-03-721)

10:30AM (47) *An extension of the recursively enumerable Turing degrees.* Preliminary report. **Stephen G. Simpson**, Pennsylvania State University (983-03-1213)

AMS Special Session on Operator Algebras, Quantization, and Noncommutative Geometry: A Centennial Celebration in Honor of J. V. Neumann and M. H. Stone, I

8:00 AM – 10:50 AM

Organizers: **Robert S. Doran**, Texas Christian University
Richard V. Kadison, University of Pennsylvania

8:00AM ► (48) *Quasideterminants and their applications.* Preliminary report. **Israel Gelfand***, Rutgers University, **Sergei Gelfand**, American Mathematical Soc, **Vladimir Retakh** and **Robert Lee Wilson**, Rutgers University (983-16-712)

9:00AM ► (49) *A Selective History of the Stone-von Neumann Theorem.* **Jonathan M. Rosenberg**, University of Maryland (983-46-729)

9:30AM (50) *From the Stone-von Neumann Theorem to the equivariant Brauer group and beyond.* **Dana P Williams**, Dartmouth College (983-46-632)

10:00AM (51) *Dimensions in group algebras.* Preliminary report. **Nigel Higson**, Penn State University (983-19-937)

10:30AM (52) *The Index of Elliptic Operators and K Theory for Discrete Groups.* **Paul Frank Baum**, Penn State (983-20-1034)

AMS Special Session on Special Functions and q-Series, I

8:00 AM – 10:55 AM

Organizer: **Mourad E. H. Ismail**, University of South Florida

8:00AM (53) *Work of Mizan Rahman.* Preliminary report. **Richard Askey**, University of Wisconsin-Madison (983-33-13)

8:30AM (54) *q-Extensions of Tratnik's systems of multivariable orthogonal Racah and Wilson polynomials.* Preliminary report. **George Gasper***, Northwestern University, and **Mizan Rahman**, Carleton University, Canada (983-33-771)

9:00AM (55) *Systems of Multivariable Biorthogonal q-Polynomials.* **George Gasper**, Northwestern University, and **Mizan Rahman***, Carleton University (983-33-1356)

9:30AM (56) *An Unpublished Manuscript by G. N. Watson on Modular Equations.* **Bruce C. Berndt**, University of Illinois at Urbana-Champaign (983-11-1354)

10:00AM (57) *Stochastic processes and orthogonal polynomials.* **Michael Anshelevich**, UC Riverside (983-46-163)

10:30AM (58) *Linearization Of The Product Of Two Associated q-Ultra spherical Polynomials.* Preliminary report.
Tariq M. Qazi*, Virginia State University, and **Mizan Rahman**, Carleton University (983-33-720)

AMS Special Session on Nonstandard Models of Arithmetic and Set Theory, I

8:00 AM – 10:45 AM

Organizers: **Ali Enayat**, American University
Roman Kossak, CUNY Graduate Center

8:00AM (59) *Automorphisms of models of set theory.*
Ataollah Togha, The George Washington University (983-03-1236)

8:30AM (60) *Non-standard powers and actions of groups.* Preliminary report.
Alexei Miasnikov, Graduate Center, City University of New York (983-03-1284)

9:00AM (61) *Five questions about combinatorial principles in nonstandard analysis.* Preliminary report.
Renling Jin, College of Charleston (983-03-840)

9:30AM (62) *Communities Of Consensus In The Set Theoretic Cosmos.* Preliminary report.
David J Ballard, Sonoma State University (983-03-683)

10:00AM (63) *Fully internally iterated ultrapowers and nonstandard set theory.*
Karel Hrbacek, City College of CUNY (983-03-714)

AMS Session on Number Theory, I

8:00 AM – 10:55 AM

8:00AM (64) *Pairs of homogeneous forms over p-adic fields.*
Michael P. Knapp, University of Rochester (983-11-1492)

8:15AM (65) *Three-point-ramified maps for elliptic curves and applications to the ABC Conjecture.* Preliminary report.
Lily S. Khadjavi*, Loyola Marymount University, and **Victor Scharaschkin**, University of Southern California (983-11-1448)

8:30AM (66) *Mordell-Weil groups of ellipticcurves over large fields.*
Bo-Hae Im, Indiana University, Bloomington (983-11-1389)

8:45AM (67) *An irrationality measure for Liouville numbers and conditional measures for Euler's constant.*
Jonathan Sondow, New York, NY (983-11-1325)

9:00AM (68) *A Criterion for Vandiver in Function Fields.*
Joseph Palen, Millsaps College (983-11-1261)

9:15AM ► (69) *Polynomials with {0,1} coefficients and repeated noncyclotomic factors.* Preliminary report.
Michael J. Mossinghoff, Davidson College (983-11-1254)

9:30AM ► (70) *An Extension of a Theorem of D. H. Lehmer.* Preliminary report.
Lenny K Jones, Shippensburg University (983-11-1184)

9:45AM (71) *A New Invariant for the* $\mathrm{Gal}(\bar{\mathbb{Q}}/\mathbb{Q})$ *Action on Dessins d'Enfants.*
Melanie Eggers Wood, Duke University (983-11-1113)

10:00AM (72) *On Primes in the Fibonacci and Lucas Sequences.*
Curtis N Cooper, Central Missouri State University (983-11-993)

10:15AM (73) *Universal Kummer congruences mod prime powers.*
Arnold Adelberg, Grinnell College (983-11-913)

10:30AM (74) *Identities between certain powers and products of* η. Preliminary report.
Adrian D Stanger, BYU (983-11-748)

10:45AM (75) *Hecke Correspondence on Conjugates of Hecke Groups.*
Daniel T Russo, Dickinson College (983-11-710)

AMS Session on Analysis, I

8:00 AM – 10:55 AM

8:00AM (76) *Helly's Selection Principle for functions of bounded p-variation.* Preliminary report.
John E Porter, Murray State University (983-26-130)

8:15AM (77) *A pointwise convergence and Bessel capacity.*
Javad Namazi, Fairleigh Dickinson University (983-26-52)

8:30AM (78) *Fuzzy Ostrowski Type Inequalities.* Preliminary report.
George A Anastassiou, University of Memphis (983-26-210)

8:45AM (79) *The cardinal series is the limiting form of Lagrange's interpolation formula.* Preliminary report.
Nasser Dastrange, Buena Vista University (983-26-787)

9:00AM ► (80) *Difference Free Subsets of the Real Numbers.* Preliminary report.
Kandasamy Muthuvel, UW Oshkosh, WI (983-26-1109)

9:15AM (81) *Some new generalizations of Hilbert's integral inequalities and their applications.* Preliminary report.
Lokenath Debnath, University of Texas-Pan American (983-26-858)

9:30AM ► (82) *Analysis of Functions With Exactly n Collinear Critical Points.* Preliminary report.
Jon H Bigler* and **Lenny K Jones**, Shippensburg University (983-26-1495)

9:45AM (83) *Approximation of functions with derivatives in an Orlicz space.*
David Swanson, Texas A&M University (983-26-1229)

10:00AM (84) *Topologizing the Space of All Generalized Riemann Integrable Functions.*
J Alan Alewine, Vanderbilt University/McKendree College (983-28-965)

10:15AM ► (85) *A Complete System of Orthogonal Step Functions.* Preliminary report.
Huaien Li* and **David C Torney**, Los Alamos National Laboratory (983-30-1393)

10:30AM (86) *Heat trace asymptotics defined by transfer boundary conditions.*
Peter B Gilkey, University of Oregon, **Klaus Kirsten** and **Dmitri V Vassilevich***, MPI (Leipzig) (983-58-1045)

10:45AM (87) *On m-accretive Schrödinger-type operators with singular potentials on manifolds of bounded geometry.*
Ognjen B Milatovic, Fitchburg State College (983-58-638)

SIAM Minisymposium on Life Sciences

8:00 AM – 10:55 AM

Organizer: **Tim Elston**, North Carolina State University and the University of North Carolina at Chapel Hill

8:00AM (88) *Engineered gene circuits: A playground for physicists and mathematicians.*
Jeff M Hasty, Department of Bioengineering, University of California, San Diego (983-92-1363)

8:45AM ► (89) *Microsimulation of organogenetic hijacking by Bacillus anthracis.* Preliminary report.
Tom Kepler, Duke University (983-92-1296)

9:30AM (90) *An integrated model of signal transduction, adaptation, and motor control in E. coli.* Preliminary report.
Hans G. Othmer*, University of Minnesota, and **R Albert**, same (983-92-628)

10:15AM ► (91) *Modeling Operon Dynamics.*
Michael C. Mackey, McGill University (983-92-574)

MAA Session on Innovative Use of the World Wide Web in Teaching Mathematics, I

8:00 AM - 10:35 AM

Organizers: **Brian E. Smith**, McGill University
Marcelle Bessman, Jacksonville University
Marcia P. Birken, Rochester Institute of Technology
Thomas E. Leathrum, Jacksonville State University
David M. Strong, Pepperdine University
Joe Yanik, Emporia State University

8:00AM ► (92) *How to use the web to save yourself time without shortchanging your students.* Preliminary report.
Jeffrey Feuer, Coastal Carolina University (983-A1-607)

8:20AM ► (93) *Qualitative and Quantitative Analyses of WeBWorK, a web-based, immediate feedback homework program for college mathematics classes.* Preliminary report.
Angelo Segalla*, **Alan Safer**, California State University, Long Beach, and **Vicki Roth**, University of Rochester (983-A1-499)

8:40AM ► (94) *Promoting Reading Skills and Readiness for Lectures via Online Reading Quizzes.* Preliminary report.
Peter H Berman* and **Andrew Feist**, Duke University (983-A1-495)

9:00AM ► (95) *MUTester: A Web-based Computer System Supporting a Personalized System of Instruction Environment.*
B. Lynn Bodner* and **Richard A. Kuntz**, Monmouth University (983-A1-416)

9:20AM (96) *Increasing Student Participation via Online Communication in Calculus Courses.*
Timothy D Comar, Benedictine University (983-A1-403)

9:40AM ► (97) *Teaching and Tutoring Mathematics Online II.* Preliminary report.
Kirk Benningfield, Smarthinking (983-A1-395)

10:00AM ► (98) *Experiences Teaching an On-Line Mathematical Modeling course using WebCT.* Preliminary report.
Paul R. Patten, North Georgia College & State University (983-A1-373)

10:20AM (99) *Online Databases: Weekly Web Reports and Access to Grades.*
John M. Harris, Furman University (983-A1-365)

MAA Session on Classroom Demonstrations and Course Projects that Make a Difference, I

8:00 AM - 10:55 AM

Organizers: **David R. Hill**, Temple University
Sarah L. Mabrouk, Framingham State College
Lila F. Roberts, Georgia Southern University

8:00AM ► (100) *Boston's BIG DIG: Getting Down and Dirty with Volume Approximations.*
David H Carhart* and **Karen J Schroeder**, Bentley College (983-B1-61)

8:15AM ► (101) *Personalizing Derivatives and Antiderivatives with Geometer's Sketchpad, a CBR, and a TI-83 Plus.*
Judy S O'Neal, North GA College & State University (983-B1-162)

8:30AM ► (102) *The MURED NASA PAIR Project at California State University Northridge.* Preliminary report.
Carol Shubin, California State University Northridge (983-B1-418)

8:45AM ► (103) *A Trilogy of "Army of Darkness"-Like Scenarios.*
Scott Charles Gensler, United States Military Academy (983-B1-517)

9:00AM ► (104) *Pitter, patter, POW! Raindrops and a WWII sea battle.*
Katherine Socha, Michigan State University (983-B1-386)

9:15AM ► (105) *Interactive MS Excel Workbooks For Classroom Demonstrations and Course Projects.*
Sarah L Mabrouk, Framingham State College (983-B1-583)

9:30AM ► (106) *Bringing Elementary Montessori Materials to the College Classroom.* Preliminary report.
Theodore S. Erickson, Wheeling Jesuit University (983-B1-561)

9:45AM ► (107) *"Real World" Projects for Linear Algebra.*
Carl V. Lutzer, Rochester Institute of Technology (983-B1-414)

10:00AM ► (108) *An Effective, Inexpensive and Simple Demonstrator for a Linear Algebra Course.*
Douglas L. Oliver, University of Toledo (983-B1-382)

10:15AM ► (109) *Visualizations for Geometric Related-Rates and Optimization Problems.*
David R Hill, Temple University, and **Lila F. Roberts***, Georgia Southern University (983-B1-576)

10:30AM ► (110) *Military Application Projects in Multivariable Calculus.* Preliminary report.
Denise A Jacobs* and **Paul L Goethals**, United States Military Academy (983-B1-487)

10:45AM ► (111) *Visualizing the Mathematics of Planetary Theory.* Preliminary report.
Sandra M. Caravella, Centenary College (983-B1-314)

AMS Special Session on Advances in Spherical Designs and Codes, I

8:30 AM - 10:55 AM

Organizers: **Béla Bajnok**, Gettysburg College
Neil J. A. Sloane, AT&T Shannon Labs

8:30AM (112) *Using additive number theory to construct spherical designs.* Preliminary report.
Béla Bajnok, Gettysburg College (983-05-832)

9:00AM (113) *The Nonexistence of Certain Tight Spherical Designs.*
Eiichi Bannai*, Graduate School of Mathematics, Kyushu University, Fukuoka, Japan, **Akihiro Munemasa**, Kyushu University, and **Boris Venkov**, Russian Academy of Sciences (983-05-698)

10:00AM ► (114) *Nonexistence results for some spherical designs.*
Danyo Petrov Danev, Linköping University, Sweden, **Peter Georgiev Boyvalenkov*** and **Silvia Boumova**, Institute of Mathematics and Informatics, Sofia, Bulgaria (983-51-1090)

10:30AM ► (115) *Recent results on the existence of spherical 3-designs.*
Danyo Petrov Danev*, Linköping University, Sweden, **Peter Georgiev Boyvalenkov** and **Silvia Boumova**, Institute of Mathematics and Informatics, Sofia, Bulgaria (983-51-1088)

AMS Special Session on Discrete Models, I

8:30 AM - 10:55 AM

Organizers: **Cris Moore**, University of New Mexico and Santa Fe Institute
Dana Randall, Georgia Institute of Technology

8:30AM ► (116) *The Phase Diagram of the Biased Integer Partitioning Problem.*
Christian Borgs, Jennifer Tour Chayes*, Microsoft Research, **Stephan Mertens**, Universitaet Magdeburg, and **Boris Pittel**, Ohio State University (983-68-912)

9:00AM (117) *Gibbs Extremality for the Hard-Core Model on a Bethe Lattice.* Preliminary report.
Graham R. Brightwell, London School of Economics, and **Peter Winkler***, Bell Labs, Lucent Technologies (983-82-1048)

9:30AM ► (118) *The Rotor-Router Model.*
Lionel Levine*, University of California, Berkeley, and **James Propp**, University of Wisconsin, Madison (983-05-1145)

10:00AM (119) *Random Surfaces: Large Deviations and Gibbs Measure Classifications.* Preliminary report.
Scott R. Sheffield, Microsoft Research (983-60-865)

10:30AM (120) *Stationary Determinantal Processes (Fermionic Lattice Gases).*
Russell D Lyons, Indiana University and Georgia Tech (983-82-867)

AMS Session on Ordinary Differential Equations

8:30 AM - 10:40 AM

8:30AM ► (121) *Quasilinearization for a Nonlinear Initial Value Problem on Time Scales.*
Bonita A. Lawrence*, Marshall University, and **Billur Kaymakcalan**, Georgia Southern University (983-34-1266)

8:45AM (122) *Summing Formal Solutions to Advanced and Delayed Equations.* Preliminary report.
Michael J. Spurr* and **David W. Pravica**, East Carolina University (983-34-1300)

9:00AM ► (123) *Bifurcations of bounded solutions of ordinary differential equations depending on a parameter.*
Yu Shu-Xiang, American Mathematical Society (983-34-39)

9:15AM (124) *Eigenvalue Continuity and Differentiability With Respect to Parameters for Stieltjes Self-Adjoint Boundary Value Problems.*
Laurie Battle, University of Tennessee (983-34-129)

9:30AM (125) *Existence of Solutions for Fourth Order Boundary Value Problems on a Time Scale.*
Johnny Henderson, Baylor University, and **William Yin***, LaGrange College (983-34-952)

9:45AM (126) *On a class of functional integro-differential stochastic evolution equations.* Preliminary report.
Mark A McKibben*, Goucher College, and **Dave N Keck**, Ohio University (983-34-618)

10:00AM (127) *Impulsive hybrid Control systems.*
Seenith Sivasundaram, Embry-Riddle Aeronautical University (983-34-958)

10:15AM (128) *An Approximate Analytical Solution for a Fractional van der Pol Equation.*
Sandra Rucker* and **Ronald E. Mickens**, Clark Atlanta University (983-34-1167)

10:30AM (129) *Boundary Behavior of Blow up Solutions to some Weighted Nonlinear Differential Equations.*
Ahmed Mohammed, Ball State University (983-34-101)

MAA General Contributed Paper Session, I

8:30 AM - 10:55 AM

Organizers: **Michael A. Jones**, Montclair State University
Steven M. Hetzler, Salisbury University
Shawnee L. McMurran, California State University at San Bernardino

8:30AM ► (130) *Changes in College Algebra.*
Scott R. Herriott, Maharishi University of Management (983-Z1-334)

8:45AM ► (131) *Calculus on a Limited Access Web Page.* Preliminary report.
Kenneth L Price, UW Oshkosh (983-Z1-1496)

9:00AM ► (132) *University Students' Understanding of Calculus Concepts.* Preliminary report.
Theodosis Zachariades*, University of Athens, Greece, **Constantinos P Christou** and **Demetra Pitta-Pantazi**, University of Cyprus (983-Z1-405)

9:15AM ► (133) *Students' Representational Approaches to Solving Calculus Problems: Examining the Role of the Graphing Calculator.*
Nina R. Girard, University of Pittsburgh at Johnstown (983-Z1-425)

9:30AM ► (134) *Learning statistics with Scientific WorkPlace.* Preliminary report.
Morteza Seddighin, Indiana University East (983-Z1-496)

9:45AM ► (135) *Risk: A Building Block for Probability and Statistics Courses.*
Reza D Noubary, Bloomsburg University (983-Z1-231)

10:00AM ► (136) *Determination of unknown proteins from 1-D electrophoresis gel data using statistical models.* Preliminary report.
Edward J Carroll, Jr*, **Lawrence Clevenson** and **Carol A Shubin**, California State University Northridge (983-Z1-415)

10:15AM ► (137) *Effective Projects in the Large Statistics Class.*
Brian E Smith, McGill University (983-Z1-389)

10:30AM ► (138) *Optimizing Final Examination Scheduling at the Naval Academy.* Preliminary report.
David L Zane, United States Naval Academy (983-Z1-731)

10:45AM ► (139) *University Timetabling and Graph Coloring - Theory and Practice.*
Timothy A. Redl, Rice University (983-Z1-1289)

AMS-SIAM Special Session on Dynamical Systems and Oceanography, I

9:00 AM - 10:55 AM

Organizers: **Reza Malek-Madani**, U.S. Naval Academy
Peter A. McCoy, U.S. Naval Academy

9:00AM (140) *Lagrangian Transport and its Implications for Ocean Modeling.*
C.K.R.T. Jones*, University of North Carolina at Chapel Hill, **Kayo Ide**, Department of Atmospheric Sciences and Institute of Geophysics and Planetary Physics, UCLA, and **Leonid Kuznetsov**, University of North Carolina at Chapel Hill (983-86-1258)

9:30AM (141) *Hyperbolicity and Lagrangian Predictability in Physical Oceanography.*
A Denny Kirwan, Jr.*, **Michael Toner** and **Bruce Lipphardt, Jr.**, University of Delaware (983-37-979)

10:00AM (142) *Lobes Dynamics, Global Horseshoes, and Statistics of Particle Trajectories in a Meandering Jet Model.*
Stephen Wiggins, University of Bristol (983-37-1204)

10:30AM (143) *A new approach to transport in the large-scale atmosphere and ocean circulations.*
Kayo Ide, University of California, Los Angeles (983-86-1386)

MAA Minicourse #12: Part A

9:00 AM - 11:00 AM

Getting students involved in undergraduate research.
Organizers: **Aparna W. Higgins**, University of Dayton
Joseph A. Gallian, University of Minnesota, Duluth

MAA Minicourse #1: Part A

9:00 AM - 11:00 AM

Teaching introductory statistics using a workshop approach.
Organizer: **James H. Albert**, Bowling Green State University

MAA Minicourse #7: Part A

9:00 AM - 11:00 AM

The mathematics of presidential and other elections.
Organizer: **Steven J. Brams**, New York University

MAA Panel Discussion

9:00 AM - 10:20 AM

Knowledge for teaching algebra: Issues from The Mathematical Education of Teachers.
Organizer: **Joan Ferrini-Mundy**, Michigan State University
Moderator: **Gail F. Burrill**, Michigan State University
Panelists: **Daniel Chazan**, University of Maryland
Anthony L. Peressini, University of Illinois at Urbana-Champaign
Joan Ferrini-Mundy

MAA CUPM Subcommittee on Curriculum Reform Across the First Two Years Panel Discussion

9:00 AM - 10:20 AM

Reflections on the Conference to Improve College Algebra.
Organizer: **Donald B. Small**, U. S. Military Academy
Moderator: **Bernard L. Madison**, University of Arkansas
Panelists: **John C. Maceli**, Ithaca College
Philip H. Mahler, Middlesex Community College
Alexander H. Fluellen, Clark Atlanta University
Norma M. Agras, Miami-Dade Community College

AMS Invited Address

10:05 AM - 10:55 AM

(144) *Partial hyperbolicity.*
Charles C. Pugh, University of California Berkeley (983-37-12)

AMS-MAA Invited Address

11:10 AM - NOON

(145) *Discrete mathematics and mechanical engineering.*
Edward R. Scheinerman, Johns Hopkins University (983-05-15)

Exhibits and Book Sales

NOON - 5:30 PM

Math on the Web, I

12:30 PM - 4:50 PM

12:30PM (146) *Overview of MathML Markup.*
Bob Mathews, Design Science

2:00PM (147) *Math on the Web with* Mathematica *technology.*
Tom Wickham-Jones, Wolfram Research

3:00PM (148) *Mathematics on the Web.*
Patrick Ion, AMS

4:30PM (149) *Creating interactive Web pages with MathML.*
Robert Miner, Design Science

AMS Colloquium Lectures:Lecture I

1:00 PM - 1:50 PM

(150) *Spectra of hyperbolic surfaces and applications, I.*
Peter Sarnak, Courant Institute and Princeton University

MAA Invited Address

2:15 PM - 3:05 PM

► (151) *Four colors suffice: a history and proof of the four-color problem.*
Robin J Wilson, Open University, UK (983-A0-883)

AMS-MAA-MER Special Session on Mathematics and Education Reform, II

2:15 PM – 5:45 PM

Organizers: **Naomi Fisher**, University of Illinois at Chicago
William H. Barker, Bowdoin College
Jerry L. Bona, University of Illinois at Chicago
Kenneth C. Millett, University of California Santa Barbara

2:15PM (152) *Opportunities and Challenges in the School-Undergraduate Continuum.*
Bill Haver, Virginia Commonwealth University, and **Eric Robinson***, Ithaca College (983-97-927)

2:45PM (153) *Opportunities and Challenges in the School-Undergraduate Continuum. Part II.*
Bill Haver*, Virginia Commonwealth University, and **Eric Robinson**, Ithaca College (983-97-1503)

3:15PM ► (154) *Some Articulation Issues between High School and College Mathematics Education.* Preliminary report.
John C Maceli, Ithaca College (983-97-976)

3:45PM (155) *What graduates of reform mathematics programs bring to college mathematics.*
Dan Fendel, San Francisco State University (983-97-1175)

4:15PM (156) *Mathematical Content in Standards-Based Curricula.*
Sol Garfunkel, COMAP (983-97-1384)

4:45PM (157) *Panel on the Mathematical Needs of Teachers.*
Eric E Robinson*, Ithaca College, **Joan Ferrini-Mundy***, Michigan State University, **Ira Papick***, University of Missouri, and **Amy Cohen-Corwin***, Rutgers University (983-97-892)

AMS-SIAM Special Session on Dynamical Systems and Oceanography, II

2:15 PM – 4:40 PM

Organizers: **Reza Malek-Madani**, U.S. Naval Academy
Peter A. McCoy, U.S. Naval Academy

2:15PM ► (158) *Indistinguishable States: An Unified Approach to the Analysis and Prediction of Dynamical Systems Given Imperfect Nonlinear Models.* Preliminary report.
Leonard A Smith*, London School of Economics, **Kevin Judd**, University of Western Australia, and **Mark Roulston**, Pembroke College, Oxford (983-37-1280)

2:45PM ► (159) *Chaotic Transport in Meandering Jets.*
Larry J. Pratt*, Woods Hole Oceanographic Institution, **Guocheng Yuan**, Brown University, **Chris Jones**, University of North Carolina, and **Susan M Lozier**, Duke University (983-37-794)

3:15PM (160) *Cross-jet transport and mixing in a meandering jet.*
Guo-Cheng Yuan*, Environmental Modeling Center, **Lawrence J. Pratt**, Woods Hole Oceanographic Institution, and **Christopher K.R.T. Jones**, University of North Carolina at Chapel Hill (983-86-1412)

3:45PM (161) *Assimilation of Lagrangian drifter data into ocean models.*
Leonid Kuznetsov*, University of North Carolina at Chapel Hill, **Kayo Ide**, Department of Atmospheric Sciences and Institute of Geophysics and Planetary Physics, UCLA, and **Chris K.R.T. Jones**, University of North Carolina at Chapel Hill (983-86-1256)

4:15PM ► (162) *Identifying Lagrangian structures in the Eastern Gulf of Mexico.*
Amal Asim El Moghraby*, Brown University, **Christopher K. R. T Jones**, UNC - Chapel Hill, and **Leonid Kuznetsov**, Brown University (983-37-1422)

AMS-ASL Special Session on Interactions Between Logic, Group Theory and Computer Science, II

2:15 PM – 5:40 PM

Organizers: **Alexandre V. Borovik**, UMIST
Alexei Myasnikov, City College of CUNY

2:15PM ► (163) *Computer Science and Group Theory.* Preliminary report.
Robert Gilman, Stevens Institute of Technology (983-20-1078)

3:15PM (164) *What is an Algorithm?*
Yuri Gurevich, Microsoft Research (983-03-1194)

4:15PM ► (165) *Multiplicative measures on free groups and regular languages.*
Vladimir N Remeslennikov, Institute of mathematics SO RAN, Omsk, Russia (983-20-950)

4:45PM (166) *Weak identities and discriminating groups.* Preliminary report.
Martin D Kassabov, Yale University (983-20-591)

5:15PM (167) *Discriminating and Squarelike Groups.* Preliminary report.
Anthony M Gaglione*, U.S. Naval Academy, **Dennis Spellman**, Temple University, and **Benjamin Fine**, Fairfield University (983-20-58)

AMS Special Session on Advances in Spherical Designs and Codes, II

2:15 PM – 6:10 PM

Organizers: **Béla Bajnok**, Gettysburg College
Neil J. A. Sloane, AT&T Shannon Labs

2:15PM ► (168) *New Spherical Designs in Four and Five Dimensions.* Preliminary report.
R. H. Hardin, Pataskala, Ohio, and **N.J.A. Sloane***, AT&T Shannon Labs (983-52-920)

2:45PM ► (169) *Non-Unique Optimal Spherical Codes of Dimension Three.*
James R Buddenhagen, retired (983-52-870)

3:15PM ► (170) *Spherical Designs via Extremal Sytems.* Preliminary report.
Ian H Sloan, University of New South Wales (983-41-572)

3:45PM ► (171) *Nested polytopes for the construction of spherical designs.* Preliminary report.
David Colton Torney, Los Alamos National Laboratory (983-52-100)

4:15PM (172) *Hilbert identities and spherical designs.*
Bruce Reznick, University of Illinois at Urbana-Champaign (983-05-1220)

4:45PM (173) *Spherical Crystallography: The Thomson Problem Revisited.*
David R. Nelson, Lyman Laboratory, Harvard University (983-82-1120)

5:15PM ► (174) *Defect Scars in Spherical Crystals.*
Mark J Bowick, Syracuse University (983-82-960)

5:45PM (175) *Dynamical Systems, Curves and Error Control for Continuous Alphabet Sources.*
Vinay A Vaishampayan*, **N. J. A. Sloane**, AT&T Shannon Laboratory, and **Sueli I. R. Costa**, Instituto de Matematica (983-94-1018)

AMS Special Session on Algebras, Actions, and Algorithms, II

2:15 PM - 5:35 PM

Organizers: **Edward S. Letzter**, Temple University
Martin Lorenz, Temple University

2:15PM (176) *Noncommutative Quadric Surfaces.* Preliminary report.
S Paul Smith*, Univ. of Washington, and **M Van den Bergh**, Limburgs Universitair Centrum (983-14-831)

2:45PM (177) *Exotic Noncommutative Surfaces I.*
Daniel S Rogalski, University of Washington (983-16-663)

3:15PM (178) *Exotic noncommutative surfaces II.* Preliminary report.
Dennis S. Keeler*, MIT, **Daniel Rogalski**, Univ. of Washington, and **J. T. Stafford**, Univ. of Michigan (983-16-646)

3:45PM (179) *The Noncommutative Projective Schemes and the Point Schemes.*
Izuru Mori, Syracuse University (983-16-578)

4:15PM (180) *Frobenius bimodules between noncommutative spaces.*
Christopher J Pappacena, Baylor University (983-18-744)

4:45PM (181) *Affinization: 20 years later.*
Jason P Bell, University of Michigan (983-16-648)

5:15PM (182) *Computing Generators for Rings of Multiplicative Invariants.*
Marc S Renault, Shippensburg University (983-13-758)

AMS Special Session on Discrete Models, II

2:15 PM - 5:40 PM

Organizers: **Cris Moore**, University of New Mexico and Santa Fe Institute
Dana Randall, Georgia Institute of Technology

2:15PM (183) *Spectral Analysis of Power Law Graphs.*
Milena Mihail, Georgia Tech (983-05-1206)

2:45PM (184) *Epidemics, Erdos numbers, and the Internet: Graphs and networks in the real world.*
Mark Newman, University of Michigan (983-92-887)

3:45PM Break

4:15PM (185) *Robustness in some discrete dynamical models.*
Michel Morvan, Ecole normale supérieure de Lyon and Institut universitaire de France (983-68-1074)

4:45PM ► (186) *Computing with DNA and RNA.*
Laura F Landweber, Princeton University (983-92-1414)

5:15PM ► (187) *Proofreading Tile Sets: Error Correction in Algorithmic Self-Assembly.* Preliminary report.
Renat Bekbolatov and **Erik Winfree***, California Institute of Technology (983-92-819)

AMS Special Session on Recent Advances in Riemannian and Lorentzian Geometries, II

2:15 PM - 5:35 PM

Organizers: **Krishan L. Duggal**, University of Windsor
Ramesh Sharma, University of New Haven

2:15PM (188) *Harmonic sections in contact geometry.*
Philippe Rukimbira, Florida International University (983-53-35)

2:45PM (189) *Boundaries, Static Spacetimes, and Group Actions.* Preliminary report.
Steven G. Harris, Saint Louis University (983-83-805)

3:15PM (190) *Warped Products and Volume Comparison.* Preliminary report.
Paul E. Ehrlich, Dept. of Mathematics, University of Florida (983-53-319)

3:45PM (191) *Conjugate Points in Some Pseudoriemannian 2-step Nilpotent Lie Groups.*
Changrim Jang, University of Ulsan, Ulsan, Republic of Korea, and **Phillip E. Parker***, Wichita State University (983-53-1187)

4:15PM (192) *Geometric and algebraic properties of the skew-symmetric curvature operator, the higher order Jacobi operator, and the Szabo operator.*
Iva Stavrov, University of Oregon (983-53-40)

4:45PM (193) *Compact complex manifolds with toric symmetry and vanishing first Chern class.* Preliminary report.
K Abe, University of Connecticut, **G Grantcharov***, Florida International University, and **D Grantcharov**, University of California at Riverside (983-53-1195)

5:15PM ► (194) *Group invariant classification of orthogonal webs in the Euclidean and Minkowski planes.*
Raymond G McLenaghan, University of Waterloo, **Roman G Smirnov***, University of Paderborn, and **Dennis The**, University of British Columbia (983-53-1064)

AMS Special Session on Primes and Knots, II

2:15 PM - 6:00 PM

Organizers: **Jack Morava**, Johns Hopkins University
Stavros Garoufalidis, Georgia Institute of Technology
Masanori Morishita, Kanazawa University

2:15PM (195) *Various limits of the colored Jones polynomials of the figure-eight knot.* Preliminary report.
Hitoshi Murakami, Tokyo Institute of Technology (983-57-1159)

3:15PM (196) *The Kontsevich integral of the unknot.*
Dylan P. Thurston, Harvard University (983-55-1504)

4:15PM (197) *Loop spaces of orbit configuration spaces and chord diagrams on surfaces.* Preliminary report.
Toshitake Kohno, University of Tokyo (983-55-1353)

5:15PM (198) *On cyclotomic expansion of quantum 3-manifold invariants.* Preliminary report.
Thang T. Le, SUNY Buffalo (983-57-1165)

AMS Special Session on Computability and Models, II

2:15 PM - 6:10 PM

Organizers: **Douglas Cenzer**, University of Florida
Valentina S. Harizanov, The George Washington University

2:15PM (199) *Algebraic and computability questions arising from fuzzy logics.* Preliminary report.
Michael C. Laskowski, University of Maryland (983-03-1391)

2:45PM (200) *The isomorphism problem for computable structures.* Preliminary report.
Wesley C. Calvert, University of Notre Dame (983-03-915)

3:15PM (201) *Differential Geometry and Computability Theory.*
Robert I. Soare, University of Chicago (983-03-1226)

3:45PM (202) *Applications of Computability Theory to Differential Geometry.* Preliminary report.
Barbara F. Csima, University of Chicago (983-03-1225)

4:15PM (203) *Covering filters in the lattice of Π^0_1 classes.* Preliminary report.
Douglas Cenzer, University of Florida, and **Farzan Riazati***, University of Wisconsin-Fond du Lac (983-03-1063)

4:45PM (204) *Effectiveness and infinite variable words.*
David Reed Solomon*, Notre Dame, and **Joe Miller**, Indiana University-Bloomington (983-03-1430)

5:15PM ► (205) *Proof-theoretic strength of the stable marriage theorem.*
Douglas Cenzer*, University of Florida, and **Jeffrey Remmel**, University of California San Diego (983-03-1211)

5:45PM (206) *Some Facts about Linear Orderings Provable in RT^2_2.* Preliminary report.
Denis R. Hirschfeldt*, University of Chicago, and **Richard A. Shore**, Cornell University (983-03-1379)

AMS Special Session on Operator Algebras, Quantization, and Noncommutative Geometry: A Centennial Celebration in Honor of J. V. Neumann and M. H. Stone, II

2:15 PM – 5:35 PM

Organizers: **Robert S. Doran**, Texas Christian University
Richard V. Kadison, University of Pennsylvania

2:15PM (207) *Non-commutative Conditional Expectations and Their Applications.*
Richard V Kadison, University of Pennsylvania (983-81-651)

3:15PM (208) *On the generator problem of von Neumann algebras.*
Liming Ge, Univ. of New Hampshire/Chinese Academy of Sciences (983-46-853)

3:45PM (209) *Cohomology for factors with property Γ of Murray and von Neumann.*
Erik Christensen, University of Copenhagen, **Florin Pop**, Wagner College, **Allan Sinclair**, University of Edinburgh, and **Roger Smith***, Texas A&M University (983-46-833)

4:15PM (210) *Local structure of non-commutative L_p spaces.*
Zhong-Jin Ruan, University of Illinois (983-46-856)

4:45PM (211) *Quantum Metric Spaces.* Preliminary report.
Marc A. Rieffel, University of California, Berkeley (983-46-64)

5:15PM (212) *Conjugacy of Countable Discrete Amenable Group Outer Actions on AFD Factors.* Preliminary report.
Yoshikazu Katayama, Osaka Kyoiku University, and **Masamichi Takesaki***, UCLA (983-46-838)

AMS Special Session on Special Functions and q-Series, II

2:15 PM – 6:10 PM

Organizer: **Mourad E. H. Ismail**, University of South Florida

2:15PM (213) *Classical elliptic function invariants and q-series.* Preliminary report.
Stephen C. Milne, The Ohio State University (983-33-1103)

2:45PM (214) *q-Taylor series for entire functions.*
Dennis W. Stanton*, University of Minnesota, and **Mourad E. H. Ismail**, University of South Florida (983-33-984)

3:15PM ► (215) *Asymptotics of zeros of basic sine and cosine functions.*
Sergei K. Suslov, Arizona State University (983-33-1239)

3:45PM (216) *Poisson kernels for little q-Jacobi functions.*
Erik Koelink, Technische Universiteit Delft (983-33-1076)

4:15PM (217) *On the Askey-Wilson function.* Preliminary report.
Jasper V Stokman, Universiteit van Amsterdam (983-33-882)

4:45PM (218) *A second addition formula for continuous q-ultraspherical polynomials motivated by quantum groups.* Preliminary report.
Tom H Koornwinder, Korteweg-de Vries Institute, University of Amsterdam (983-33-1035)

5:15PM (219) *A new bilateral Bailey lemma.*
Michael J Schlosser, University of Vienna (983-33-1382)

5:45PM ► (220) *A matrix version of the bispectral property: matrix valued Jacobi polynomials.* Preliminary report.
F. Alberto Grünbaum, Math Dept UC Berkeley (983-35-989)

AMS Special Session on Dynamics, Physics, and Probability: The Work of the 2002 Nemmers Prize Winner, Yakov Sinai

2:15 PM – 6:00 PM

Organizers: **John M. Franks**, Northwestern University
Jeff Xia, Northwestern University

2:15PM (221) *u-Gibbs measures in ergodic theory.*
Dmitry Dolgopyat, University of Maryland (983-37-801)

3:15PM ► (222) *Arithmetical Dynamical Systems.*
Jeffrey C. Lagarias, AT&T Labs (983-37-709)

4:15PM (223) *Some recent advances in stochastic hydrodynamics.*
Weinan E, Princeton University (983-37-1156)

5:15PM (224) *Ergodicity, mixing, and scales in the stochastically forced Navier-Stokes equation.*
Jonathan C. Mattingly, Duke University (983-37-1537)

AMS Special Session on Nonstandard Models of Arithmetic and Set Theory, II

2:15 PM – 6:05 PM

Organizers: **Ali Enayat**, American University
Roman Kossak, CUNY Graduate Center

2:15PM (225) *Coding in fragments of arithmetic.*
Paola D'Aquino, Seconda Univ. di Napoli, and **Julia Knight***, University of Notre Dame (983-03-464)

3:15PM (226) *Turing upper bounds of countable jump ideals and Scott sets.*
Alex M McAllister, Centre College (983-03-897)

3:45PM (227) *Measure theory in weak theories of nonstandard arithmetic.*
Jeremy Avigad, Carnegie Mellon University (983-03-1190)

4:15PM (228) *Diversity in the Substructure Lattice of a Model of PA.*
James H. Schmerl, University of Connecticut (983-03-983)

5:15PM (229) *A model theoretic approach to questions in bounded arithmetic.* Preliminary report.
Zofia Adamowicz, Mathematical Institute, Polish Academy of Sciences (983-03-1350)

5:45PM (230) *From Arithmetic to Large Cardinals via NFU.* Preliminary report.
Ali Enayat, American University (983-03-1071)

MAA Minicourse #13: Part A

2:15 PM – 4:15 PM

Incorporating discrete mathematics in the preparation of K-12 mathematics teachers.
Organizer: **Lolina Alvarez**, New Mexico State University

MAA Minicourse #2: Part A

2:15 PM – 4:15 PM

Java applets in teaching mathematics.
Organizers: **Joe Yanik**, Emporia State University
David M. Strong, Pepperdine University

MAA Minicourse #8: Part B

2:15 PM – 4:15 PM

Mathematical finance.
Organizers: **Walter R. Stromquist**
Alan Durfee, Mount Holyoke College

AMS Session on Partial Differential Equations

2:15 PM – 5:25 PM

2:15PM (231) *Entropy and A Posteriori Error Estimates for Conservation Laws.* Preliminary report.
Marc E Laforest, Colorado State University (983-35-1488)

2:30PM (232) *Solitons and Particle Decay for Completely Integrable Nonlinear Partial Differential Equations.*
Hieu D Nguyen, Rowan University (983-35-634)

2:45PM ► (233) *Darboux Transformations of the Variable Wave Speed Equation.* Preliminary report.
Fred Hickling*, **Daniel J. Arrigo**, University of Central Arkansas, and **Garth Johnson**, Univ. California Santa Barbara (983-35-1275)

3:00PM (234) *Charpit's method and symmetry analysis.*
Danny Arrigo, University of Central Arkansas (983-35-1273)

3:15PM (235) *J-self-adjointness of a class of Dirac-type operators.*
Radu C Cascaval* and **Fritz Gesztesy**, University of Missouri-Columbia (983-35-1305)

3:30PM (236) *Numerical study of a parabolic equation of mixed type.* Preliminary report.
M Affouf, Kean University (983-35-1121)

3:45PM ► (237) *Quantization Of Spin Direction For Solitary Waves In A Uniform Magnetic Field.*
Qazi Enamul Hoq*, University Of North Texas, and **Henry A. Warchall**, NSF (983-35-788)

4:00PM (238) *Blow-up Behavior of the Solution for a Degenerate Semilinear Parabolic Problem with a Localized Nonlinear Reaction.*
C. Y. Chan, University of Louisiana at Lafayette, and **N. E. Dyakevich***, California State University at San Bernardino (983-35-1104)

4:15PM (239) *Existence of solutions to a nonlinear system of partial differential equations modeling the flow of fluids with capillary effects.* Preliminary report.
Diane L Denny, University of Wyoming (983-35-1457)

4:30PM ► (240) *Recent Advances in Lorentz Wave Maps with Symmetries.* Preliminary report.
Tadg H Woods*, University of Oregon, and **P. J. Pohjanpelto**, Oregon State University (983-35-1410)

4:45PM (241) *The Large Time Behavior and The Stability of Solutions of a Fixed Interface Boundary Value Problem.* Preliminary report.
Chi-Kan Chen, University of Central Arkansas (983-35-786)

5:00PM ► (242) *A reflection formula for elliptic differential equations.*
Tatiana Savina, Northwestern University (983-35-315)

5:15PM (243) *Results for an Inverse Problem Related to the 2-dimensional Lamé System: A Preliminary Report.* Preliminary report.
Michael Dobranski, University of Kentucky (983-35-1224)

AMS Session on Number Theory, II

2:15 PM – 5:40 PM

2:15PM (244) *Existence of Primitive Polynomials With Three Coefficients Prescribed.*
Donald D Mills, Southern Illinois University at Carbondale (983-11-652)

2:30PM (245) *The Igusa Local Zeta Function of the Cubic Polynomial* $f(x) = x_1^3 + \cdots + x_n^3$. Preliminary report.
Annalee H Wiswell*, Scripps College, and **Benjamin Marko**, The University of Akron (983-11-643)

2:45PM ► (246) *Zeroing the baseball umpire indicator.* Preliminary report.
Christopher S Simons and **Marcus Wright***, Rowan University (983-11-579)

3:00PM ► (247) *An analogue to Gauss' Lemma for Number Fields.*
Arturo Magidin*, University of Montana, and **David McKinnon**, University of Waterloo (983-11-57)

3:15PM Break.

3:30PM (248) *Finite Subextensions of 1-Maximal Fields.*
Anthony J Bevelacqua, University of North Dakota (983-12-1375)

3:45PM (249) *Elasticities of Block Monoids of the Form* $\mathcal{B}(\mathbf{Z}_n, S)$. Preliminary report.
Karl M. Kattchee, University of Wisconsin-La Crosse (983-13-1477)

4:00PM (250) *Some Normal Monomial M-Primary Ideals.* Preliminary report.
Heather A Coughlin, University of Oregon (983-13-1445)

4:15PM (251) *Properties of U-Factorizations.*
Joe A Stickles*, University of Evansville, **Michael Axtell**, Wabash College, **Sylvia Forman**, Moravian College, and **Nick Roersma**, Wabash College (983-13-1435)

4:30PM ► (252) *Classifying Serre Classes of Artinian Modules over a Noetherian Commutative Ring.* Preliminary report.
Manuel Lopez, Wesleyan University (983-13-1427)

4:45PM (253) *Term Orders on the Polynomial Ring and the Cantor Set.*
Wayne Tarrant, Western Kentucky University (983-13-851)

5:00PM (254) *Weak Bourbaki Unmixed Rings: A Step Towards Non-Noetherian Cohen-Macaulayness.*
Tracy Dawn Hamilton, California State University Sacramento (983-13-769)

5:15PM (255) *Star-operations induced by overrings.* Preliminary report.
Sharon M Clarke, University of Iowa (983-13-743)

5:30PM (256) *Constructing Witt-Burnside Rings.*
Jesse Colin Elliott, U.C. Berkeley (983-13-323)

AMS Session on Probability

2:15 PM – 5:25 PM

2:15PM (257) *Estimating the Gaussian isoperimetric constant on finite sets.*
Christian Houdré, Georgia Institute of Technology, and **Shobhana Murali***, Lehigh University (983-60-1480)

2:30PM (258) *A Local Limit Theorem for a Family of Non-Reversible Finite Markov Chains.*
Elizabeth L. Wilmer, Oberlin College (983-60-1475)

2:45PM ► (259) *On a Class of Nilpotent Markov Chains, I. The Spectrum of the Covariance Operator.*
Abbas M. Alhakim*, University of Delaware, **Janusz Kawczak** and **Stanislav Molchanov**, UNC Charlotte (983-60-1455)

3:00PM ► (260) *A new fast and robust technique for pricing and hedging Asian options.*
Georgios Vasileiou Dalakouras, University of Michigan (983-60-1450)

3:15PM (261) *Properties of correlation measures.*
Thomas M Lewis*, Furman University, and **Geoffrey Pritchard**, The University of Auckland (983-60-1360)

3:30PM ► (262) *Making coprimality more likely.* Preliminary report.
Yung-Pin Chen, Lewis & Clark College (983-60-1292)

3:45PM ► (263) *Determining Transient Probability Functions of M/M/1 Queueing Systems with Catastrophes-A Dual Process/ Randomization Approach.*
Alan C. Krinik*, **Michael L. Green**, **Randall J. Swift**, California State Polytechnic University, Pomona, **Gerardo Rubino**, INRIA, and **Holly Lam**, California State Polytechnic University, Pomona (983-60-1270)

4:00PM (264) *On Random Trigonometric Polynomials.* Preliminary report.
Robert Bozeman* and **M Sambandham**, Morehouse College (983-60-964)

4:15PM Break.

4:30PM (265) *Analytic Processes.* Preliminary report.
Randall J Swift, California State Polytechnic University Pomona (983-60-954)

4:45PM ► (266) *Programming a Molecular Electronic Device Using Neuro-Dynamic Programming.* Preliminary report.
Christopher P Husband, Rice University (983-60-891)

5:00PM (267) *Complex Stochastic Calculus.* Preliminary report.
Mylan Redfern, University of Southern Mississippi (983-60-780)

5:15PM (268) *Exact Laplace Transforms via the Hadamard Factorization.*
Fred Torcaso, The Johns Hopkins University (983-60-703)

AMS Session on Analysis, II

2:15 PM – 5:55 PM

2:15PM (269) *An meromorphic function solutions of Diophantine's type of equations.*
C.C. Yang, The Hong Kong Univ. of Sci.&Tech. (983-30-26)

2:30PM (270) *Harmonic de la Vallée Poussin means.* Preliminary report.
Stacey A Mueller, University of Kentucky (983-30-675)

2:45PM (271) *On the growth of harmonic polynomials.* Preliminary report.
Mohammed A. Qazi*, Tuskegee University, and **Qazi I. Rahman**, Universite de Montreal (983-30-935)

3:00PM (272) *Polya-Schoenberg conjecture type problems for harmonic univalent mappings.*
Om P Ahuja*, **Jay M Jahangiri**, Kent State University, and **Herb Silverman**, College of Charleston (983-30-938)

3:15PM (273) *Perturbation of a Univalent Functions.*
David E Tepper, Baruch College, CUNY (983-30-1046)

3:30PM ► (274) *Elliptic functions and the Ahlfors map.*
Tom Tegtmeyer, Truman State University (983-30-1073)

3:45PM (275) *Some q-Convexity Properties of Coverings of Complex Manifolds.*
Michael Fraboni, Moravian College (983-32-1171)

4:00PM (276) *Zeros of a Product of Solutions of Linear Differential Equations.*
Djamel Benbourenane, Valdosta State University (983-30-1235)

4:15PM (277) *An inequality related to Hardy's Inequality and Paley's Theorem for H_1.* Preliminary report.
Beth A. Osikiewicz*, Kent State University, Tuscarawas Campus, and **Andrew Tonge**, Kent State University (983-30-1244)

4:30PM ► (278) *Democracy and the Hyperbolic Unit Disk.* Preliminary report.
Dov N. Chelst, DeVry College - North Brunswick (983-30-1388)

4:45PM (279) *Convex mappings of domains in $\mathbb{C}^n$.* Preliminary report.
Ted J. Suffridge, University of Kentucky (983-32-1367)

5:00PM (280) *Convex Mappings of the Ball in $\mathbb{C}^n$ That Are Half-Plane Mappings in One Coordinate.* Preliminary report.
Jerry R Muir, Jr.*, Rose-Hulman Institute of Technology, and **Ted J Suffridge**, University of Kentucky (983-32-705)

5:15PM (281) *How Cauchy missed Ramanujan's ${}_1\psi_1$ summation.*
Warren P Johnson, Bates College (983-33-1403)

5:30PM ► (282) *Finding zeta(2p) from a product of sines.*
Thomas J. Osler, Rowan University (983-33-1019)

5:45PM (283) *Special cases of the Wiener-Wintner Theorem.* Preliminary report.
Sherry E. Scott, Bowie State University (983-43-1348)

SIAM Minisymposium on the Stability of Nonlinear Dispersive Waves, I

2:15 PM - 4:50 PM

Organizer: **Robert L. Pego**, University of Maryland

2:15PM (284) *Waves in free surfaces and interfaces.*
Walter Craig, McMaster University

2:50PM (285) *Semiclassical Asymptotics for the Focusing Nonlinear Schrödinger Equation.*
Peter D Miller, University of Michigan (983-35-1481)

3:25PM Break

3:45PM (286) *Stability and instability results for nonlinear dispersive wave equations.*
Jerry Bona, University of Illinois at Chicago

4:20PM (287) *Stability of vortex solutions in the two-dimensional Navier-Stokes equation.* Preliminary report.
Thierry Gallay, University of Grenoble, and **C. Eugene Wayne***, Boston University (983-35-1446)

SIAM Minisymposium on Undergraduate Opportunities in Applied Mathematics

2:15 PM - 5:00 PM

Organizer: **Terry L. Herdman**, Virginia Polytechnic Institute and State University

2:15PM ► (288) *Math Modeling Projects.*
David S Ross*, **Sophia Maggelakis** and **Bernard Brooks**, Rochester Institute of Technology (983-97-1359)

2:45PM (289) *Continuous Mathematical Contest in Modeling Problem.*
Kelly Black, University of New Hampshire

3:15PM (290) *Discrete Mathematical Contest in Modeling Problem.*
Don Miller, St Mary's College

3:45PM (291) *Internships.*
Angela Shiflet, Wofford College

4:15PM **Careers in Applied Mathematics Panel Discussion**

MAA Session on Innovative Use of the World Wide Web in Teaching Mathematics, II

2:15 PM - 5:10 PM

Organizers: **Brian E. Smith**, McGill University
Marcelle Bessman, Jacksonville University
Marcia P. Birken, Rochester Institute of Technology
Thomas E. Leathrum, Jacksonville State University
David M. Strong, Pepperdine University
Joe Yanik, Emporia State University

2:15PM ► (292) *The National Curve Bank http://curvebank.calstatela.edu.*
Shirley B. Gray, Dept. of Mathematics, California State University, Los Angeles (983-A1-28)

2:35PM ► (293) *www.Use the SMART Board.edu.*
Michael R. Huber* and **David A Smith**, US Military Academy (983-A1-219)

2:55PM ► (294) *Helping Preservice Teachers Evaluate Mathematical Web Sites Using the Standards for Teaching and Learning.*
Joanne C Caniglia* and **Ellen Hoffman**, Eastern Michigan University (983-A1-291)

3:15PM ► (295) *Integrating Mobile Computing with Wireless Network Capabilities in the Mathematics Classroom.* Preliminary report.
William L Crowley* and **Edgar K Rugenstein**, United States Military Academy (983-A1-248)

3:35PM ► (296) *Learning and Reinforcement of Fundamental Skills in a Multivariable Calculus Course with Web Assignments.*
William L. Fehlman II*, **Michael Jaye** and **Shaw Yoshitani**, United States Military Academy (983-A1-87)

3:55PM Break

4:15PM ► (297) *An Inventive Use of the WWW as a Teaching and Learning Tool in Mathematics: Structured Web Materials for Courses Across the Mathematics Canon.*
M Padraig McLoughlin, Morehouse College (983-A1-361)

4:35PM ► (298) *Listening to the Primes: Applying Multimedia to the Teaching of Number Theory.* Preliminary report.
Chris K Caldwell, University of Tennessee, Martin (983-A1-321)

4:55PM ► (299) *Innovative Uses of a Variety of Intelligent Technologies in Teaching College Algebra.*
Om P. Ahuja, Kent State University (983-A1-145)

MAA Session on Getting Students to Discuss and to Write About Mathematics, I

2:15 PM - 6:10 PM

Organizer: **Sarah L. Mabrouk**, Framingham State University

2:15PM ► (300) *Communicating Mathematics: What's All the Buzz About?* Preliminary report.
Bart D. Stewart* and **Jeff A. Libby**, United States Military Academy (983-D1-213)

2:30PM ► (301) *W.R.I.T.E.: Writing's Role in Thoughtful Endeavors.*
Catherine M. Miller, University of Northern Iowa (983-D1-352)

2:45PM (302) *On-line discussion groups as a tool to enhance Writing Across the Curriculum projects.*
Benjamin V.C. Collins, University of Wisconsin-Platteville (983-D1-98)

3:00PM ► (303) *Effects of Reflective Notebooks on Perceptions of Learning in a Mathematics Classroom.* Preliminary report.
Tracie McLemore Salinas, University of Tennessee, Knoxville (983-D1-1298)

3:15PM ► (304) *"Appealing" Mathematics: Communicating Beyond the Test.*
Joanne C. Caniglia, Eastern Michigan University (983-D1-168)

3:30PM ► (305) *Communicating Mathematics: "Is it 'Write' to discuss Mathematics?'.* Preliminary report.
Jeff A. Libby* and **Bart D. Stewart**, United States Military Academy (983-D1-214)

3:45PM ► (306) *"Take Boards!": An effective approach routinely employed by instructors at USMA whereby students discuss, perform, and present mathematics.* Preliminary report.
Eric Wesley Drake, United States Military Academy (983-D1-238)

4:00PM ► (307) *Using Classroom Presentations to Improve Undergraduate Proof Skills.* Preliminary report.
Jeffrey Feuer, Coastal Carolina University (983-D1-606)

4:15PM ► (308) *Talking Math Over The Thanksgiving Dinner Table.*
William K Farmer* and **Michael Huber**, United States Military Academy (983-D1-205)

4:30PM ► (309) *Speaking Three Different Languages: The Contextual, The Mathematical And The Physical Languages: "Forcing" Students To Understand "Their" Mathematics.*
Dvora Peretz, Michigan State University (983-D1-91)

4:45PM ► (310) *Developing Math Communication Skill Through Class Participation.* Preliminary report.
Maria K. Robinson, University of Arizona (983-D1-356)

5:00PM ► (311) *Writing and Discussing the Limit Concept in Calculus: A Class Project.*
Victor U. Odafe, Bowling Green State University (Firelands) (983-D1-88)

5:15PM ► (312) *Understanding the fundamental theorem of calculus through writing.*
Lew Ludwig, Denison University (983-D1-485)

5:30PM ► (313) *Communicating Cryptanalytic Process in a Mathematical Cryptology Course.* Preliminary report.
Brian J. Winkel, United States Military Academy (983-D1-204)

5:45PM ► (314) *Preservice Elementary School Teachers' Perceptions of Reading and Writing in Mathematics Classes.* Preliminary report.
Gwen L Fisher, Cal Poly State University, San Luis Obispo (983-D1-599)

6:00PM (315) *Active Learning in Core Mathematics Courses at NC State University.* Preliminary report.
Jo-Ann Cohen* and **Michael Shearer**, North Carolina State University (983-D1-1208)

MAA Session on Quantitative Literacy in Practice: What Is it and What Works?

2:15 PM – 5:15 PM

Organizer: **Richard A. Gillman**, Valparaiso University

2:15PM ► (316) *The Quantitative Literacy Initiative at Macalester College.*
Karen Saxe, Macalester College (983-E1-60)

2:35PM (317) *Quantitative Literacy at Dominican University.*
Paul R Coe* and **Sarah Ziesler**, Dominican University (983-E1-558)

3:00PM ► (318) *The Quantitative Reasoning Program at DePaul University.*
David Jabon* and **Georgia Tolias**, DePaul University (983-E1-523)

3:20PM (319) *The 'Q' Requirement and "Quantitative Methods" at Juniata College.*
John F. Bukowski, Juniata College (983-E1-971)

3:40PM ► (320) *How to Grow a QL Program.*
Judith F Moran, Trinity College (983-E1-868)

4:00PM ► (321) *An assessment of the quantitative reasoning skills of students taking general education mathematics courses at Virginia Commonwealth University.* Preliminary report.
Aimee J Ellington, Virginia Commonwealth University (983-E1-169)

4:20PM ► (322) *Math Placement and the General Education Requirement.*
Frances B. Lichtman, Alma College (983-E1-430)

4:40PM ► (323) *A Comparison of HCCS - Central College's Fundamentals of Mathematics (0308) Curricular Objectives with Quantitative Literacy Objectives.* Preliminary report.
Jacqueline Brannon Giles, Houston Community College System (983-E1-940)

5:00PM ► (324) *Logic in the Media, or Fallacies for Fun and Profit.*
Charlotte Gregory*, Trinity College, and **Margaret Cibes**, Hillyer College of the University of Hartford (983-E1-1210)

MAA General Contributed Paper Session, II

2:15 PM – 6:10 PM

Organizers: **Michael A. Jones**, Montclair State University
Steven M. Hetzler, Salisbury University
Shawnee L. McMurran, California State University at San Bernardino

2:15PM ► (325) *Integrating and teaching with laptops in the Calculus classroom.*
Micki McCassey* and **Alex Heidenberg**, United States Military Academy (983-Z1-454)

2:30PM ► (326) *Teaching College Algebra and Trigonometry on the Internet.*
Denise J LeGrand, University of Arkansas at Little Rock (983-Z1-777)

2:45PM ► (327) *Technology Aids Asking Conceptual Questions.* Preliminary report.
Maria K. Robinson, University of Arizona (983-Z1-553)

3:00PM ► (328) *Laptop Computers and the Handheld Calculator: Technology in the classroom.*
Elizabeth W. Schott* and **John A Wasko**, USMA, West Point, NY (983-Z1-436)

3:15PM ► (329) *Mathematics Subject Classification as a Dynamic Digraph, for Mathematics Education.*
Simon R. Quint, Richard Stockton College of New Jersey, Pomona, NJ 08240 (983-Z1-81)

3:30PM ► (330) *Maximum Toughness and Nearly Regular Graphs.*
Lynne L. Doty, Marist College, and **Kevin K. Ferland***, Bloomsburg University (983-Z1-981)

3:45PM ► (331) *Hamiltonicity in almost claw-free graphs.*
Mingquan Zhan* and **Hong-Jian Lai**, West Virginia University (983-Z1-370)

4:00PM ► (332) *Enumeration of K-Trees and Applications.*
Melkamu Zeleke*, **Mahendra Jani**, William Paterson University of NJ, and **Robert G Rieper**, William Paterson University of NJ (983-Z1-969)

4:15PM (333) *The Green's Function of the Sturm-Liouville Operator Acting on Graphs.*
Matthew E Coppenbarger, Rochester Institute of Technology (983-Z1-507)

4:30PM ► (334) *A Very Elegant Inverse Tangent Series for Differential Equations.*
Richard N Barshinger, Penn State-Scranton (983-Z1-376)

4:45PM ► (335) *Expansions in Even Generalized Spherical Harmonics in R^{k+1}.* Preliminary report.
Jean-Pierre L. Liamba, Ball State University (983-Z1-1180)

5:00PM (336) *Q-Hypoelliptic Systems of Partial Differential Equations.*
Yuan Zhong Xu, Ocean County College (983-Z1-975)

5:15PM ► (337) *Investigations of nonstandard, Mickens-type, finite-difference schemes for singular boundary value problems in cylindrical or spherical coordinates.*
Ron Buckmire, Occidental College (983-Z1-228)

5:30PM (338) *Modeling Wound Healing in Bone.*
Carryn Bellomo, Texas A&M Corpus Christi (983-Z1-243)

5:45PM ► (339) *A new look at some old formulas: developing closed forms for the sums of powers of positive integers using elementary methods.*
Gregory M Boudreaux, University of North Carolina at Asheville (983-Z1-467)

6:00PM ► (340) *Exact Finite Expansions of Infinitely Repeating Decimals.*
Fengshan Liu*, **N. R. Nandakuma**, Delaware State University, and **Michael J. Bossé**, Indiana University of Pennsylvania (983-Z1-747)

AMS-MAA Joint Committee on Teaching Assistants and Part-Time Instructors Poster Session

2:15 PM - 4:15 PM

Implementing preparation and development programs for college mathematics instructors.
Organizers: **Teri J. Murphy**, University of Oklahoma
Natasha Speer, Michigan State University

MAA Committee on the Undergraduate Program in Mathematics and the CUPM Subcommittee on Curriculum Reform Across the First Two Years Panel Discussion

2:15 PM - 3:35 PM

The impact of technology in calculus courses on long-term student performance and employment.
Organizers: **Susan L. Ganter**, Clemson University
Jack Bookman, Duke University
Panelists: **Betsy Darken**, University of Tennessee at Chattanooga
Elton Graves, Rose-Hulman Institute of Technology
Glenn W. Ledder, University of Nebraska
Howard L. Penn, U. S. Naval Academy
Debra L. Wood, University of Arizona

MAA Special Presentation

2:15 PM - 3:35 PM

An overview of interviews.
Organizers: **Dov N. Chelst**, DeVry College of Technology
John A. Vano, University of Wisconsin

AMS Special Session on Quantum Computation and Information: Mathematical Challenges, II

2:20 PM - 6:10 PM

Organizers: **Samuel J. Lomonaco, Jr.**, University of Maryland Baltimore County
Howard E. Brandt, Army Research Laboratory
Louis H. Kauffman, University of Illinois at Chicago

2:15PM Awards Ceremony

2:20PM (341) *Security proofs for quantum key distribution.*
Preliminary report.
Peter W. Shor, AT&T Labs - Research (983-81-994)

3:15PM (342) *Polynomial-Time Quantum Algorithms for Pell's Equation and the Principal Ideal Problem.*
Hallgren Sean, Caltech (983-68-1438)

3:45PM (343) *Quantum computing approaches to NP-complete problems.*
Lov K Grover, Bell Labs, Lucent (983-68-1010)

4:15PM (344) *Classical codes and quantum algorithms.*
Preliminary report.
David A Meyer, University of California/San Diego (983-68-1020)

4:45PM (345) *Quantum Dynamical Semigroup Tomography.*
Timothy F Havel, MIT (983-81-791)

5:15PM ► (346) *Scalable quantum architectures using efficient nonlocal interactions.*
Gavin K Brennen*, NIST, **Daegene D Song**, National Institute of Standards and Technology, and **Carl J Williams**, National Institutes of Standards and Technology (983-81-1246)

5:45PM (347) *Generalizations of entanglement based on lie algebras, coherent states, and convex cones.*
Howard N Barnum*, **Emanuel "Manny" Knill**, **Gerardo Ortiz** and **Lorenza Viola**, Los Alamos National Laboratory (983-81-799)

MAA Session on Environmental Mathematics in the Classroom

2:20 PM - 5:55 PM

Organizers: **Karen D. Bolinger**, Clarion University
Ben Fusaro, Florida State University

2:20PM ► (348) *Introducing a Mathematical Perspective Where It Has Rarely (In Public) Gone Before.*
Martin Walter, University of Colorado (983-F1-1262)

2:40PM ► (349) *Environmental Data to Motivates the Connections Between Algebra and Geometry.*
Don Spickler, Salisbury University (983-F1-527)

3:00PM ► (350) *Environmental plug-in models motivating students to learn algebra, precalculus, and calculus.*
M. Paul Latiolais*, Portland State University, **Nancy Zumoff**, Kennesaw State University, and **Christopher Schaufele**, Dine College (983-F1-374)

3:20PM ► (351) *Chernobyl Is Still Hot: Would You Eat the Mushrooms?*
Karen J. Schroeder* and **David H. Carhart**, Bentley College (983-F1-62)

3:40PM ► (352) *Using Difference Equations to Model Source-Sink Populations.*
Kyle L. Riley, South Dakota School of Mines and Technology (983-F1-157)

4:00PM ► (353) *Environmental Mathematics Models with Spreadsheets.*
Erich Neuwirth*, University of Vienna, and **Deane Arganbright**, University of Tennessee at Martin (983-F1-294)

4:40PM (354) *Consorting with Biologists: Approaches to Biocomplexity and Environmental Modeling.*
Ellen Cunningham, Saint Mary-of-the-Woods College (983-F1-547)

5:00PM ► (355) *Environmental Mathematics in an Integrated Science Course.*
Daniel Alexander, Drake University (983-F1-459)

5:20PM ► (356) *Mathematical Methods in Environmental Science for Non-Majors.*
Sandra Fillebrown, Saint Joseph's University (983-F1-385)

5:40PM ► (357) *The Global Positioning System, Data Analysis, and Earthquake Modeling.*
Werner Horn, Carol Shubin* and **Gerry Simila**, California State Northridge (983-F1-417)

MAA Section Officers

2:30 PM - 5:00 PM

AWM Panel Discussion

3:20 PM - 4:20 PM

Mathematics educators and mathematicians working together.

Organizers: **Bettye Anne Case**, Florida State University
Suzanne M. Lenhart, University of Tennessee
Elizabeth G. Yanik, Emporia State University

Moderators: **Elizabeth G. Yanik**
Bettye Anne Case

Panelists: **Deborah Loewenberg Ball**, University of Michigan
Hyman Bass, University of Michigan
Karen Dee Michalowicz, The Langley School (McLean, VA)
Edith Prentice Mendez, Sonoma State University

MAA Project NExT Panel Discussion

3:30 PM - 5:00 PM

Expanding your research horizons.

Organizers: **Jennifer Hontz**, Meredith College
Philip K. Hotchkiss, Westfield State College

Panelists: **John Emert**, Ball State University
Rochelle Leibowitz, DIMACS
Neil Portnoy, California State University, Chico

MAA Special Presentation

3:45 PM - 4:45 PM

Doctorates in mathematics education: Why the shortage? Where do they go? What do they do?

Organizers: **Robert E. Reys**, University of Missouri, Columbia
Robert Glasgow, Southwest Baptist University

MAA CUPM Subcommittee on Curriculum Reform Across the First Two Years Panel Discussion

3:45 PM - 5:05 PM

Small group projects in college algebra.

Organizer: **Donald B. Small**, U. S. Military Academy

Moderator: **Kathleen Snook**, U. S. Military Academy and COMAP

Panelists: **Laurette B. Foster**, Prairie View A&M University
Richard D. West, Francis Marion College
Paul Dirks, Miami-Dade Community College
Regina D. Aragon, Eastern New Mexico University

AWM Business Meeting

4:20 PM - 4:40 PM

MAA Minicourse #14: Part A

4:30 PM - 6:30 PM

Teaching a course in the history of mathematics

Organizers: **V. Frederick Rickey**, United States Military Academy
Victor J. Katz, University of District of Columbia

MAA Minicourse #3: Part A

4:30 PM - 6:30 PM

Optimization of technology in the geometry classroom.

Organizer: **Subhash C. Saxena**, Coastal Carolina University

MAA Minicourse #9: Part A

4:30 PM - 6:30 PM

Fair enough? Mathematics of equity.

Organizers: **John C. Maceli**, Ithaca College
Stanley E. Seltzer, Ithaca College

MAA Committee on the Teaching of Undergraduate Mathematics Workshop

4:30 PM - 6:30 PM

Student writing: A hands-on approach.

Organizers: **Mary Ellen Foley**, Louisiana State University, Shreveport
Kirk C. Weller, Bethel College
Douglas Kurtz, New Mexico State University
Ahmed I. Zayed, DePaul University

Graduate Student Reception

5:00 PM - 6:00 PM

Organizers: **Betty Mayfield**, Hood College
Shawnee L. McMurran, California State University San Bernardino

MAA History of Mathematics SIGMAA Panel Discussion

5:15 PM - 6:45 PM

Truth in using the history of mathematics in teaching mathematics.

Organizers: **Victor J. Katz**, University of the District of Columbia
Eisso J. Atzema, University of Maine

Panelists: **Joseph W. Dauben**, City University of New York
Fernando Q. Gouvêa, Colby College
Anthony V. Piccolina, Montclair State University

Mathematical Sciences Institutes Reception

5:30 PM - 7:30 PM

Reception for First-Time Participants

6:00 PM – 7:00 PM

History of Mathematics SIGMAA Business Meeting and Reception

6:45 PM – 8:15 PM

Organizer: **Amy Shell-Gellasch**, U. S. Military Academy

Organizational Reception for the Proposed WEB SIGMAA

7:00 PM – 8:15 PM

Young Mathematicians Network Town Meeting

7:15 PM – 8:15 PM

AMS Josiah Willard Gibbs Lecture

8:30 PM – 9:20 PM

(358) *The shape of objects in two and three dimensions: Mathematics meets computer vision.*
David B. Mumford, Brown University

AWM Reception

9:30 PM – 11:00 PM

Thursday, January 16

Employment Center

7:00 AM – 7:00 PM

Joint Meetings Registration

7:30 AM – 4:00 PM

AMS-ASL Special Session on Interactions Between Logic, Group Theory and Computer Science, III

8:00 AM – NOON

Organizers: **Alexandre V. Borovik**, UMIST
Alexei Myasnikov, City College of CUNY

8:00AM *Reasoning In A Most Likely Way.*
► (359) **Robert M. Haralick**, CUNY (983-68-1147)

9:00AM *Heuristic Algorithms and Whitehead Method.*
► (360) Preliminary report.
Alexei D. Miasnikov, CUNY (983-20-1077)

9:30AM *Genetic algorithms on groups.* Preliminary report.
► (361) **Richard F Booth**, UMIST (983-20-955)

10:00AM *The Structure of Automorphic Conjugacy in the*
► (362) *Free Group of Rank 2.*
Bilal Khan, CUNY (983-20-1148)

10:30AM Round Table Discussion

AMS Special Session on Algebras, Actions, and Algorithms, III

8:00 AM – 11:50 AM

Organizers: **Edward S. Letzter**, Temple University
Martin Lorenz, Temple University

8:00AM *Algebra of pseudo-roots of noncommutative*
(363) *polynomials.* Preliminary report.
Vladimir Retakh, Rutgers University (983-16-719)

8:30AM *Linear representations of braid groups and*
(364) *automorphism groups of free groups.*
Edward W. Formanek, Pennsylvania State University (983-20-665)

9:00AM *Polynomial detection of matrix subalgebras.*
(365) **Daniel Birmajer**, Temple University (983-16-660)

9:30AM *Maximal Orders on Projective Surfaces.*
(366) **Daniel Chan**, University of New South Wales, and **Rajesh S. Kulkarni***, Michigan State University (983-16-792)

10:00AM *An algorithm for computing maximal tori of*
(367) *centralizers of nilpotents in symmetric spaces associated with non compact simple exceptional real Lie algebras.*
Alfred G Noel, The University of Massachusetts (983-22-43)

10:30AM *Algorithms for algebraic groups and fields.*
(368) Preliminary report.
Harm Derksen, University of Michigan (983-12-396)

11:00AM *Mixed-rank quantum determinantal ideals.*
(369) Preliminary report.
K R Goodearl*, University of California at Santa Barbara, and **T H Lenagan**, University of Edinburgh (983-16-407)

11:30AM *Differential operators on the base affine space of*
(370) *an algebraic group.* Preliminary report.
T levasseur, Universite de Brest,, and **J T Stafford***, University of Michigan (983-16-765)

AMS Special Session on Quantum Computation and Information: Mathematical Challenges, III

8:00 AM – 11:55 AM

Organizers: **Samuel J. Lomonaco, Jr.**, University of Maryland Baltimore County
Howard E. Brandt, Army Research Laboratory
Louis H. Kauffman, University of Illinois at Chicago

8:00AM *Adiabatic Quantum Algorithms.*
(371) **Umesh V. Vazirani**, U.C. Berkeley (983-68-1150)

9:00AM *Adaptive Quantum Computation, Constant Depth*
(372) *Quantum Circuits and Arthur-Merlin Games.*
Barbara M Terhal, IBM Watson Research Center (983-68-300)

9:30AM *Open problems in quantum coding theory.*
(373) Preliminary report.
Eric M. Rains, Center for Communications Research, Princeton (983-81-800)

10:00AM *Multi-particle entanglement.*
► (374) **Sandu Popescu**, Bristol University (983-81-1152)

10:30AM *Continuous Quantum Hidden Subgroup Algorithms.*
(375) Preliminary report.
Samuel J Lomonaco*, University of Maryland Baltimore County, and **Louis H Kauffman**, University of Illinois at Chicago (983-81-842)

11:00AM *On the quantum derandomization of algorithms.*
(376) Preliminary report.
Michele Mosca, University of Waterloo, and Perimeter Institute for Theoretical Physics (983-68-1059)

11:30AM *Continuous Quantum Computation.*
► (377) **Joseph F Traub**, Columbia University (983-68-829)

AMS Special Session on Recent Advances in Riemannian and Lorentzian Geometries, III

8:00 AM - 11:20 AM

Organizers: **Krishan L. Duggal**, University of Windsor
Ramesh Sharma, University of New Haven

8:00AM ► (378) *Differential Topology, Differential Geometry and Hyperbolic Equations.*
Adam D Helfer, University of Missouri - Columbia (983-58-1252)

8:30AM (379) *Conformal vector fields on Kaehler manifolds and its contact hypersurfaces.*
Ramesh Sharma, University of New Haven, Connecticut, USA (983-53-1487)

9:00AM (380) *Fundamental inequalities and strongly minimal submanifolds.*
Bogdan D Suceava, California State University, Fullerton (983-53-809)

9:30AM (381) *Curvature-homogeneous indefinite Einstein metrics in dimension four: the diagonalizable case.*
Andrzej J Derdzinski, Ohio State University (983-53-793)

10:00AM (382) *Certain basic inequalities for submanifolds in (κ, μ)-spaces.*
Mukut Mani Tripathi, Lucknow University, India (983-53-295)

10:30AM (383) *Generic cut loci are dense.*
Ralph Howard, University of South Carolina (983-53-610)

11:00AM (384) *The Stability of the Friedman Model.*
Christina Sormani, Lehman College, CUNY (983-58-37)

AMS Special Session on Primes and Knots, III

8:00 AM - 11:45 AM

Organizers: **Jack Morava**, Johns Hopkins University
Stavros Garoufalidis, Georgia Institute of Technology
Masanori Morishita, Kanazawa University

8:00AM (385) *Dynamical zeta functions, Nielsen theory, and Reidemeister torsion.*
Alexander L. Fel'shtyn, University of Siegen (983-37-1505)

9:00AM (386) *Number theoretical criterion for invariance of Fox p-colorings under n-rotation.* Preliminary report.
Janek Dymara, Tadeusz Januszkiewicz, U.Wr., and **Jozef H. Przytycki***, GWU (983-57-1107)

10:00AM (387) *Knot theory and mirror symmetry.* Preliminary report.
Stavros Garoufalidis, Georgia Tech (983-57-1506)

11:00AM (388) *Non-commutative geometry, dynamics, and infinity-adic Arakelov geometry.*
Katia Consani, University of Toronto, and **Matilde Marcolli***, Max-Planck Institute, Bonn (983-14-735)

AMS Special Session on Computability and Models, III

8:00 AM - 11:55 AM

Organizers: **Douglas Cenzer**, University of Florida
Valentina S. Harizanov, The George Washington University

8:00AM (389) *A definiable yet non-Δ^0_3 orbit in the computably emunerable sets.* Preliminary report.
Peter A Cholak*, University of Notre Dame, and **Leo Harrington**, Univerity of California - Berkeley (983-03-696)

8:30AM (390) *A Concept of Computable Transformations for Locally Determined Logic Programs.* Preliminary report.
Amy K. C. S. Vanderbilt, Xavier University (983-03-1394)

9:00AM (391) *Structures Subject to Space Complexity.*
Zia Uddin, University of Florida (983-03-753)

9:30AM (392) *Preparation and Normalization Theorems.* Preliminary report.
Daniel J. Miller, University of Wisconsin-Madison (983-03-956)

10:00AM (393) *Structural properties and principal filters of the lattice of Computably Enumerable Vector Spaces.*
Rumen D. Dimitrov, The George Washington University (983-03-687)

10:30AM (394) *Interpolation Theorems for Recursive Quantum Functions in Computable Analysis.*
Iraj Kalantari* and **Larry Welch**, Western Illinois University (983-03-125)

11:00AM (395) *More Undecidable Lattices of Steinitz Exchange Systems.*
Lisa R. Galminas*, Northwestern State University of LA, and **John W. Rosenthal**, Ithaca College (983-03-1295)

11:30AM (396) *Recursive content of higher order analysis.*
Anil Nerode, Cornell University (983-03-1233)

AMS Special Session on Operator Algebras, Quantization, and Noncommutative Geometry: A Centennial Celebration in Honor of J. V. Neumann and M. H. Stone, III

8:00 AM - 11:20 AM

Organizers: **Robert S. Doran**, Texas Christian University
Richard V. Kadison, University of Pennsylvania

8:00AM (397) *Betti numbers and rigidity results for cross-product von Neumann factors.*
Sorin Popa, UCLA (983-46-1499)

9:00AM (398) *Operator Spaces: Problems associated with the quantization of Banach space theory.* Preliminary report.
Edward G Effros, UCLA (983-46-1294)

9:30AM (399) *Algebraic structure and norm in operator algebras - extensions of some results of Stone and von Neumann.*
David P Blecher, University of Houston (983-46-881)

10:00AM (400) *Applications of Injective Envelopes.*
Vern I Paulsen, University of Houston (983-46-1361)

10:30AM (401) *On the Curvature of a Completely Positive Map.*
Paul S. Muhly*, University of Iowa, and **Baruch Solel**, Technion (983-46-953)

11:00AM (402) *The algebraization of dynamics: amenability, nuclearity, quasidiagonality, and approximate finite dimensionality.* Preliminary report.
Bruce Blackadar, University of Nevada, Reno (983-46-1250)

AMS Special Session on Special Functions and q-Series, III

8:00 AM - 11:55 AM

Organizer: **Mourad E. H. Ismail**, University of South Florida

8:00AM ► (403) *On the Distribution of the Zeros of an Entire Function of Exponential Type.* **Dimiter Dryanov*** and **Qazi Rahman**, University of Montreal (983-41-147)

8:30AM ► (404) *a-Gaussian Polynomials and Finite Rogers-Ramanujan Identities.* **George E. Andrews**, Penn State University (983-33-783)

9:00AM (405) *Computer Algebra and Rogers-Ramanujan Type Identities.* **Andrew V. Sills**, Pennsylvania State University (983-11-281)

9:30AM (406) *Contiguous relations for (r, s)-hypergeometric series.* **Michitomo Nishizawa**, Graduate Scool of Mathematical Sciences, University of Tokyo (983-33-293)

10:00AM (407) *Rapid Evaluation of Prolate Spheroidal Wave Functions at Special Points on the Interval.* **Xiao Hong***, Yale University, and **Vladimir Rokhlin**, Madmax Optics, Inc. (983-33-132)

10:30AM (408) *Asymptotic expansions for second-order linear difference equations with a turning point.* **Zhen Wang** and **Roderick Wong***, City University of Hong Kong (983-41-575)

11:00AM ► (409) *Roots and completeness of the third Jackson q-Bessel function.* **Joaquin Bustoz***, Arizona State University, and **Luis Daniel Abreu**, University of Coimbra (983-33-620)

11:30AM discussion

AMS Special Session on Inverse Problems and Sampling Theory in Signal Analysis, I

8:00 AM - 11:50 AM

Organizer: **M. Zuhair Nashed**, University of Central Florida

8:00AM (410) *Sampling with prolate spheroidal wave functions.* **Gilbert G Walter**, University of Wisconsin-Milwaukee (983-41-227)

8:30AM (411) *Recovering piecewise bandlimited signals via a hierarchical system based on prolate spheroidal wave functions.* Preliminary report. **Xiaoping Shen***, Ohio University, and **Naoki Saito**, University of California-Davis (983-42-131)

9:00AM (412) *Undersampling artifacts in parallel-beam tomography.* **Adel Faridani**, Oregon State University (983-44-276)

9:30AM (413) *A general scheme for constructing inversion algorithms for cone beam CT.* **Alexander Katsevich**, University of Central Florida (983-44-636)

10:00AM ► (414) *Nonlinear network tomography.* Preliminary report. **F. Alberto Grünbaum**, UC Berkeley (983-65-987)

10:30AM (415) *Regularization of Satellite Data by Means of Wavelets.* **Willi Freeden**, University of Kaiserslautern, Geomathematics Group (983-45-821)

11:00AM (416) *A Wavelet Approach to the Inverse Problem of Geomagnetic Crustal Field Determination.* **Thorsten Maier**, University of Kaiserslautern (983-45-823)

11:30AM (417) *Regularization Techniques by Vectorial Wavelets with Applications to Pre-Maxwell Problems.* **Carsten Mayer**, University of Kaiserslautern (983-45-825)

MAA Minicourse #4: Part A

8:00 AM - 10:00 AM

Visual linear algebra.

Organizers: **Eugene A. Herman**, Grinnell College
Michael D. Pepe, Seattle Central Community College
Eric P. Schulz, Walla Walla Community College

SIAM Minisymposium on Mathematical Problems in Image Analysis

8:00 AM - 11:55 AM

Organizer: **John Goutsias**, Johns Hopkins University

8:00AM (418) *Computational Modeling.* **Donald Geman**, The Johns Hopkins University (983-68-1021)

8:45AM (419) *Inference for Range Images.* Preliminary report. **Ulf Grenander**, Brown University (983-60-896)

9:30AM (420) *Minimazing Flows for Surface Warping, Registration, and Interpolation.* **Allen Tannenbaum**, Georgia Institute of Technology (983-68-725)

10:15AM Break.

10:30AM (421) *Building Riemannian metrics between objects.* **Alain Trouvé**, University Paris 13 (983-49-1047)

11:15AM (422) *Recent Advances in Statistical Shape Estimation.* **Jong C. Ye, Natalia A. Schmid, Yoram Bresler** and **Pierre Moulin***, University of Illinois at Urbana-Champaign (983-68-1307)

SIAM Minisymposium on Dynamical Systems

8:00 AM - 12:05 PM

Organizer: **Yury Grabovsky**, Temple University

8:00AM (423) *Extrapolating experimental measurements of the complex dielectric constant.* **Graeme Walter Milton**, University of Utah (983-78-869)

8:50AM ► (424) *Kramers-Kronig Analysis, Analytic Continuation, and Singular-Value Expansions.* **Andrew M. Dienstfrey***, National Institute of Standards and Technology, and **Leslie Greengard**, New York University (983-78-1005)

9:40AM (425) *Reconstruction of the spectral representation of effective properties of a random mixture.* **Elena Cherkaev**, University of Utah (983-49-1279)

10:30AM ► (426) *Reconstruction of complex electromagnetic permittivity function from limited band measurments.* Preliminary report. **John Shopple***, University of California at San Diego, and **Yury Grabovsky**, Temple University (983-78-980)

11:20AM (427) *The spectral function of composites from reflectivity measurements.*
A R Day*, John Carroll University, **A R Grant**, Cornell University, **M F Thorpe**, Michigan State University, and **A J Sievers**, Cornell University (983-78-1112)

MAA Session on Incorporating History of Mathematics in the Mathematics Classroom, I

8:00 AM - 11:55 AM

Organizers: **Victor J. Katz**, University of the District of Columbia
Edith Prentice Mendez, Sonoma State University
Eisso J. Atzema, University of Maine

8:00AM ► (428) *Incorporating Student Research Projects on History of Mathematics into the Mathematics Curriculum.*
Annie Yi Han, BMCC-CUNY (983-G1-625)

8:20AM ► (429) *Every Student is a Potential Teacher.* Preliminary report.
Joanne Peeples, El Paso Community College (983-G1-539)

8:35AM ► (430) *On the Shoulders of Giants: Using Annotated Timelines and Biographical Scrapbook Projects in the Mathematics Classroom.*
Lynn Foshee Reed, Maggie L. Walker Governor's School (983-G1-475)

8:55AM ► (431) *Top Ten-Plus a Few: Favorite Lessons for Incorporating History of Mathematics in the Secondary Classroom.*
Elizabeth C. Rogers, Piedmont College (983-G1-428)

9:10AM ► (432) *A mathematics course for in-service teachers using materials from the MAA's Historical Module Project.*
Florence D. Fasanelli, Amer. Assoc. for the Advancement of Science (983-G1-961)

9:30AM ► (433) *Two Approaches to a History of Mathematics Course for Future Mathematics Teachers.*
Vilma Mesa*, University of Michigan, and **Patricia Wilson**, University of Georgia (983-G1-458)

9:55AM ► (434) *Course Activities to Prepare Teachers to Employ History.*
Dick Jardine, Keene State College (983-G1-176)

10:15AM ► (435) *Comparison of Classification and Solution of Cubic Equations: Al-Khayyam and Cardano :.* Preliminary report.
Bill R. Austin, University of Tennessee at Martin (983-G1-343)

10:35AM ► (436) *A liberal arts mathematics history course co-taught by future secondary teachers.*
Janet L. Beery, University of Redlands (983-G1-398)

10:55AM ► (437) *History of Mathematics for the Liberal Arts Student.*
Jane Ann Brandsma, Greensboro College (983-G1-195)

11:10AM ► (438) *Integrating the Mathematics of North American First Peoples Into the Undergraduate Curriculum.*
Charles P. Funkhouser* and **Harriet Edwards**, California State University, Fullerton (983-G1-305)

11:30AM (439) *Incorporating History in the World of Mathematics.*
Sakura S Therrien, United States Military Academy (983-G1-480)

11:45AM ► (440) *The Cosmos Corner: Utilizing Play Writing to Investigate the History of Mathematics.* Preliminary report.
Michael J. Bossé, Indiana University of Pennsylvania (983-G1-135)

MAA Session on Helping Students Give Effective Mathematics Presentations

8:00 AM - 10:50 AM

Organizers: **Suzanne Doree**, Augsburg College
Thomas Linton, Central College

8:00AM Welcome and introduction to session

8:10AM ► (441) *The Mathematical Modeling Colloquium at the University of Wisconsin-Stout.*
Steven M Deckelman, University of Wisconsin-Stout (983-H1-245)

8:25AM ► (442) *Speaking of Mathematics: Senior Comprehensive Project Presentations.*
Mary K. Porter, St. Mary's College (983-H1-519)

8:40AM ► (443) *Oral Communication of Mathematics by Students at West Virginia Wesleyan Collge.*
Michael L. Berry, West Virginia Wesleyan College (983-H1-181)

8:55AM ► (444) *Assisting Students with Composing and Evaluating Oral Presentations.* Preliminary report.
Pam Crawford, Jacksonville University (983-H1-355)

9:10AM ► (445) *Technology in student presentations.*
Nicholas A Coult, Augsburg College (983-H1-522)

9:25AM ► (446) *Improve Student Presentations Using Analytic Rubrics.*
Catherine M. Miller, University of Northern Iowa (983-H1-353)

9:40AM ► (447) *Student Presentations and Assessment.* Preliminary report.
Vincent Ferlini and **Dick Jardine***, Keene State College (983-H1-438)

9:55AM (448) *Coaching Students for Mathematics Presentations.*
Nancy Lineken Hagelgans, Ursinus College (983-H1-399)

10:10AM ► (449) *The 1-1-1-1 Presentation Preparation Procedure.*
Donald E Hooley, Bluffton College (983-H1-193)

10:25AM (450) *Sweet Fruits of Success in Preparing Student Talks.*
Therese Shelton* and **Cameron Sawyer**, Southwestern University (983-H1-513)

10:40AM (451) *Evaluating student mathematics presentations.* Preliminary report.
D. S. Franzblau, CUNY, College of Staten Island (983-H1-1222)

MAA Session on Mathematics Experiences in Business, Industry, and Government

8:00 AM - 10:55 AM

Organizer: **Philip E. Gustafson**, Mesa State College

8:05AM ► (452) *Mathematical Modeling of Food Systems for Long Term Space Missions.* Preliminary report.
John E. Cruthirds, North Georgia College & state University (983-I1-493)

8:30AM (453) *The Mathematics of Detecting, Tracking & Pre-empting Terrorist Operations.*
Thomas L. Mifflin, Metron, Inc. (983-I1-679)

8:55AM ► (454) *Picture perfect perfect picture.*
Peter Stanek, Lockheed Martin (983-I1-925)

9:20AM ► (455) *Graph Theory Problems of System Engineering.* Preliminary report.
R. Peter DeLong, Raytheon (983-I1-647)

9:45AM ► (456) *Solving $A\mathbf{x} = \mathbf{b}$: a BIG research area.*
Timothy P. Chartier, University of Washington (983-I1-677)

10:10AM ► (457) *Who really uses calculus?* Preliminary report.
Edwin P Herman, University of Wisconsin, Stevens Point (983-I1-255)

10:35AM ► (458) *Portfolio Design and the Genetic Algorithm.* Preliminary report.
Harry H. Suber, TrendLogic Associates, and **Robert M. Tardiff***, Salisbury University (983-I1-460)

MAA General Contributed Paper Session, III

8:00 AM - 11:55 AM

Organizers: **Michael A. Jones**, Montclair State University
Steven M. Hetzler, Salisbury University
Shawnee L. McMurran, California State University at San Bernardino

8:00AM (459) *Combining Modeling and Calculus in a Course for Business Majors.* Preliminary report.
Stephen Hilbert, Ithaca College (983-Z1-685)

8:15AM (460) *Differential Equations Lite (Less Filling and Tastes Great!).*
Scott Charles Gensler, United States Military Academy (983-Z1-435)

8:30AM ► (461) *An Applied Approach to Upper Level Undergraduate Mathematics: Incorporating Applications in the Curriculum.* Preliminary report.
Michelle R. DeDeo, Univ. of North Florida (983-Z1-564)

8:45AM ► (462) *Motivating Problem Solving With Problem Posing.*
Kevin Peterson, Lynchburg College (983-Z1-1230)

9:00AM ► (463) *A new twist on a proofs course.*
Michael Jones, Dept. of Mathematical Sciences/Montclair State University, and **Arup Mukherjee***, Dept. of Mathematical Sciences/ Montclair State University (983-Z1-609)

9:15AM ► (464) *Some Integration Trials on Computer Algebra Systems.* Preliminary report.
Kevin E. Charlwood, Washburn University (983-Z1-161)

9:30AM ► (465) *Hill's Substitution Ciphers using Mathematica.* Preliminary report.
Heakyung Lee, Winthrop University (983-Z1-534)

9:45AM ► (466) *The Vigenere Cipher with the TI-83.* Preliminary report.
Bill Yankosky* and **Michael Hamilton**, North Carolina Wesleyan College (983-Z1-671)

10:00AM ► (467) *Visualization of Calculus.* Preliminary report.
Ping Wang* and **Mike R Gallis**, Penn State University (983-Z1-22)

10:15AM ► (468) *Visualizing the Construction of Hyperbolic Surfaces and Three-Manifolds Using a CAS.*
Timothy D Comar, Benedictine University (983-Z1-277)

10:30AM ► (469) *Dynamic Geometry in College Mathematics Classes.*
Mary Ann Connors, Westfield State College (983-Z1-1052)

10:45AM ► (470) *The impact of problem-based learning in the teaching of geometry on future elementary school teachers.*
Gian Mario Besana, DePaul University, **Michael Fries**, DePaul, and **Vesna Kilibarda***, Indiana University Northwest (983-Z1-843)

11:00AM ► (471) *Helping Pre-service and Inservice Elementary School Teachers Gain a Deeper Understanding of Geometry.* Preliminary report.
Brenda Strassfeld, New York University (983-Z1-183)

11:15AM ► (472) *A Common Question Yields an Answer in Content: Finding the NCTM Content Standards in Undergraduate Mathematics.*
Eileen Fernandez* and **Michael A. Jones**, Montclair State University (983-Z1-890)

11:30AM ► (473) *Topics Classes in Mathematics for Secondary Teachers.* Preliminary report.
Brigitte Lahme* and **Jerry G Morris**, Sonoma State University (983-Z1-806)

11:45AM ► (474) *Forgotten, but Relevant, Studies in Mathematics Education.* Preliminary report.
David E. Boliver, Univ. of Central Oklahoma (983-Z1-404)

AMS Session on Applications of Mathematics, I

8:15 AM - 11:55 AM

8:15AM (475) *Blending Instantaneous and Continuous Phenomena in Feynman's Operational Calculus: An Introduction.*
G. W. Johnson, University of Nebraska at Lincoln, and **Lance Nielsen***, Creighton University (983-46-746)

8:30AM (476) *Ground Penetrating Radar Imaging Using Wavelet Method.*
Fengshan Liu, **Yi Ling***, Delaware State University, **Xianggen Xia**, University of Delaware, and **Xiquan Shi**, Delaware State University (983-45-880)

8:45AM (477) *Decomposition-based Algorithms for Large-scale Discrete Optimization.* Preliminary report.
Matthew V Galati* and **Ted K Ralphs**, Lehigh University (983-90-654)

9:00AM ► (478) *Generalized Spectral Analysis of Large Sets of Voting Data.* Preliminary report.
David Thomas Uminsky* and **Michael Orrison**, Harvey Mudd College (983-20-1472)

9:15AM (479) *Complex behavior in a model of human language.*
W Garrett Mitchener, Princeton University (983-92-1067)

9:30AM ► (480) *A Population Model of Prion Dynamics.* Preliminary report.
Meredith L. Greer, Bates College (983-92-1345)

9:45AM (481) *Extending the (Hexa-)Rhombic Dodecahedral Model of the Genetic Code: the Code's Four 6-fold Degeneracies and the Ten Orthogonal Projections of the 5-cube as 3-cube.* Preliminary report.
David James Halitsky, Computer Systems Technology (983-92-151)

10:00AM ► (482) *An Intelligent Agent Model for Human-Environment Interactions.*
Catherine A Roberts, College of the Holy Cross (983-92-111)

10:15AM ► (483) *Optimal Harvesting Strategy for the Control of a Protected Population.*
Rene' A. Salinas, University of Tennessee (983-92-1392)

10:30AM ► (484) *Numerical results of optimal control applied to an integro-difference model with applications to biology.*
Holly Gaff*, **Hem Raj Joshi**, **Suzanne Lenhart** and **Louis Gross**, University of Tennessee (983-92-828)

10:45AM ► (485) *Estimation of Hodgkin-Huxley Model Parameters Using Current-Clamp Data.* Preliminary report.
Allan R Willms*, University of Canterbury, and **Daniel Myall**, University of Otago (983-92-934)

11:00AM ► (486) *Subset Take-away on Graphs.* Preliminary report.
Robert M Riehemann, University of Kentucky (983-91-1474)

11:15AM ► (487) *Optimal Voting Strategies for "The Weakest Link".* Preliminary report.
Amy D Winter, Cornell College (983-91-1186)

11:30AM (488) *Pareto Optimality with Coherent Measures of Risk.*
David C. Heath*, Carnegie Mellon University, and **Hyejin Ku**, UNC Charlotte (983-90-70)

11:45AM ► (489) *The Consistency of Two Markets.*
David Heath, Carnegie Mellon University, and **Hyejin Ku***, The Univ. of North Carolina, Charlotte (983-28-80)

AMS Session on Operator Theory

8:15 AM – 11:55 AM

8:15AM (490) *Best projections of Gabor multiplier type.* Preliminary report.
Krzysztof Nowak, Drexel University (983-42-1465)

8:30AM (491) *Orthogonal Wavelets in Higher Dimensions.*
Denise A Jacobs, United States Military Academy (983-42-1432)

8:45AM ► (492) *Embeddings of Fourier-Lebesgue Spaces into Modulation Spaces: Optimality of Sufficient Conditions.*
Yevgeniy V. Galperin, Sacred Heart University (983-42-1419)

9:00AM (493) *Littlewood-Paley theory associated with Schrödinger operators with hyperbolic secant potentials.*
Shijun Zheng, University of Maryland (983-42-1335)

9:15AM (494) *The Caldero'n reproducing formula and rough singular integrals.*
Dmitry Ryabogin, The University of Missouri, Columbia (983-42-1075)

9:30AM (495) *Spline interpolation in integral geometry.*
Isaac Pesenson, Temple University (983-41-1058)

9:45AM (496) *Approximation by countably hypercyclic operators.*
T Gabriel Prajitura, SUNY Brockport (983-47-126)

10:00AM (497) *On the norm of a composition operator with linear fractional symbol.*
Christopher Hammond, University of Virginia (983-47-122)

10:15AM (498) *Wavelets and Bellman Functions.* Preliminary report.
Janine Wittwer, Williams College (983-47-121)

10:30AM (499) *Frequency estimation and vortex analysis using wavelet coefficients.* Preliminary report.
Joel K Glenn, Colorado College (983-43-110)

10:45AM (500) *On joint perturbations of Gabor frames.*
Joseph D Lakey, New Mexico State University, and **Ying Wang***, Marywood University (983-43-774)

11:00AM (501) *Lorentz Composition Operators on Weighted Bergman Spaces.*
Raimundo M Kovac, Rhode Island College (983-47-1196)

11:15AM (502) *A Characterization Theorem for AF Groupoids and Some Related Results.* Preliminary report.
Ryan J. Zerr, Iowa State University (983-47-1174)

11:30AM (503) *On Fourier and Wavelet Transforms of Tempered Distributions.*
George K. Yang, Tennessee State University (983-42-926)

11:45AM (504) *Bellman function and dimension free estimates of Riesz transforms.* Preliminary report.
Oliver Dragicevic* and **Alexander L. Volberg**, Michigan State University (983-42-1219)

AMS-MAA-MER Special Session on Mathematics and Education Reform, III

8:30 AM – 11:50 AM

Organizers: **Naomi Fisher**, University of Illinois at Chicago
William H. Barker, Bowdoin College
Jerry L. Bona, University of Illinois at Chicago
Kenneth C. Millett, University of California Santa Barbara

8:30AM ► (505) *Introduction and Background for "Undergraduate Programs and Courses in the Mathematical Sciences: A CUPM Curriculum Guide".* Preliminary report.
Harriet S. Pollatsek, Mount Holyoke College (983-97-1151)

9:00AM ► (506) *Panel on Undergraduate Programs and Courses in the Mathematical Sciences: A CUPM Curriculum Guide.* Preliminary report.
Harriet S. Pollatsek*, Mount Holyoke College, **Susanna Epp***, DePaul University, **Susan Ganter***, Clemson University, and **William Haver***, Virginia Commonwealth University (983-97-966)

10:30AM ► (507) *Mathematical Thinking and the CUPM Curriculum Guide.*
Susanna S. Epp, DePaul University (983-97-1128)

11:00AM (508) *Undergraduate Issues for research universities.* Preliminary report.
David M. Bressoud, Macalester College (983-97-728)

11:30AM ► (509) *The CUPM Curriculum Foundations Project: Looking at the first two years.*
Susan L. Ganter, Clemson University (983-97-770)

AMS Special Session on Advances in Spherical Designs and Codes, III

8:30 AM – 11:55 AM

Organizers: **Béla Bajnok**, Gettysburg College
Neil J. A. Sloane, AT&T Shannon Labs

8:00AM Discussion.

8:30AM ► (510) *Spherical codes: bounds and constructions.*
Thomas Ericson, Linköping University, Sweden (983-51-946)

9:30AM (511) *On s-distance sets on p concentric spheres in Euclidean space.*
Etsuko Bannai, Graduate School of Mathematics, Kyushu University, Fukuoka, Japan (983-05-707)

10:00AM (512) *Minimal Riesz Energy Points on d-Manifolds.* Preliminary report.
D. Hardin and **E. B. Saff***, Vanderbilt University (983-52-1309)

10:30AM ► (513) *Almost orthogonal vectors.* Preliminary report.
William J. Martin, Worcester Polytechnic Institute (983-51-1397)

11:00AM ► (514) *Packings of directions with minimal variance of projection.*
Jiří Janáček, Institute of Physiology ASCR, Prague, Czech Republic (983-51-948)

11:30AM (515) *Encoding plane triangulations and fullerenes.*
Jack E Graver, Syracuse University (983-05-619)

AMS Special Session on Discrete Models, III

8:30 AM – 11:55 AM

Organizers: **Cris Moore**, University of New Mexico and Santa Fe Institute
Dana Randall, Georgia Institute of Technology

8:30AM ► (516) *Algorithms for Estimating Trends in a Stream of Network Packets Using Little Memory.*
Erik D. Demaine*, Massachusetts Instiute of Technology, **Alejandro Lopez-Ortiz** and **J. Ian Munro**, University of Waterloo (983-68-850)

9:00AM (517) *Communication complexity and regular languages.*
Denis Therien, McGill (983-68-650)

9:30AM (518) *Muirhead-Rado Inequality for Hermitian Operators.*
Leonard J Schulman, Caltech (983-05-1411)

10:00AM Break

10:30AM (519) *Rapidly Mixing Markov Chains for Sampling Contingency Tables with a Constant Number of Rows.* Preliminary report.
Mary Cryan, **Martin Dyer**, University of Leeds, **Leslie Ann Goldberg**, University of Warwick, **Mark Jerrum**, University of Edinburgh, and **Russell Martin***, University of Warwick (983-68-1177)

11:00AM (520) *Probabilistic Packet Marking for Distributed Denial of Service Attacks.*
Micah Adler, University of Massachusetts, Amherst (983-94-1425)

11:30AM (521) *The Number of Bit Comparisons Used by Quicksort.* Preliminary report.
James Allen Fill*, The Johns Hopkins University, and **Svante Janson**, Uppsala University (983-68-1002)

AMS Session on Group Theory

8:30 AM – 11:55 AM

8:30AM (522) *The Nonabelian Tensor Square of 2-Engel Groups.*
Russell D. Blyth, Saint Louis University, **Robert Fitzgerald Morse**, University of Evansville, and **Joanne L. Redden***, Illinois College (983-20-1321)

8:45AM (523) *Thompson's Group & Amenability.*
John R Donnelly, SUNY Binghamton (983-20-1201)

9:00AM (524) *Covering and Avoidance in a Direct Product.*
Joseph Petrillo, SUNY Binghamton (983-20-1179)

9:15AM (525) *Modular representations of the supergroup $GL(m|n)$ and a new proof of the Mullineux conjecture.*
Jonathan R. Kujawa, University of Oregon (983-20-1029)

9:30AM (526) *Homological Functors of p-Groups of Class 2.*
Michael R Bacon*, USC Sumter, and **Luise-Charlotte Kappe**, SUNY Binghamton (983-20-836)

9:45AM (527) *Capable p-groups of nilpotency class 2.*
Luise-Charlotte Kappe*, SUNY Binghamton, and **Michael R Bacon**, USC Sumter (983-20-837)

10:00AM (528) *Restricting modular spin representations of symmetric and alternating groups to Young-type subgroups.*
Aaron M Phillips, University of Oregon (983-20-699)

10:15AM (529) *Sylow Theory for Association Schemes and Table Algebras.*
Paul-Hermann Martin Zieschang, University of Texas at Brownsville (983-20-381)

10:30AM (530) *An elementary approach to the Monster.*
Christopher S Simons, Rowan University (983-20-282)

10:45AM (531) *Recent advances in c-compact groups.*
Gábor Lukács, York University (983-22-641)

11:00AM (532) *Central Sets in Adequate Partial Semigroups.* Preliminary report.
Jillian E McLeod, Mount Holyoke College (983-22-1257)

11:15AM ► (533) *Wave graph bases of tensor invariants of $SO(2n+1)$ and G_2.* Preliminary report.
Alec Mihailovs, Shepherd College (983-22-1116)

11:30AM (534) *Protopological Groups and Normal Systems.*
Julie C Jones, Sam Houston State University (983-22-310)

11:45AM (535) *Topologically pure injectives in the category of LCA groups.* Preliminary report.
Peter Loth, Sacred Heart University (983-22-230)

MAA Session on Applications of Abstract Algebra

8:30 AM – 11:25 AM

Organizers: **Robert E. Lewand**, Goucher College
George Mackiw, Loyola College

8:30AM ► (536) *Finite Elliptic Curve Groups and Public Key Cryptography.*
John H Wilson, Centre College (983-J1-397)

8:50AM ► (537) *Applying abstract algebra to molecular spectroscopy: a classroom project.*
Janet L. Beery*, University of Redlands, and **Jodye I. Selco**, California State Polytechnic University, Pomona (983-J1-503)

9:10AM ► (538) *Adding Error Correcting Capabilities to the Mod 11 ISBN Scheme.*
George Mackiw*, Loyola College in Maryland, and **Aileen Cuddy**, Baltimore, MD (983-J1-222)

9:30AM ► (539) *Using Groups to Generate Automata.* Preliminary report.
Michael J Bardzell* and **Kathleen M Shannon**, Salisbury University (983-J1-216)

9:50AM ► (540) *Counting Contra Dances: A Kinesthetic Application of Group Theory.*
Larry Copes, Institute for Studies in Educational Mathematics (ISEM) (983-J1-347)

10:10AM ► (541) *Using Maple to Illustrate Abstract Algebra Applications.*
Neil P Sigmon, Radford University (983-J1-524)

10:30AM ► (542) *Group Rings and Diagrams in Undergraduate Abstract Algebra.*
Deborah Sherman Denvir, Marshall University (983-J1-473)

10:50AM ► (543) *Primitive Shift Registers.*
Jo Ann Fellin, OSB, Benedictine College (983-J1-32)

11:10AM ► (544) *The Algebra of Spacetime.* Preliminary report.
Alfonso F Agnew, California State University at Fullerton (983-J1-486)

MAA Project NExT Panel Discussion

8:30 AM – 10:00 AM

Writing and publishing expository articles about mathematics.

Organizers: **T. Christine Stevens**, St. Louis University
Joseph A. Gallian, University of Minnesota, Duluth
Aparna W. Higgins, University of Dayton

Panelists: **Edward G. Dunne**, AMS
Deanna B. Haunsperger, Carleton College
Martha J. Siegel, Towson University
Francis E. Su, Harvey Mudd College

AWM Emmy Noether Lecture

9:00 AM - 9:50 AM

(545) *Five little crystals and how they grew.*
Jean E. Taylor, Rutgers University

AMS-SIAM Special Session on Dynamical Systems and Oceanography, III

9:00 AM - 11:25 AM

Organizers: **Reza Malek-Madani**, U.S. Naval Academy
Peter A. McCoy, U.S. Naval Academy

9:00AM (546) *Dynamical Systems Theory and Lagrangian Transport: New Tools for the Analysis of Flow Fields Derived From Data and Models.*
Stephen Wiggins, University of Bristol (983-37-1203)

9:30AM (547) *Periodic orbits and disturbance growth in geophysical fluid flows.*
R M Samelson, COAS, Oregon State University (983-76-895)

10:00AM (548) *Proper Orthogonal Decomposition: A New Look and Applications to Oceanography.* Preliminary report.
Igor Mezic, University of California, Santa Barbara (983-37-778)

10:30AM ► (549) *Scale Dependent Dispersion and Geometry in Barotropic Turbulence.* Preliminary report.
Andrew C Poje, College of Staten Island, CUNY (983-76-1185)

11:00AM ► (550) *Numerical computation of invariant manifolds of distinguished hyperbolic trajectories of a quasigeostrophic ocean model.*
Ana Maria Mancho*, **Des Small**, **Steve Wiggins**, University of Bristol, and **Kayo Ide**, Department of Atmospheric Sciences and Institute of Geophysics and Planetary Physics, UCLA (983-37-1346)

MAA Minicourse #10: Part A

9:00 AM - 11:00 AM

Turning a nonscience or developmental course into a capstone mathematical experience.

Organizers: **James T. Sandefur**, Georgetown University
Rosalie A. Dance, University of the Virgin Islands

MAA Minicourse #15: Part A

9:00 AM - 11:00 AM

Real fun exploring basic mathematics.

Organizers: **Shawnee L. McMurran**, California State University San Bernardino
Robert G. Stein, California State University San Bernardino

AMS Session on Difference Equations

9:00 AM - 11:55 AM

9:00AM ► (551) *A Characterization for the Length of Cycles of the N - Number Ducci Game.*
Diana M Thomas*, **John G Stevens**, Montclair State University, and **Neil Calkin**, Clemson University (983-39-285)

9:15AM (552) *Instability of Difference Equations.* Preliminary report.
Zhivko S. Athanassov, Institute of Mathematics, Bulgarian Academy of Sciencies (983-39-973)

9:30AM (553) *Stability, Oscillations and Chaos in a Discrete Time Model of Combat.*
H Sedaghat, Virginia Commonwealth University (983-39-254)

9:45AM (554) *Optimal Harvesting in an Integro-difference population model.*
Hem Raj Joshi* and **Suzanne Lenhart**, University of Tennessee (983-39-139)

10:00AM ► (555) *Some results and open problems for the difference equation* $x_n = p + \frac{x_{n-l}}{x_{n-k}}$.
Richard DeVault, Northwestern State University of Louisiana (983-39-127)

10:15AM ► (556) *Unbounded Solutions of a Max-Type Difference Equation.*
Michael A Radin*, Rochester Institute of Technology, and **Candace M Kent**, Virginia Commonwealth University (983-39-102)

10:30AM ► (557) *On Difference Equation* $x_{n+1} = \frac{1}{Ax_n^p + x_{n-1}^q}$.
V. L. Kocic, Xavier University of Louisiana (983-39-1170)

10:45AM ► (558) *An Update on the Difference Equation* $x_{n+1} = \begin{cases} \frac{x_n + x_{n-1}}{3}, & tabif\ 3 | x_n + x_{n-1} \\ x_n + x_{n-1}, & otherwise \end{cases}$.
Preliminary report.
Jeffrey J Feuer*, **Stephen Bismarck**, Coastal Carolina University, and **Carrie Messer**, Charleston, SC (983-39-336)

11:00AM Break.

11:15AM ► (559) *Oscillation of First-Order Neutral Difference Equations with Maxima.* Preliminary report.
Nader Kouhestani, **Dimitar Mishev***, Prairie View A&M University, **William Patula** and **Hristo Voulov**, Southern Illinois University Carbondale (983-39-29)

11:30AM (560) *Asymptotic analysis by the saddle point method of a data-handling system with many sources.*
Diego E Dominici, University of Illinois at Chicago (983-41-855)

11:45AM ► (561) *Bell Summability.* Preliminary report.
Gerald M. Higdon, Fitchburg State College (983-40-1209)

MAA Committee on Mathematics and the Environment Panel Discussion

9:00 AM - 10:20 AM

Sample mathematics lessons integrating environmental issues.

Organizer: **Patricia Clark Kenschaft**, Montclair State University

Panelists: **Greg A. Langkamp**, Seattle Central Community College
Martin E. Walter, University of Colorado at Boulder

Nancy E. Zumoff, Kennesaw State University

MAA Panel Discussion

9:00 AM – 10:20 AM

NSF funding opportunities for learning and teaching in the mathematical sciences.

Organizers: **Elizabeth J. Teles**, National Science Foundation
Lee L. Zia, National Science Foundation
James H. Lightbourne, National Science Foundation

MAA Committee on the Undergraduate Program in Mathematics Panel Discussion

9:00 AM – 10:20 AM

Undergraduate Programs and Courses in the Mathematical Sciences: A CUPM Curriculum Guide.

Organizers: **Harriet S. Pollatsek**, Mount Holyoke College
Susanna S. Epp, DePaul University
Panelists: **Susan L. Ganter**, Clemson University
William E. Haver, Virginia Commonwealth University
Harriet S. Pollatsek
Susan L. Ganter

MAA Committee on the Undergraduate Program in Mathematics Poster Session

9:00 AM – 11:00 AM

First college-level mathematics courses.

Organizers: **Donald B. Small**, U. S. Military Academy
Sara Bush, Wiley College
Dorothy Hunter, Huston-Tillotson College

Exhibits and Book Sales

9:30 AM – 5:30 PM

Math on the Web, II

10:00 AM – 4:05 PM

10:00AM (562) *MathML, OpenMath, and Web services.*
David Carlisle, The Numerical Algorithms Group Ltd.

11:15AM (563) *Creating mathematical documents for the Web with* Scientific Workplace.
Barry MacKichan, MacKichan, Inc.

12:15PM (564) *TeX to Web conversion.*
Stan Devitt, Stratum Technical Services Ltd.

1:00PM (565) *MathML in the digital library of mathematical functions.*
Bruce Miller, NIST

2:00PM (566) Maple *on the Web: New technologies, products, and applications.*
Tom Lee, Waterloo Maple

3:00PM (567) *Creating interactive Web pages with MathML.*
Robert Miner, Design Science

3:45PM (568) *Displaying MathML in browsers.*
Bob Mathews, Design Science

AMS Special Presentation

10:00 AM – 11:00 AM

Who wants to be a mathematician?

Organizers: **Michael A. Breen**, AMS
Annette W. Emerson, AMS
William T. Butterworth, Barat College

MAA Invited Address

10:05 AM – 10:55 AM

(569) *Some Mathematical Insights Related to Automobile Drag Racing.*
Richard A. Tapia, Rice University (983-A0-680)

MAA Minicourse #5: Part A

10:15 AM – 12:15 PM

Using and adapting online materials.

Organizers: **David A. Smith**, Duke University
Lang Moore, Duke University
Douglas E. Ensley, Shippensburg University
Franklin A. Wattenberg, U.S. Military Academy

MAA Project NExT-Young Mathematicians Network Panel Discussion

10:45 AM – 12:05 PM

Keeping the platters spinning: Effective time management.

Organizers: **Karrolyne Fogel**, California Lutheran University
J. Lyn Miller, Slippery Rock University
Panelists: **Raymond L. Johnson**, University of Maryland
Cynthia J. Woodburn, Pittsburg State University
William E. Fenton, Bellarmine College

MAA Panel Discussion

10:45 AM – 12:05 PM

How can placement testing be improved?

Organizers: **Susan L. Forman**, Bronx Community College
Bernard L. Madison, University of Arkansas
Panelists: **Judy E. Ackerman**, Montgomery College
Judy Marwick, Morton College
Johnny W. Lott, University of Montana
Susan L. Forman
Bernard L. Madison

MAA Committee on the Mathematical Education of Teachers Panel Discussion

10:45 AM - 12:05 PM

The nature of mathematics knowledge and knowledge of mathematics learning needed by secondary school mathematics teachers in an era of technology.

Organizer: **M. Kathleen Heid**, The Pennsylvania State University

Panelists: **Karen J. Graham**, University of New Hampshire
Walter I. Seaman, University of Iowa
Richard J. Stanley, University of California Berkeley
Zalman P. Usiskin, University of Chicago
Skip Wilson, Virginia Polytechnic Institute and State University
James T. Fey, University of Maryland
M. Kathleen Heid

SIAM Invited Address

11:10 AM - NOON

(570) *Numerical approximations for optimization and control of dynamical systems.*
John A. Burns, Virginia Polytechnic Institute and State University

AMS Colloquium Lectures:Lecture II

1:00 PM - 1:50 PM

(571) *Spectra of hyperbolic surfaces and applications, II.*
Peter Sarnak, Courant Institute and Princeton University

AMS-MAA-MER Special Session on Mathematics and Education Reform, IV

1:00 PM - 3:30 PM

Organizers: **Naomi Fisher**, University of Illinois at Chicago
William H. Barker, Bowdoin College
Jerry L. Bona, University of Illinois at Chicago
Kenneth C. Millett, University of California Santa Barbara

1:00PM ► (572) *Forum on Strategies for Increasing the Diversity of Students in Mathematics.*
Naomi Fisher*, University of Illinois at Chicago, **Dennis Davenport***, Miami University, **Raymond Johnson***, University of Maryland, College Park, **Roosevelt Johnson***, National Science Foundation, **Robert Megginson***, Mathematical Sciences Research Institute, **Teri Murphy***, University of Oklahoma, and **Ami Radunskaya***, Pomona College (983-97-768)

2:30PM Questions and answers, and discussion.

AMS-SIAM Special Session on Dynamical Systems and Oceanography, IV

1:00 PM - 3:25 PM

Organizers: **Reza Malek-Madani**, U.S. Naval Academy
Peter A. McCoy, U.S. Naval Academy

1:00PM ► (573) *A new dynamical systems theory for boundary layer separations of 2D incompressible flows and its applications to Gulf stream separations.*
Shouhong Wang, Indiana University (983-86-1062)

1:30PM (574) *Renormalization, Singular Perturbation and Applications to Geophysical Fluid Dynamics.*
Djoko Wirosoetisno, Indiana University (983-41-1380)

2:00PM (575) *Systematic Strategies for Stochastic Mode Reduction in Climate.*
Andrew J. Majda, **Ilya Timofeyev** and **Eric Vanden-Eijnden***, Courant Institute (983-60-1462)

2:30PM (576) *An Evolution Operator Approach to Stochastic Transport.*
Erik M Bollt*, Clarkson University, **Ira Schwartz**, US Naval Laboratory, and **Lora Billings**, Montclair State University (983-37-1023)

3:00PM (577) *A direct data assimilation method for Lagrangian observations in meteorology and oceanography.*
Kayo Ide, University of California, Los Angeles (983-86-1383)

AMS Special Session on Advances in Spherical Designs and Codes, IV

1:00 PM - 3:55 PM

Organizers: **Béla Bajnok**, Gettysburg College
Neil J. A. Sloane, AT&T Shannon Labs

1:00PM (578) *Covers of complete graphs and equi-isoclinic subspaces.*
Chris D. Godsil, University of Waterloo (983-05-998)

2:00PM (579) *Grassmannian Designs.*
Christine Bachoc, Universite de Bordeaux (983-05-695)

2:30PM ► (580) *Algorithms for distributing points on a sphere and plane.*
Chjan C Lim*, Math Sciences, RPI, **S M Assad**, National U. of Singapore, and **Joseph Nebus**, RPI (983-94-888)

3:00PM (581) *A Note on Group Codes and their Links with Association Schemes.*
Michele Elia, Politecnico di Torino, Torino, Italy (983-05-664)

3:30PM ► (582) *On the number of linear independent binary vectors with applications to the construction of linear codes and orthogonal arrays.*
Steven B Damelin*, **Greg Michalski**, Georgia Southern University, **Gary Mullen**, Penn State University, and **David Stone**, Georgia Southern University (983-15-165)

AMS Special Session on Highlights of Recent Workshops Held by the Board on Mathematical Sciences and their Applications

1:00 PM - 4:10 PM

Organizers: **David Eisenbud**, Mathematical Sciences Research Institute
Scott T. Weidman, National Research Council

1:00PM ► (583) *Opportunities and Challenges from Systems Biology.*
Douglas A. Lauffenburger, MIT (983-92-1498)

2:00PM ► (584) *Finding the Needle in the Haystack: Knowledge Representation and Inference For Multisource Fusion.*
Kathryn Blackmond Laskey, George Mason University (983-62-1497)

3:00PM (585) *Mathematics and the Internet.*
Donald Towsley, University of Massachusetts (983-94-1515)

3:45PM Discussion

AMS Special Session on Quantum Computation and Information: Mathematical Challenges, IV

1:00 PM - 3:55 PM

Organizers: **Samuel J. Lomonaco, Jr.**, University of Maryland Baltimore County
Howard E. Brandt, Army Research Laboratory
Louis H. Kauffman, University of Illinois at Chicago

1:00PM (586) *Anyons in a spin model on the honeycomb lattice.*
Alexei Y Kitaev, Caltech (983-81-930)

2:00PM (587) *The Hilbert series of measures of entanglement for 4 qubits.* Preliminary report.
Nolan R Wallach, University of California, San Diego (983-81-848)

2:30PM (588) *Quantum Entanglement and Topological Entanglement.* Preliminary report.
Louis Hirsch Kauffman*, University of Illinois at Chicago, and **Samuel J. Lomonaco, Jr.**, University of Maryland Baltimore County (983-81-803)

3:00PM (589) *Quantum and Classical Reverse Shannon Theorems.* Preliminary report.
Charles H Bennett, IBM Research Yorktown (983-81-939)

3:30PM (590) *Noiseless Quantum Information Processing.*
Paolo Zanardi, Institute for Scientific Interchange Foundation (983-81-995)

AMS Special Session on Computational Algebraic and Analytic Geometry for Low-Dimensional Varieties, I

1:00 PM - 3:50 PM

Organizers: **Mika K. Seppälä**, Florida State University
Emil J. Volcheck, Baltimore, Maryland

1:00PM (591) *On cohomology classes related to uniformization, the Liouville equation, and the dilogarithm.*
Ettore Aldrovandi, Florida State University (983-30-776)

1:30PM (592) *A variation on a theme of Nash.*
Paolo Aluffi, Florida State University (983-14-684)

2:00PM (593) *Algorithms for short geodesics.*
Jane Gilman*, Rutgers University Newark, and **Linda Keen**, Lehman College, City University of New York (983-30-1173)

2:30PM (594) *Ovals of real trigonal Riemann surfaces.*
Milagros Izquierdo*, Linkopings Universitet, and **Antonio F Costa**, UNED (983-14-71)

3:00PM (595) *Moduli of path families on hyperelliptic algebraic curves.* Preliminary report.
Mika Seppala, Florida State University and University of Helsinki (983-14-264)

3:30PM (596) *Hyperelliptic Curves with Extra Involutions.*
Tony Shaska*, University of California at Irvine, and **Jaime Gutierrez**, Universitad de Cantabria (983-14-115)

AMS Special Session on Modular Forms, Elliptic Curves, and Related Topics, I

1:00 PM - 3:50 PM

Organizers: **Cristina M. Ballantine**, College of the Holy Cross
Sharon M. Frechette, College of the Holy Cross
Holly J. Rosson, St. Mary's College of Maryland

1:00PM (597) *Supersingular j-invariants.*
Ken Ono, University of Wisconsin at Madison (983-11-942)

2:00PM (598) *On the sizes of gaps in the Fourier expansion of modular forms.*
Emre Alkan, University of Wisconsin (983-11-982)

2:30PM (599) *Toward an exhaustion theorem.* Preliminary report.
Julee Kim, Uinversity of Illinois at Chicago (983-22-1055)

3:00PM (600) *Moments of L-functions of Maass forms and the Riemann zeta function.* Preliminary report.
Jennifer Beineke*, Western New England College, and **Daniel Bump**, Stanford University (983-11-706)

3:30PM (601) *Sums of Squares and Congruence Restrictions of the Theta Function.* Preliminary report.
Kurt E Ludwick, Salisbury University (983-11-141)

AMS Special Session on Banach Space Theory and Convex Geometry, I

1:00 PM - 4:15 PM

Organizers: **Teck-Cheong Lim**, George Mason University
Mikhail Ostrovskii, The Catholic University of America

1:00PM (602) *A survey of non linear quotients.* Preliminary report.
William B. Johnson, Texas A&M University (983-46-860)

2:00PM (603) *Recent developments in the theory of twisted sums of Banach spaces.*
Nigel J Kalton, University of Missouri (983-46-669)

3:00PM (604) *On geometric structure of Marcinkiewicz spaces.* Preliminary report.
Anna H Kamińska, The University of Memphis (983-46-970)

3:30PM (605) *The Busemann-Petty problem via spherical harmonics(expository talk).*
Alexander Koldobsky, University of Missouri-Columbia (983-52-189)

AMS Special Session on Primes and Knots, IV

1:00 PM - 3:45 PM

Organizers: **Jack Morava**, Johns Hopkins University
Stavros Garoufalidis, Georgia Institute of Technology
Masanori Morishita, Kanazawa University

1:00PM (606) *On some equations in the Grothendieck-Teichmueller group.*
Hiroaki Nakamura, Okayama University (983-11-1042)

2:00PM (607) *Galois p-groups unramified at p.*
Nigel Boston, University of Wisconsin - Madison (983-11-1027)

3:00PM (608) *Galois groups and modular varieties.* Preliminary report.
Alexander Goncharov, Brown University (983-14-1043)

AMS Special Session on Operator Algebras, Quantization, and Noncommutative Geometry: A Centennial Celebration in Honor of J. V. Neumann and M. H. Stone, IV

1:00 PM - 3:50 PM

Organizers: **Robert S. Doran**, Texas Christian University
Richard V. Kadison, University of Pennsylvania

1:00PM (609) *Singly generated planar algebras and subfactors.* Preliminary report.
Dietmar Bisch, Vanderbilt University (983-46-691)

1:30PM (610) *Construction of spatial E_0-semigroups of $B(H)$..* Preliminary report.
Robert T. Powers, University of Pennsylvania (983-46-608)

2:00PM (611) *Noncommutative dynamics, moment polynomials, and dilations.*
William B. Arveson, UC Berkeley (983-46-1442)

2:30PM (612) *On shifts of Minimal Index on the Hyperfinite II_1 Factor.*
Geoffrey L. Price, U. S. Naval Academy (983-46-449)

3:00PM (613) *Applications of the work of Stone and von Neumann to the theory of wavelets.* Preliminary report.
Judith A. Packer, University of Colorado at Boulder (983-46-928)

3:30PM (614) *A Natural Topology on the Kasparov Groups.* Preliminary report.
Michael V. Pimsner, University of Pennsylvania (983-46-1299)

AMS Special Session on Nonstandard Models of Arithmetic and Set Theory, III

1:00 PM - 3:45 PM

Organizers: **Ali Enayat**, American University
Roman Kossak, CUNY Graduate Center

1:00PM (615) *Reflections on non-standard models.*
Haim Gaifman, Columbia University (983-03-1205)

2:00PM (616) *Nonstandard standard systems.* Preliminary report.
Roman Kossak, Graduate Center, City University of New York (983-03-1168)

2:30PM (617) *AC fails in the natural analogues of V and L that model the stratified fragment of ZF.* Preliminary report.
Thomas Forster, Cambridge University (983-03-1263)

3:00PM (618) *Working with models of set theory with nonstandard integers.* Preliminary report.
Harvey M Friedman, The Ohio State University (983-03-1108)

AMS Special Session on Inverse Problems and Sampling Theory in Signal Analysis, II

1:00 PM - 4:20 PM

Organizer: **M. Zuhair Nashed**, University of Central Florida

1:00PM (619) *Non-uniform weighted average sampling and reconstruction in shift invariant and wavelet spaces.*
Akram Aldroubi, Vanderbilt University (983-94-782)

1:30PM (620) *A spectral view of cascade approximations, subdivision algorithms, and wavelet duality.*
Palle E. T. Jorgensen, University of Iowa (983-41-86)

2:00PM (621) *Sampling Techniques in Shift-Invariant Spaces.*
Karlheinz U Groechenig, UNiversity of Connecticut (983-94-642)

2:30PM (622) *Banach frames in Sampling Theory.*
Hans G. Feichtinger, Dept. Math., Univ. Vienna, NuHAG (983-46-945)

3:00PM (623) *Kernels of positive linear functionals and sampling theory.*
Jean-Pierre Gabardo*, McMaster University, and **Deguang Han**, University of Central Florida (983-44-704)

3:30PM ► (624) *Oversampling and aliasing in shift-invariant spaces.* Preliminary report.
Jeffrey A Hogan*, University of Arkansas, and **Joseph D Lakey**, New Mexico State University (983-42-134)

4:00PM (625) *Fourier Series on the Cantor Set.*
Matthew C Fickus* and **Robert S. Strichartz**, Cornell University (983-42-1146)

MAA Minicourse #11: Part A

1:00 PM - 3:00 PM

Symmetry for all.
Organizer: **George Baloglou**, SUNY Oswego

MAA Minicourse #16: Part A

1:00 PM - 3:00 PM

Cwatsets: A research experience for undergraduates.
Organizer: **Gary J. Sherman**, Rose-Hulman Institute of Technology

MAA Minicourse #6: Part A

1:00 PM - 3:00 PM

WeBWorK, an internet-based system for generating and delivering homework problems to students.
Organizers: **Arnold K. Pizer**, University of Rochester
Michael E. Gage, University of Rochester
Vicki Roth, University of Rochester

AMS Session on Control Theory

1:00 PM - 2:10 PM

1:00PM (626) *Solution of Delay Systems by Hybrid Functions.*
Mohsen Razzaghi, Mississippi State University (983-49-65)

1:15PM (627) *Variational principles for the canonical Lie group connection in dimension five.*
Gerard Thompson and **Igor Strugar***, The University of Toledo (983-49-1473)

1:30PM (628) *Two Problems Appeared in Optimal Control Theory.* Preliminary report.
Hongwei Lou, Fudan University (983-49-674)

1:45PM (629) *A strong approximation theory for strong solutions of stochastic calculus of variations problems.* Preliminary report.
John Gregory, Southern Illinois University Carbondale (983-49-694)

2:00PM (630) *Volterra-Stieltjes Integral Equations and Stability of Nonlinear Discrete Control Systems.*
Dmitry Altshuller, St. Petersburg State University (983-93-77)

AMS Session on Dynamical Systems

1:00 PM - 2:55 PM

1:00PM ► (631) *Billiards and closed orbits in subriemannian geometry.*
Vadim Zharnitsky* and **Yuliy Baryshnikov**, Bell Laboratories (983-37-1217)

1:15PM (632) *Topological Model of Polynomials of Simple Siegel Disk Type.*
Gaofei Zhang, The City University of New York (983-37-329)

1:30PM (633) *Quasilinearization and Rapid Covergence for Boundary value problems on Unbounded Domains.*
Paul W Eloe, University of Dayton (983-34-1231)

1:45PM ► (634) *The Discrete Markus-Yamabe Problem with Nilpotent Jacobians.* Preliminary report.
Marc Chamberland, Grinnell College (983-37-84)

2:00PM ► (635) *The Discrete Time Voter Model with Confidence Levels.* Preliminary report.
Stephen G. Hartke, Rutgers University (983-37-1311)

2:15PM (636) *Dynamics of the Restricted Collinear Three-body Problem.* Preliminary report.
Samuel R Kaplan*, University of North Carolina at Asheville, **Ernesto A Lacomba**, Universidad Autonoma Metropolitana - Iztapalapa, and **Jaume Llibre**, Universitat Autonoma de Barcelona (983-37-198)

2:30PM (637) *Regularly almost periodic ambits.*
Alica Miller* and **Joseph Rosenblatt**, University of Illinois at Urbana-Champaign (983-37-1387)

2:45PM ► (638) *The Road To Bifurcation is Filled With Polynomial Curves, Too!* Preliminary report.
Chip Ross, Bates College (983-37-1478)

AMS Session on Applications of Mathematics, II

1:00 PM - 3:55 PM

1:00PM ► (639) *Composite materials and Jordan Algebras.*
Erin Blew, The College of New Jersey, **Matthew Jacobs**, Duke University, **Matthew Macauley***, Harvey Mudd College, **John Quah**, Bates College, and **Elianna Ruppin**, California State University (983-74-211)

1:15PM (640) *Influence of Temperature on Multigrain Thin Film Deposition.* Preliminary report.
Anthony L Tongen*, Trinity International University, **David L Chopp**, Northwestern University, and **Adama Tandia**, Corning (983-70-1320)

1:30PM ► (641) *Numerical Solution of the One and Two Layer Linear Quasi-Geostrophic Wave Equations using Transfer Matrix Methods.*
Russell L Herman, UNC Wilmington (983-76-1371)

1:45PM ► (642) *Constant Mean-Curvature Surfaces with Variable Contact Angle.*
Svetlana Bukharina* and **David S. Ross**, Rochester Institute of Technology (983-76-1068)

2:00PM (643) *Approximate solutions to the Boussinesq equation.*
Aleksey Sergeevich Telyakovskiy*, Rose-Hulman Institute of Technology, **Myron B Allen**, **Frederico Furtado**, University of Wyoming, and **Gastao Braga**, UFMG (983-74-1114)

2:15PM ► (644) *Wave Propagation in Transient Thermoelastic Problems.*
Jun Wang, ALabama State University (983-74-83)

2:30PM (645) *Optimal design of turbines with an attached mass.*
C. Maeve McCarthy*, Murray State University, and **Boris Belinskiy**, University of Tennessee at Chattanooga (983-49-963)

2:45PM ► (646) *Symmetry analysis of the reduced Maxwell Bloch equations with a permanent dipole.*
Chad Fendt*, **Danny Arrigo** and **Steve Addison**, University of Central Arkansas (983-78-1024)

3:00PM (647) *A new symmetric hyperbolic formulation for the ADM system.* Preliminary report.
Alexander M. Alekseenko*, University of Minnesota, Minneapolis, and **Douglas N. Arnold**, Institute for Mathematics and its Applications, University of Minnesota (983-83-1149)

3:15PM (648) *Initiation of free-radical polymerization waves.*
Laura R Ritter*, Northwestern University, **W.E. Olmstead** and **V.A. Volpert** (983-45-673)

3:30PM (649) *Reconstruction of Spatial Heat Sources in Heat Conduction Problems.* Preliminary report.
Ping Wang*, Penn State University, and **Kewang Zheng**, Hebei University of Science and Technology (983-35-21)

3:45PM (650) *Error Estimates for Boundary Value Problems of Ito-Type.* Preliminary report.
G. S. Ladde, University of Texas at Arlington, and **M Sambandham***, Morehouse College (983-60-962)

SIAM Minisymposium on the Stability of Nonlinear Dispersive Waves, II

1:00 PM - 3:15 PM

Organizer: **Robert L. Pego**, University of Maryland

1:00PM (651) *Selection of the ground state.*
Michael Weinstein, Lucent Technologies

1:35PM (652) *Snaking bifurcation in parametrically forced nonlinear Schrodinger equation.*
Keith Promislow, Simon Fraser University

2:10PM (653) *Stability and bifurcation of passive defects.*
Arnd Scheel, University of Minnesota (983-35-730)

2:45PM (654) *Asymptotic stability criteria for solitary waves on lattices.*
Robert Pego, University of Maryland at College Park

SIAM Minisymposium on Hyperbolic Conservation Laws and Related Topics

1:00 PM - 2:55 PM

Organizers: **Barbara Lee Keyfitz**, University of Houston
Marshall Slemrod, University of Wisconsin
Konstantina Trivisa, University of Maryland, College Park

1:00PM (655) *Analysis of finite depth waterwave with a variable bottom.*
Sijue Wu, University of Maryland and Harvard University (983-35-818)

1:30PM (656) *The Evans function and stability criteria for degenerate viscous shock waves.*
Peter Howard, Texas A&M (983-35-802)

2:00PM (657) *Large-Time Behavior of Real Compressible Reacting Flows in Combustion.*
Dehua Wang, University of Pittsburgh (983-35-742)

2:30PM (658) *L^1 stability of discrete Boltzmann equations.*
Seung-Yeal Ha, University of Wisconsin-Madison (983-35-717)

MAA Session on Innovative Use of the World Wide Web in Teaching Mathematics, III

1:00 PM - 3:45 PM

Organizers: **Brian E. Smith**, McGill University
Marcelle Bessman, Jacksonville University
Marcia P. Birken, Rochester Institute of Technology
Thomas E. Leathrum, Jacksonville State University
David M. Strong, Pepperdine University
Joe Yanik, Emporia State University

1:00PM ► (659) *Using Lite Applets to Create Interesting Interactive Web-based Homework.*
Frank A Wattenberg, United States Military Academy (983-A1-873)

1:20PM ► (660) *Designing Interactive Web based Modules for Mathematics Learning.* Preliminary report.
Morteza Seddighin, Indiana University East (983-A1-342)

1:40PM (661) *Interactive Mathlets from Mathwright.*
Dan Kalman, American University (983-A1-420)

2:00PM ► (662) *A Use of the World Wide Web in a General Education Course.* Preliminary report.
Marko Kranjc, Western Illinois University (983-A1-406)

2:20PM ► (663) *The Probability/Statistics Object Library.* Preliminary report.
Kyle Siegrist, University of Alabama in Huntsville (983-A1-377)

2:40PM ► (664) *Trigonometry laboratories using Mathematical Java and Java Sketchpad.*
Michael E. Mays, West Virginia University (983-A1-358)

3:00PM ► (665) *Using a Mathlet to Enhance Understanding of Parametric Equations.*
Teri J Murphy, University of Oklahoma (983-A1-346)

3:20PM ► (666) *The Math Tools Digital Library.*
Eugene A. Klotz, The Math Forum, Drexel University (983-A1-478)

MAA Session on Classroom Demonstrations and Course Projects that Make a Difference, II

1:00 PM - 3:55 PM

Organizers: **David R. Hill**, Temple University
Sarah L. Mabrouk, Framingham State College
Lila F. Roberts, Georgia Southern University

1:00PM ► (667) *A Cube Group Puzzle.*
Dale K Hathaway, Olivet Nazarene University (983-B1-188)

1:15PM ► (668) *The Gini Index: A Project for 2nd Semester Calculus.*
Daniel J. Teague, NC School of Science & Mathematics (983-B1-223)

1:30PM ► (669) *Workshop Calculus at Rochester Institute of Technology.* Preliminary report.
Sophia Maggelakis* and **Marcia Birken**, Rochester Institute of Technology (983-B1-236)

1:45PM (670) *How to get a good project from your precalculus students.*
Krista J Taylor, Shawnee State University (983-B1-481)

2:00PM ► (671) *Perfect Partners: Modeling of Discrete Dynamical Systems and Technology.*
William P Fox, Francis Marion University (983-B1-237)

2:15PM ► (672) *River Pollution and Land Mines: Providing Diversity and Focus in Core Curriculum Mathematics Projects.*
Brian J. Lunday* and **Bart D. Stewart**, United States Military Academy (983-B1-215)

2:30PM ► (673) *Sports Projects in an ODE Course.* Preliminary report.
Roland Minton, Roanoke College (983-B1-257)

2:45PM ► (674) *Tacos for Everyone! Projects for Introductory Probability through Advanced Actuarial Science students.* Preliminary report.
Lisa Elaine Marano, West Chester University of Pennsylvania (983-B1-146)

3:00PM ► (675) *A Demonstration of the Use of the Traveling Salesperson Problem in Finite Mathematics.*
Paul Kochanowski* and **Morteza Shafii-Mousavi**, Indiana University South Bend (983-B1-103)

3:15PM ► (676) *Learning Style Projects for "Mathematics for the Liberal Arts" Courses.*
Bruce N. Wahl, Northern Virginia Community College (983-B1-301)

3:30PM ► (677) *Use of the Computer Algebra System DERIVE in a Multivariable Calculus Course.* Preliminary report.
Manmohan Kaur, Benedictine University (983-B1-274)

3:45PM ► (678) *Teaching Quantitative Analysis for Undergraduate Students.* Preliminary report.
Robert L Luo, Richard Stockton College of New Jersey, Pomona, NJ 08240-0195 (983-B1-639)

MAA Session on Incorporating History of Mathematics in the Mathematics Classroom, II

1:00 PM - 3:00 PM

Organizers: **Victor J. Katz**, University of the District of Columbia
Edith Prentice Mendez, Sonoma State University
Eisso J. Atzema, University of Maine

1:00PM ► (679) *Little Visits With "The Old Dead Guys".*
Sarah L Mabrouk, Framingham State College (983-G1-515)

1:20PM ► (680) *A Different Kind of Mathematical Modeling.*
Agnes M Kalemaris, SUNY Farmingdale (983-G1-344)

1:35PM (681) *A Seminar on the Foundations of Calculus Incorporating Original Sources.*
Robert E Bradley, Adelphi University (983-G1-409)

2:00PM ► (682) *The bridge between the continuous and the discrete via original sources.* Preliminary report.
David J Pengelley, New Mexico State University (983-G1-196)

2:25PM ► (683) *Incorporating Cayley's Colorgroups Into the Teaching of Abstract Algebra.*
Stephanie Cawthorne, Marymount University (983-G1-325)

2:45PM *Introducing Logic via Turing Machines.*
► (684) **Jerry M Lodder**, New Mexico State University (983-G1-275)

MAA Session on Initiating and Sustaining Undergraduate Research Projects and Programs

1:00 PM - 3:55 PM

Organizers: **James A. Davis**, University of Richmond
Suzanne M. Lenhart, University of Tennessee
Daniel J. Schaal, South Dakota State University

1:00PM *How to Get Started in Undergraduate Research:*
► (685) *Insights from a Beginner.* Preliminary report.
Sonya S Stanley, Samford University (983-01-1269)

1:20PM *Four-Fold Factoring and Other Adventures in*
► (686) *Independent Learning.*
Ezra Brown, Virginia Tech (983-01-957)

1:40PM *Initiating and Continuing Undergraduate Research:*
(687) *Using the Fusion Method of Traditional, Moore, and Constructivism to Encourage, Enhance, and Establish Undergraduate Research in Mathematics.*
M. Padraig McLoughlin, Morehouse College (983-01-559)

2:00PM *Research Activities of Alma College Students.*
► (688) **Aklilu Zeleke**, Alma College (983-01-441)

2:20PM *Delay Models-The Impact of Delaying the Flu*
► (689) *Vaccine on Public Health.* Preliminary report.
Lih-Ing Wu Roeger*, Texas Tech University, and **James Blackburn-Lynch**, Berea College (983-01-411)

2:40PM *Engaging First Year Students in Mathematical*
(690) *Research.*
Rick Gillman, Valparaiso University (983-01-390)

3:00PM *Some suggestions to make undergraduate research*
► (691) *more successful.* Preliminary report.
Jeffrey Feuer, Coastal Carolina University (983-01-322)

3:20PM *Opportunities for Undergraduate Projects at Liberal*
(692) *Arts Baccalaureate Colleges.*
Kenneth J Bernard, Chowan College (983-01-270)

3:40PM *The first steps in undergraduate research.*
► (693) **Tatyana Flesher*** and **Eleonor Holder**, Medgar Evers College, CUNY (983-01-171)

AMS-MAA Presentation

1:00 PM - 2:00 PM

What it's like to serve as an NSF Program Director.
Organizer: **Henry A. Warchall**, National Science Foundation
Presenters: **Maria Helena Noronha**, California State University, Northridge
Lynne H. Walling, University of Colorado, Boulder

AMS Special Presentation

1:00 PM - 2:30 PM

Graphic depiction of mathematics: Tips for minimizing hassles with your publisher.
Presenters: **Stephen Moye**, AMS
Tom Kacvinsky, AMS

MAA Panel Discussion

1:00 PM - 2:20 PM

Improving graduate education: Lessons learned on what works.
Organizers: **James H. Lightbourne**, National Science Foundation
Deborah F. Lockhart, National Science Foundation

MAA Panel Discussion

1:00 PM - 2:20 PM

Successful strategies for implementing a Texas-style (modified Moore method) course.
Organizers: **W. Ted Mahavier**, Lamar University
James P. Ochoa, Hardin-Simmons University
Panelists: **E. Lee May**, Salisbury University
David McRae, Woodberry Forest School
G. Edgar Parker, James Madison University
Shing S. So, Missouri University

MAA Project NExT Panel Discussion

1:00 PM - 2:30 PM

How to assess a mathematics program.
Organizer: **Mary D. Shepherd**, Northwest Missouri State University
Panelists: **Michael Button**, The Master's College
Bernard L. Madison, University of Arkansas
William A. Marion, Jr., Valparaiso University
William O. Martin, North Dakota State University
Barbara M. Moskal, Colorado School of Mines

MAA Panel Discussion

1:00 PM - 2:20 PM

Integrating calculus, precalculus, and algebra.
Organizer: **Laura A. Taalman**, James Madison University
Panelists: **Nancy Baxter Hastings**, Dickinson College
Robert P. Hostetler, Pennsylvania State University Erie-The Behrend College
Dennis C. Ebersole, Northampton Community College
Robin J. Gottlieb, Harvard University
Jack Bookman, Duke University
Laura A. Taalman

MAA Session on The History of Mathematics in the Americas

1:05 PM - 3:55 PM

Organizers: **Amy E. Shell-Gellasch**, United States Military Academy

Daniel E. Otero, Xavier University

1:05PM *J. C. Fields and Research Mathematics in Canada.*
► (694) **Tom Archibald**, Acadia University (983-C1-93)

1:30PM (695) *Early Twentieth Century Historians Look at Nineteenth Century Mathematics in America: A Comparison of the Views of Florian Cajori and David Eugene Smith.*
Eileen F. Donoghue, College of Staten Island, City University of New York (983-C1-531)

1:55PM
► (696) *The History of Mathematics in Brazil: a general view starting from the arrival of the Portuguese to the present.*
Sergio Nobre, UNESP - BRAZIL (983-C1-408)

2:20PM
► (697) *Mathematicians of the Colonial Period of Latin America.*
Elizabeth C. Rogers, Piedmont College (983-C1-299)

2:45PM
► (698) *Mathematics of the Ña Ñu (the Otomíes).* Preliminary report.
Thomas E. Gilsdorf, University of North Dakota (983-C1-159)

3:10PM
► (699) *Mathematics and the Military in the early Spanish colonies.*
C Edward Sandifer, Western Connecticut State U (983-C1-142)

3:35PM
► (700) *Three Examples of Mathematical Reasoning from the Printed Works of Peru in the Sixteenth and Seventeenth Centuries.* Preliminary report.
Bruce S Burdick, Roger Williams University (983-C1-500)

AMS Session on Lattice Theory

1:15 PM – 3:40 PM

1:15PM (701) *The endomorphism kernel property in finite distributive lattices and de Morgan algebras.*
T. S. Blyth, University of St Andrews, **Jie Fang***, University of Los Andes, and **H. J. Silva**, New University of Lisbon (983-06-612)

1:30PM (702) *Convex Partition Lattices.*
Scott R Sykes, University of West Georgia (983-06-1372)

1:45PM (703) *Distributive lattices and representations of rank two simple Lie algebras.* Preliminary report.
Scott J Lewis*, **Robert G Donnelly** and **Robert Pervine**, Murray State University (983-06-1470)

2:00PM (704) *Galois module structure of $K^\times/K^{\times p}$ for $[K:F]=p^n$.* Preliminary report.
Ján Mináč, University of Western Ontario, **Andy Schultz**, Stanford University, and **John Swallow***, Davidson College (983-12-852)

2:15PM (705) *Distributive lattices and the fundamental representations of the odd orthogonal Lie algebras.* Preliminary report.
Robert G. Donnelly, Murray State University (983-06-1471)

2:30PM
► (706) *Hamiltonicity of the cartesian product of two directed cycles minus a subgroup.*
Micah Israel Miller*, Bowdoin College, **Victoria Barone** and **Matthew Mauntel**, Notre Dame (983-00-779)

2:45PM (707) *Representaion of algebraic lattices in propositional logic.*
Chihiro Oshima, The University of Iowa (983-03-1028)

3:00PM (708) *Computational Complexity of the Congruence Extension Property for Algebras.*
Joy L Becker, University of Wisconsin-Stout (983-08-900)

3:15PM
► (709) *Minimum Cardinality of Finitely Nonassociative Groupoids.* Preliminary report.
William P. Wardlaw, U. S. Naval Academy (983-08-1160)

3:30PM
► (710) *Attempts at the Classification of the Complexity Structure of Translation Equivalence on $2^{2^{<\omega}}$.* Preliminary report.
Charles M. Boykin, University of North Texas (983-03-1051)

AMS Special Session on Discrete Models, IV

1:30 PM – 3:55 PM

Organizers: **Cris Moore**, University of New Mexico and Santa Fe Institute
Dana Randall, Georgia Institute of Technology

1:30PM
► (711) *On the Random k-SAT Threshold.* Preliminary report.
Dimitris Achlioptas*, Microsoft Research, and **Yuval Peres**, UC, Berkeley (983-05-1056)

2:00PM (712) *Random MAX SAT, random MAX CUT, and their phase transitions.*
Don Coppersmith, David Gamarnik, IBM Research, **Mohammad Hajiaghayi**, MIT, and **Gregory B Sorkin***, IBM Research (983-60-1454)

2:30PM
► (713) *The Scaling Window for Percolation on the n-cube.*
Christian Borgs*, **Jennifer Tour Chayes**, Microsoft Research, **Remco van der Hofstad**, Eindhoven University of Technology, **Gordon Slade**, University of British Columbia, and **Joel Spencer**, Courant Institute (983-05-916)

3:00PM (714) *A Phase Transition for Avoiding a Giant Component.*
Tom Bohman, Carnegie Mellon University, and **Jeong Han Kim***, Microsoft Research (983-05-1443)

3:30PM (715) *Balls into Bins: The Rich get Richer.* Preliminary report.
Joel H Spencer, Courant Institute (983-05-929)

MAA Project NExT-Young Mathematicians Network Poster Session

2:00 PM – 4:00 PM

Organizers: **Kenneth A. Ross**, University of Oregon
Kevin E. Charlwood, Washburn University

Summer Program for Women in Mathematics (SPWM) Reunion

2:00 PM – 4:00 PM

Program participants will describe their experiences.

Organizers: **Murli M. Gupta**, George Washington University
E. Arthur Robinson, Jr., George Washington University

AMS Invited Address

2:15 PM – 3:05 PM

(716) *Dimers and amoebas.*
Andrei Okounkov, University of California Berkeley (983-05-02)

MAA-ASL Panel Discussion

2:45 PM - 4:05 PM

The role of logic in learning to write proofs.
Organizers: **Jeff L. Hirst**, Appalachian State University
Daniel Vellman, Amherst College
Panelists: **Susanna S. Epp**, DePaul University
Connie M. Campbell, Millsaps College
Jeff L. Hirst
Daniel Vellman

MAA Session for Chairs

2:45 PM - 4:05 PM

Organizers: **Daniel P. Maki**, Indiana University
Catherine M. Murphy, Purdue University Calumet

MAA History of Mathematics SIGMAA Panel Discussion

3:00 PM - 4:20 PM

The history of curricular change: Linear algebra 1950-2000.
Organizers: **Walter J. Meyer**, Adelphi University
Jack Winn, SUNY at Farmingdale
Joseph Malkevitch, York College (CUNY)
Panelists: **Philip J. Davis**, Brown University
Carl C. Cowen, Purdue University
Harold M. Edwards, NYU-Courant Institute
Kenneth M. Hoffman, Massachusetts Institute of Technology
Gilbert Strang, Massachusetts Institute of Technology

AMS Invited Address

3:20 PM - 4:10 PM

(717) *Problems with multiple scales: Analysis, modeling and computations.*
Weinan E, Princeton University

AMS-MAA Joint Prize Session and Reception

4:25 PM - 6:30 PM

SIGMAA on Environmental Mathematics Reception and Lecture

5:45 PM - 7:15 PM

Lehigh University Reception

5:45 PM - 7:00 PM

National Security Agency Special Presentation

5:45 PM - 7:45 PM

Women in Mathematics: Past, Present, and Future.
Organizers: **Antonia Bluher**, National Security Agency
Michelle D. Wagner, National Security Agency

Ohio State Alumni and Friends Reception

5:45 PM - 7:45 PM

MAA Two-Year College Reception

5:45 PM - 7:00 PM

SIGMAA on Statistics Education

6:00 PM - 8:00 PM

2003 business meeting and lecture.
Organizer: **Mary Sullivan**, Rhode Island College

Association of Gay, Lesbian, Bisexual and Transgendered Mathematicians Reception

6:00 PM - 8:00 PM

New Mexico State University Mathematics Association Reception

6:00 PM - 7:00 PM

MER Banquet

6:30 PM - 9:30 PM

United States Military Academy Department of Mathematical Sciences Reception

6:30 PM - 9:30 PM

Meet at the meeting message board in the convention center at 6:30 p.m.

MAA Special Presentation

7:30 PM - 9:00 PM

Eine Klein (Mathematische) Nachtmusik
Presenter: **Erich Neuwirth**, University of Vienna

Knitting Network

8:15 PM - 9:45 PM

Friday, January 17

PME and MAA Student Chapter Advisors' Breakfast

7:00 AM - 8:15 AM

Employment Center

7:00 AM - 7:30 PM

Joint Meetings Registration

7:30 AM - 4:00 PM

AMS-MAA-SIAM Special Session on Research in Mathematics by Undergraduates, I

8:00 AM - 10:50 AM

Organizers: **Darren A. Narayan**, Rochester Institute of Technology
Carl V. Lutzer, Rochester Institute of Technology
Tamara A. Burton, Rochester Institute of Technology

8:00AM ► (718) *Classifying polygonal chains of six segments.* Preliminary report.
Thomas James Clark, Calvin College (983-57-112)

8:30AM ► (719) *A Gradient Flow for the Rope Length of Knotted Strings.* Preliminary report.
Michael J Piatek, Duquesne University (983-57-738)

9:00AM ► (720) *A Cross-Cultural Study on the Effects of Immunization Against Rubella.*
Carmen Michael Piccolo* and **Lora Billings**, Montclair State University (983-92-541)

9:30AM ► (721) *Diffusion Based Models for Image Processing.* Preliminary report.
Jon Stanich, Duquesne University (983-35-623)

10:00AM ► (722) *Asymptotic analysis of finite deformation in a nonlinear transversely isotropic incompressible hyperelastic half-space subjected to a tensile point load.*
Ethan T Coon, University of Rochester (983-74-521)

10:30AM ► (723) *Some Analysis on Markowitz Efficient frontier.*
Allison Beste, Trinity University, **Dennis Leventhal**, Carnegie Mellon University, **Qin Lu**, Lafayette College, and **Jared Williams***, Hendrix College (983-90-451)

AMS-MAA Special Session on The History of Mathematics, I

8:00 AM - 10:55 AM

Organizers: **Joseph W. Dauben**, Lehman College
David E. Zitarelli, Temple University

8:00AM ► (724) *Mathematics from ancient Iraq in the Ashmolean Museum, Oxford.* Preliminary report.
Eleanor Robson, All Souls College, Oxford (983-01-73)

8:30AM (725) *The number zero: Its origin and its use.*
Abdulalim A Shabazz, Lincoln University (983-01-808)

9:00AM ► (726) *The Mathematics Textbook and the Disappointed Daughter: History of a Mathematical Urban Legend.* Preliminary report.
Kim Plofker* and **E. Allyn Smith**, Brown University (983-01-653)

9:30AM (727) *What did Galileo's experiments mean to him? Folio 116v and the Mirandum Paradox.*
Alexander J Hahn, University of Notre Dame (983-01-772)

10:00AM ► (728) *Chinese Trigonometry in 18th Century China.*
Jiang-Ping Jeff Chen*, St. Cloud State University, MN, and **Minghui Hu**, University of California, Irvine (983-01-217)

10:30AM (729) *Jews and mathematics: Outline of an unwritten book.*
Reuben Hersh, University of New Mexico (983-01-55)

AMS Special Session on Wavelets, Frames and Operator Theory, I

8:00 AM - 10:50 AM

Organizers: **Christopher Heil**, Georgia Institute of Technology
Palle Jorgensen, University of Iowa
David Larson, Texas A&M University

8:00AM (730) *Symmetric Univariate QM Filters with Gaussian Decay.* Preliminary report.
Manos I. Papadakis*, **Qiyu Sun**, **Zhemin Tan**, **Ioannis A. Kakadiaris**, **Donald K. Kouri**, University of Houston, and **David J Hoffman**, Ameas Laboratory (983-42-750)

8:30AM (731) *Symmetric Univariate QM Filters with Gaussian Decay II.* Preliminary report.
Qiyu Sun*, **Manos Papadakias**, **Zhemin Tan**, **Donald K. Kouri**, University of Houston, **David J. Hoffman**, Iowa State University, and **Ioannis A. Kakadiaris**, University of Houston (983-42-1037)

9:00AM (732) *Optimal Shift-Invariant Spaces.* Preliminary report.
A. Aldroubi, Vanderbilt University, **C. A. Cabrelli**, Universidad de Buenos Aires, **D. P. Hardin**, Vanderbilt University, and **U M Molter***, Universidad de Buenos Aires (983-41-1081)

9:30AM (733) *Continuous orthogonal wavelets on semi-regular triangulations.* Preliminary report.
Douglas P. Hardin*, Vanderbilt University, and **Bruce Kessler**, Western Kentucky University (983-41-879)

10:00AM (734) *Density of Weighted Wavelet Frames.*
Christopher Heil, Georgia Institute of Technology, and **Gitta Kutyniok***, University of Paderborn (983-42-722)

10:30AM (735) *On the connectivity of wavelets.*
Guido L Weiss, Washington University in St. Louis (983-41-845)

AMS Special Session on Discrete Dynamics and Difference Equations, I

8:00 AM - 10:55 AM

Organizers: **Saber N. Elaydi**, Trinity University
Gerasimos Ladas, University of Rhode Island

8:00AM ► (736) *Anatomy of a Chaotic Attractor.*
A A King, University of Tennessee, Knoxville, **J M Cushing**, **R F Costantino**, University of Arizona, **Shandelle M Henson***, Andrews University, **R A Desharnais**, California State University, Los Angeles, and **B Dennis**, University of Idaho (983-92-1409)

8:30AM ► (737) *A Discrete Competition Model.* Preliminary report.
J. Cushing*, **R. F. Costantino**, University of Arizona, **Jeff Edmunds**, Mary Washington College, and **Shandelle M Henson**, Andrews University (983-92-1281)

9:00AM (738) *Bifurcation of Maps and Cycling In Genetic Systems.* Preliminary report.
Robert J Sacker* and **Hubertus F Von Bremen**, University of Southern California (983-39-1228)

9:30AM ► (739) *Dynamical Properties of the Discrete Larvae-Pupae-Adults Population Model.* Preliminary report.
Jerry J Chen, University of Delaware (983-37-688)

10:00AM ► (740) *Periodically Forced Metapopulation Dynamics.*
Abdul-Aziz Yakubu, Howard University (983-92-630)

10:30AM (741) *Discrete-Time Models for Periodic Diseases with Integer Valued Populations.*
Ronald E Mickens, Clark Atlanta University (983-39-991)

AMS Special Session on Homotopy Theory, I

8:00 AM - 10:50 AM

Organizers: **Kristine Baxter Bauer**, Johns Hopkins University
J. Michael Boardman, Johns Hopkins University
Nitu Kitchloo, Johns Hopkins University
Jean-Pierre Meyer, Johns Hopkins University
Jack Morava, Johns Hopkins University
W. Stephen Wilson, Johns Hopkins University

8:00AM (742) *On the Cohomology of the Steenrod Algebra Modulo Nilpotents.*
Leyla Batakci, Elizabethtown College (983-55-697)

8:30AM (743) *The Dieudonné Ring for Ordinary Homology.* Preliminary report.
Kimberly R Elce, CSU, Sacramento (983-55-977)

9:00AM (744) *The $\bar{\partial}$ operator in holomorphic K-theory.* Preliminary report.
Dana Powell Rowland, Merrimack College (983-55-1216)

9:30AM (745) *Flat Model Structures on Chain Complex Categories.*
James R Gillespie, Wesleyan University (983-55-919)

10:00AM (746) *The Long Exact (Pi, Ext)-Sequence in the Second Variable and the Long Exact (Pi, Ext)-Sequence of a Triple.*
C Joanna Su, Providence College (983-55-587)

10:30AM (747) *A homotopy structure on the category of parity complexes.* Preliminary report.
Lucian M Ionescu, Illinois State University (983-18-220)

AMS Special Session on Computational Algebraic and Analytic Geometry for Low-Dimensional Varieties, II

8:00 AM - 10:50 AM

Organizers: **Mika K. Seppälä**, Florida State University
Emil J. Volcheck, Baltimore, Maryland

8:00AM (748) *Arithmetic in Purely Cubic Function Fields I.* Preliminary report.
Mark L. Bauer, Centre for Applied Cryptographic Research, University of Waterloo (983-11-724)

8:30AM (749) *Arithmetic in Purely Cubic Function Fields II.* Preliminary report.
Renate Scheidler, University of Calgary (983-14-1314)

9:00AM (750) *Class Number Computations in Cubic Function Fields.* Preliminary report.
Andreas Stein, University of Illinois at Urbana-Champaign (983-11-658)

9:30AM ► (751) *A comparison of smoothness-testing strategies for solving hyperelliptic curve discrete logarithm problems.* Preliminary report.
Michael J Jacobson, University of Calgary (983-11-635)

10:00AM (752) *Restriction of Syzygies.* Preliminary report.
David Eisenbud, MSRI (983-14-1303)

10:30AM ► (753) *Interval arithmetic for function fields over finite fields.* Preliminary report.
Kiran S Kedlaya, University of California, Berkeley (983-14-668)

AMS Special Session on Modular Forms, Elliptic Curves, and Related Topics, II

8:00 AM - 10:50 AM

Organizers: **Cristina M. Ballantine**, College of the Holy Cross
Sharon M. Frechette, College of the Holy Cross
Holly J. Rosson, St. Mary's College of Maryland

8:00AM (754) *Sums of special values of L-functions attached to modular forms.*
Dominic A Lanphier, Kansas State University (983-11-367)

8:30AM (755) *Explicit action of Hecke operators on Hilbert-Siegel modular forms.*
Suzanne Caulk, University of Rochester (983-11-563)

9:00AM (756) *Reductions of an elliptic curve and associated groups.*
William D Duke, UCLA (983-11-1054)

9:30AM (757) *On the existence of certain functionals.*
Ramin Takloo-Bighash, Princeton University (983-11-739)

10:00AM (758) *A character formula for compact elements.* Preliminary report.
Jonathan Korman, Univ. of Toronto (983-22-156)

10:30AM (759) *Twisted Local Zeta Functions and Eigenvalues of Monodromy.* Preliminary report.
Diane Meuser, Boston University (983-12-830)

AMS Special Session on Banach Space Theory and Convex Geometry, II

8:00 AM - 10:55 AM

Organizers: **Teck-Cheong Lim**, George Mason University
Mikhail Ostrovskii, The Catholic University of America

8:00AM ► (760) *On closed sets with convex projections in Hilbert space.*
Jan J. Dijkstra, Vrije Universiteit - Amsterdam, and **Stoyu T. Barov***, Ball State University (983-52-42)

8:30AM (761) *Some Mapping Properties of p-summing Operators with Hilbertian Domain.*
Qingying Bu, University of Mississippi (983-46-567)

9:00AM (762) *Weaker forms of unconditionality in Banach spaces.* Preliminary report.
E Odell, The University of Texas at Austin (983-46-767)

9:30AM (763) *On quasi-affine transforms of Read's operator.*
Thomas B. Schlumprecht*, Texas A&M University, and **Vladimir Troitsky**, University of Alberta (983-46-949)

10:00AM (764) *Saturating constructions for normed Spaces.*
Stanislaw J Szarek, Case Western Reserve University, and **Nicole Tomczak-Jaegermann***, University of Alberta (983-46-1166)

10:30AM (765) *Stable renorming of non-commutative L^p-spaces.* Preliminary report.
Haskell Rosenthal, University of Texas at Austin, Austin, TX (983-46-1193)

AMS Session on Functional Analysis, I

8:00 AM – 10:55 AM

8:00AM (766) *On a construction of hyperconvex spaces.* Preliminary report.
Brian Maurizi, Claremont McKenna College (983-46-1355)

8:15AM (767) *The Radon-Nikodym property for the projective tensor product of Banach spaces.* Preliminary report.
Patrick N Dowling, Miami University (983-46-1349)

8:30AM (768) *Ternary Rings of Operators and C*-algebras.*
Manmohan Kaur*, Benedictine University, and **Zhong-Jin Ruan**, University of Illinois at Urbana-Champaign (983-46-1277)

8:45AM (769) *Ergodic Type Theorems for Semi-Finite von Neumann Algebras.*
Genady Ya. Grabarnik, IBM T.J. Watson Research Center, and **Alexander A. Katz***, St.John's University (983-46-1232)

9:00AM ► (770) *Sums of commutators in operator algebras.*
Ciprian S Pop, Texas A&M University (983-46-1223)

9:15AM ► (771) *The Ball-Generated Property in Operator Spaces.*
Sudeshna Basu, Howard University (983-46-1065)

9:30AM (772) *Observations on the relative tensor product of modules over a von Neumann algebra.*
David Sherman, University of Illinois at Urbana-Champaign (983-46-1026)

9:45AM (773) *Biorthogonal Systems in Banach Spaces.* Preliminary report.
Michael A Coco, University of South Carolina (983-46-1013)

10:00AM (774) *The Ordered Topology of Hyperreal Numbers.* Preliminary report.
Amir A Maleki, Howard University (983-46-923)

10:15AM (775) *Strong Dunford-Pettis sets and spaces of operators.* Preliminary report.
Ioana Ghenciu* and **Paul W Lewis**, University of North Texas (983-46-893)

10:30AM (776) *Exhaustivity in Topological Riesz Spaces with the Principal Projection Property.* Preliminary report.
Kimberly O. Muller, University of North Texas (983-46-859)

10:45AM (777) *Revisiting the Weierstrass Approximation Theorem.*
Donald P. Minassian, Butler University (983-41-820)

AMS Session on Statistics and Numerics

8:00 AM – 10:55 AM

8:00AM (778) *Wavelet Collocation for ODE Boundary Value Problems.* Preliminary report.
Bentley Garrett* and **Ian Gladwell**, Southern Methodist University (983-00-1240)

8:15AM ► (779) *Should it matter which group is chosen as the control group?* Preliminary report.
John P Klein, Medical College of Wisconsin, and **Mouchumi Bhattacharyya***, University of the Pacific (983-62-1401)

8:30AM (780) *Modeling and Analysis of Time Till Failure of Pipe Liners.*
Mahmoud Yousef*, Central Missouri State University, and **Raja Nassar**, Louisiana Tech University (983-62-1158)

8:45AM (781) *A test for bivariate two sample location problem.*
Sunil K Mathur, St. Cloud State University (983-62-936)

9:00AM ► (782) *Suggested Diagnostics for Application of Benford's Law in Auditing and Fraud Detection.* Preliminary report.
Richard J. Cleary, Bentley College (983-62-672)

9:15AM ► (783) *On the uniformity of distributions of points on a sphere obtained by Sequences of Voronoi diagrams.*
S Prakash, Johns Hopkins University (983-65-1483)

9:30AM (784) *The Numerical Calculation of the Annual Percentage Rate of an Installment Loan by Iteration.*
Constantine Georgakis, DePaul University (983-65-1417)

9:45AM ► (785) *A Discrete Model for Elastic Strings.* Preliminary report.
Mark S. Korlie, Montclair State University (983-65-1400)

10:00AM (786) *Overrelaxation On Chain.*
Saadat Moussavi, University of Wisconsin-Oshkosh (983-65-1255)

10:15AM (787) *Limited Newton's Step Algorithm for Convex Programming Problems.*
Yixun Shi, Bloomsburg University of Pennsylvania (983-65-921)

10:30AM (788) *On the use of infinite elements for the determination of optimal closure patterns based on stress analysis.*
Dawn Alisha Lott*, New Jersey Institute of Technology, and **Hans R. Chaudhry**, NJ Institute of Technology (983-65-822)

10:45AM ► (789) *Trivariate Spline Approximations of 3D Navier-Stokes Equations.*
Gerard M Awanou* and **Ming Jun Lai**, University of Georgia (983-65-56)

MAA Session on Best Statistics Projects/Activities, I

8:00 AM – 10:55 AM

Organizers: **Carolyn K. Cuff**, Westminster College
Mary M. Sullivan, Rhode Island College

8:00AM ► (790) *Teaching Logistic Regression Using Examples from Sports.* Preliminary report.
Farzad D Noubary, Penn State University (Schreyer Honors College) (983-L1-233)

8:30AM ► (791) *From Basic Stats Class to the Real World: Using the media, real data, and scholarly journals to introduce students to the uses of statistics.*
Jan O Case, Jacksonville State University (983-L1-372)

9:00AM (792) *Just-In-Time Interesting Data.*
John D. McKenzie, Jr., Babson College (983-L1-543)

9:30AM ► (793) *Introducing Minimum Variance Unbiased Estimators.*
Daniel J. Teague, NC School of Science & Mathematics (983-L1-221)

10:00AM ► (794) *Projects in a Probability and Statistics Course at West Point.*
John A Picciuto and **Steven B Horton***, United States Military Academy (983-L1-311)

10:30AM ► (795) *Using Probability Theory Software in Mathematical Statistics Projects.* Preliminary report.
Andrew G Glen, United States Military Academy (983-L1-366)

MAA Session on Rethinking the Courses Below Calculus, I

8:00 AM – 10:55 AM

Organizers: **Mary Robinson**, University of New Mexico

Sheldon P. Gordon, SUNY at Farmingdale
Florence S. Gordon, New York Institute of Technology
Arlene H. Kleinstein, SUNY at Farmingdale

8:00AM (796) *Mathematical Requirements of the Managerial, Social and Life/Health Sciences.* **Scott R. Herriott**, Maharishi University of Management (983-M1-333)

8:20AM ► (797) *Mathematical Modeling in College Algebra.* Preliminary report. **Robert Lee Mayes**, West Virginia University (983-M1-393)

8:40AM ► (798) *Moving Forward with "Contemporary College Algebra" at Prairie View A&M University.* **Laurette Blakey Foster**, Prairie View A&M University (983-M1-689)

9:00AM ► (799) *Designing Courses to Improve Access to Mathematics.* **Laurie B Hopkins**, Columbia College (983-M1-388)

9:20AM ► (800) *Anticipating Calculus: A Spiral Approach Using Mathematica Labs.* **Barry Cherkas**, Hunter College (CUNY) (983-M1-424)

9:40AM ► (801) *Precalculus: Concepts in Context.* **Marsha J. Davis***, Eastern Connecticut State University, **Judith F. Moran**, Trinity College, and **Mary Murphy**, Smith College (983-M1-533)

10:00AM ► (802) *Mathematical Methods: Topics in Precalculus and Discrete Mathematics.* **Al Cuoco**, Center for Mathematics Education, EDC (983-M1-262)

10:20AM ► (803) *Mathematical Modeling and Problem Solving: Another view of college algebra.* **William P. Fox**, Francis Marion University (983-M1-240)

10:40AM ► (804) *In Retrospect: Expectations For And Evaluation Of "Mathematical Thinking" (a new course for general education).* Preliminary report. **Jacqueline A Hall**, Longwood University (983-M1-504)

MAA Session on Strategies for Increasing the Diversity of Students in Mathematics

8:00 AM - 10:55 AM

Organizers: **Marjorie Enneking**, Portland State University
Wade Ellis, West Valley College
William Hawkins, SUMMA
Robert E. Megginson, University of Michigan
Kenneth C. Millett, University of California, Santa Barbara
William Y. Velez, University of Arizona

8:00AM ► (805) *Cultivating Talent at the Summer Institute in Mathematics for Undergraduates (SIMU): Turning Challenges into Opportunities.* **Herbert Antonio Medina***, Loyola Marymount University, and **Ivelisse Rubio**, University of Puerto Rico - Humacao (983-Q1-152)

8:30AM ► (806) *Persistence in Mathematics by Underrepresented Students—Experiences of the Oregon State University Math Excel Program.* **Thomas P Dick*** and **Michael Little Crow**, Oregon State University (983-Q1-85)

9:00AM ► (807) *Perceptions of Minority Students Concerning Selection of a Mathematics Teaching Career.* Preliminary report. **Mourat Tchoshanov***, **Sally Blake**, UTEP, and **Connie Della Piana**, NSF (983-Q1-94)

9:30AM ► (808) *Successful Strategies to Increase the Recruitment, Retention, and Graduation of Underrepresented Groups in Mathematics and Science.* Preliminary report. **Mazen Shahin**, Delaware State University (983-Q1-457)

10:00AM ► (809) *High-school outreach activities at New Mexico State University.* Preliminary report. **Theodore Stanford**, New Mexico State University (983-Q1-488)

10:30AM ► (810) *Public Secrets: A Summer Experience in Mathematics for Oklahoma Teenagers.* **David E. Boliver**, Univ. of Central Oklahoma (983-Q1-392)

SIGMAA on Research in Undergraduate Mathematics Education, I

8:00 AM - 10:55 AM

Organizers: **James F. Cottrill**, Illinois State University
Anne E. Brown, Indiana University South Bend

8:00AM ► (811) *Preservice Elementary Teachers' Understanding of Measurement Concepts.* Preliminary report. **Susan L. Addington**, California State University, San Bernardino (983-K1-542)

8:20AM ► (812) *Case Study of a Ph.D. Mathematician Teaching College Algebra (second report).* Preliminary report. **Shandy Hauk***, **April Judd** and **Jenq-Jong Tsay**, University of Northern Colorado (983-K1-862)

8:40AM (813) *Why Students Have Difficulties with Transformations of Functions.* **Bernadette Baker**, Drake University, **Clare Hemenway**, University of Wisconsin Marathon County, and **Maria Trigueros***, ITAM (983-K1-502)

9:00AM ► (814) *Undergraduates' Difficulties with Algebraic Concepts in a "Non-standard" Number System.* **Jennifer Christian Smith**, University of Texas at Austin (983-K1-741)

9:20AM ► (815) *Carla and the left coset: The specific and the general in mathematical language, notation, and thinking.* **Bradford R Findell**, University of Georgia (983-K1-554)

9:40AM (816) *A Calculus Graphing Schema Revisited.* **Bernadette M. Baker***, Drake University, **Laurel Cooley**, York College - City University of New York, and **Maria Trigueros**, Instituto Technologico Autonomo Mexico (983-K1-445)

10:00AM ► (817) *The Concept of Point: A Historical and Metaphorical Perspective.* **J A Bergner***, Salisbury University, and **N Presmeg**, Illinois State University (983-K1-368)

10:20AM (818) *An Analysis of College Students' Reasoning about Percents.* Preliminary report. **David Jabon** and **Georgia Tolias***, DePaul University (983-K1-509)

10:40AM ► (819) *Pedagogy and Curriculum of Introductory College Mathematics Courses.* **Elizabeth C. Rogers**, Piedmont College (983-K1-309)

MAA General Contributed Paper Session, IV

8:00 AM – 10:55 AM

Organizers: **Michael A. Jones**, Montclair State University
Steven M. Hetzler, Salisbury University
Shawnee L. McMurran, California State University at San Bernardino

8:00AM ► (820) *How I Became a PICO Organizer.* Preliminary report.
Ann E Moskol, Rhode Island College (983-Z1-549)

8:15AM ► (821) *Where Have All the Math Majors Gone?—Some Techniques to Increase the Number of Math Majors in a Program.*
John A. Picciuto*, **John S Billie** and **Scott Gensler**, United States Military Academy (983-Z1-491)

8:30AM ► (822) *Using Electronic Communication Tools to Increase Office Hour Effectiveness.*
Michael J Fisher, California State University, Fresno (983-Z1-278)

8:45AM ► (823) *Why Go Wireless? Observations from the Classroom.* Preliminary report.
Edgar K Rugenstein* and **William L Crowley**, United States Military Academy (983-Z1-313)

9:00AM ► (824) *Steiner's Deltoid, an animated version.*
Angelo Segalla, California State Universtiy, Long Beach (983-Z1-1362)

9:15AM ► (825) *EXCELlent Visual Cues.* Preliminary report.
Jeff A. Libby* and **Bart D. Stewart**, United States Military Academy (983-Z1-212)

9:30AM (826) *Effective Student Presentations in a Liberal Arts Setting.*
Lisa Townsley, Benedictine University (983-Z1-164)

9:45AM ► (827) *The Cartesian Triad: Algebra, Geometry and the Cartesian Coordinate System - A Focus on Middle School Math Teachers.*
Don Spickler, Salisbury University (983-Z1-528)

10:00AM ► (828) *Japanese Lesson Study and the Teaching of Elementary Statistics.*
Thomas W Judson*, Harvard University, **Dwayne Derryberry**, University of Puget Sound, **Alison Paradise**, Univeristy of Puget Sound, and **Matt Pickard**, University of Puget Sound (983-Z1-197)

10:15AM (829) *Reducing Mathematics Anxiety, Improving Standards, and Maximizing Student Participation and Student Interaction Using Special Techniques and Peer Responsibility.*
Mike J Bankhead, Bellarmine University (983-Z1-931)

10:30AM (830) *The Integration of Mathematics Science, and Engineering Through Standards-Based, Enrichment, and Safety-Net Activities.*
Faiz B Al-Rubaee, University of North Florida (983-Z1-232)

10:45AM ► (831) *Pre-Service Elementary Education Majors:Concrete, Transitional, or Formal Thinkers?*
Scott E Inch, Bloomsburg University (983-Z1-1249)

PME Council

8:00 AM – 11:00 AM

AMS Session on Combinatorics, I

8:15 AM – 10:55 AM

8:15AM ► (832) *Improved Pebbling Bounds.* Preliminary report.
Melody Chan, Yale University (983-05-1423)

8:30AM ► (833) *Random Growth of Caterpillar Graphs.* Preliminary report.
Gabriel Zimmer, East Tennessee State University (983-05-1416)

8:45AM ► (834) *Algorithmic advances in finding cycles of certain lengths in graphs.*
Stephen E. Shauger, Coastal Carolina University (983-05-1415)

9:00AM ► (835) *Even Submatrices of Zero-One Matrices.* Preliminary report.
Joe Johnson, East Tennessee State University (983-05-1413)

9:15AM ► (836) *On the degree of local permutation polynomials.* Preliminary report.
Wiebke S Diestelkamp*, University of Dayton, **Stephen G Hartke**, Rutgers University, and **Rachael H Kenney**, North Carolina State University (983-05-1402)

9:30AM ► (837) *A Variant of Hadamard's Conjecture.* Preliminary report.
Justin D Christian, University of Wyoming (983-05-1315)

9:45AM ► (838) *Random Walks, Trees and Extensions of Riordan Group Techniques.* Preliminary report.
Naiomi T. Cameron, Harvey Mudd College (983-05-1276)

10:00AM (839) *t-Split Interval Orders.*
Trisha Moller, Lehigh University (983-05-1274)

10:15AM ► (840) *The m-Step, Same-Step, and Any-Step Competition Graphs.*
Wei Ho, Harvard University (983-05-1218)

10:30AM ► (841) *The Probabilities of Odd/Even Combinations in Lotto.*
David R. Stone and **Patricia B Humphrey***, Georgia Southern University (983-05-1154)

10:45AM ► (842) *Multidesigns for higher lambda.*
Atif A Abueida, University of Dayton, and **Mike Daven***, Mount Saint Mary College (983-05-1115)

AMS Special Session on Algebraic Topology Based on Knots, I

8:30 AM – 10:50 AM

Organizers: **Mark E. Kidwell**, U.S. Naval Academy
Jozef H. Przytycki, The George Washington University
Yongwu Rong, The George Washington University

8:30AM (843) *Some experiments towards the algebraic topology of 3-manifold invariants.* Preliminary report.
Fernando J. O. Souza, University of Iowa (983-57-1460)

9:00AM (844) *Braid group representations from hyperplane arrangements.* Preliminary report.
Ruth Lawrence*, Hebrew University of Jerusalem, Israel, and **Ofer Ron**, Hebrew University of Jerusalem, ISRAEL (983-57-1490)

9:30AM (845) *Turaev-Viro invariants away from roots of unity.*
Charles D Frohman, University of Iowa, and **Joanna Kania-Bartoszynska***, Boise State University (983-57-1238)

10:00AM (846) *Remarks on the Geometry of the Jones Polynomial.* Preliminary report.
Oliver Dasbach*, Louisiana State University, and **Xiao-Song Lin**, University of California, Riverside (983-57-1459)

10:30AM (847) *Deformations of triangulations on surfaces.*
Feng Luo*, Rutgers University, and **Ben Chow**, UCSD (983-57-1302)

AMS Session on Geometry and Topology, I

8:30 AM – 10:55 AM

8:30AM ► (848) *An elementary, purely geometrical classification of the 17 planar crystallographic groups (wallpaper patterns).*
George Baloglou, SUNY Oswego (983-51-51)

8:45AM ► (849) *Petrie Schemes and Petrie Polygons.*
Gordon Ian Williams, Moravian College (983-52-737)

9:00AM (850) *A discrete computation of the volume of the Birkhoff polytope.* Preliminary report.
Matthias Beck* and **Dennis Pixton**, SUNY Binghamton (983-52-41)

9:15AM (851) *Mathematical Aspects of Kaluza-Klein Gravity.* Preliminary report.
David E Betounes, University of Southern Mississippi (983-53-756)

9:30AM (852) *Isospectral Deformations on $SU(n)$.*
Emily B. Proctor, Dartmouth College (983-53-854)

9:45AM (853) *Precompactness of solutions of the Ricci flow in the absence of injectivity radius estimates.* Preliminary report.
David Glickenstein, UC San Diego (983-53-1198)

10:00AM (854) *Moduli space of symmetric connections.* Preliminary report.
Stanislav Dubrovskiy, Northeastern University (983-53-119)

10:15AM (855) *Semilattices On Compact Spaces.* Preliminary report.
T. Banakh, Ivan Franko LVIV National University, **O. Gutik**, Pidstrygach Institute of Applied Problems of Mechanics and Mathematics of National Academy of Science, and **M Rajagopalan***, Tennessee State University (983-54-594)

10:30AM (856) *T2-(Surface) Topology of Chemical Bond.* Preliminary report.
Okan Gurel*, IBM, and **Demet Gurel**, Touro College (983-54-1267)

10:45AM (857) *Topology and Geometry of Moduli Spaces of Multipolygonal Linkages.* Preliminary report.
Michael Edward Holcomb, Louisiana State University (983-54-1436)

AMS Invited Address

9:00 AM – 9:50 AM

(858) *Efficient algorithms for finding a random needle in a combinatorial haystack.*
Dana Randall, Georgia Institute of Technology (983-68-03)

ASL Invited Address

9:00 AM – 9:50 AM

(859) *Model theory and differential algebra.*
David E. Marker, University of Illinois at Chicago

AMS Special Session on Stochastic and Multiscale Problems in the Sciences, I

9:00 AM – 10:50 AM

Organizers: **Weinan E**, Princeton University
Shiyi Chen, Johns Hopkins University
Eric Vanden-Eijnden, New York University-Courant Institute

9:00AM (860) *An Atomistic/Continuum simulation of Multiscale Fluid Flows.*
Shiyi Chen* and **Xiaobo Nie**, The Johns Hopkins University (983-76-1162)

9:30AM (861) *Hybrid atomistic-continuum methods for multiscale hydrodynamics.*
Nicolas G Hadjiconstantinou, MIT (983-76-1434)

10:00AM (862) *Modeling and Simulation of Martensitic Microstructure.*
Bo Li, University of Maryland (983-74-1161)

10:30AM (863) *Conformational Dynamics in Complex Systems: Theory and Computational Aspects.*
Weinan E, Princeton University, **Weiqing Ren**, Insitute for Advanced Study, and **Eric Vanden-Eijnden***, Courant Institute (983-60-1476)

MAA Minicourse #12: Part B

9:00 AM – 11:00 AM

Getting students involved in undergraduate research.
Organizers: **Aparna W. Higgins**, University of Dayton
Joseph A. Gallian, University of Minnesota, Duluth

MAA Minicourse #1: Part B

9:00 AM – 11:00 AM

Teaching introductory statistics using a workshop approach.
Organizer: **James H. Albert**, Bowling Green State University

MAA Minicourse #7: Part B

9:00 AM – 11:00 AM

The mathematics of presidential and other elections.
Organizer: **Steven J. Bram**, New York University

MAA Session on Assessment of Student Learning: Models and Methodology, I

9:00 AM – 10:55 AM

Organizers: **Jay A. Malmstrom**, Oklahoma City Community College
Linda Martin, Albuquerque-TVI
Mercedes A. McGowen, William Rainey Harper College

9:00AM ► (864) *A Project Based Assessment of General Education Requirements.* Preliminary report.
Jay A Malmstrom, Oklahoma City Community College (983-N1-427)

9:20AM (865) *Assessment of General Education Mathematics Requirements.* Preliminary report.
Richard D. West, Francis Marion University (983-N1-489)

9:40AM ► (866) *Starting Student Portfolios.* Preliminary report.
Brian Hopkins* and **Kathy Safford-Ramus**, Saint Peter's College (983-N1-383)

10:00AM (867) *The Evolution of a Departmental Assessment Plan.*
Barbara M. Moskal, Colorado School of Mines (983-N1-33)

10:20AM ► (868) *Assessing An Undergraduate Major in Mathematics-A Model.*
James R. Fulmer* and **Thomas C. McMillan**, University of Arkansas at Little Rock (983-N1-1253)

10:40AM (869) *The Keyboard vs. The Pencil: One approach to incorporating technology into assessment.*
Elizabeth W. Schott*, **Michelle M. McCassey**, **John A. Wasko** and **Alex J. Heidenberg**, USMA, West Point, NY (983-N1-448)

MAA-University of Arizona Special Presentation

9:00 AM - 10:55 AM

Course in interdisciplinary business mathematics (repeated from 1:00 p.m. to 3:00 p.m. and 5:00 p.m. and 7:00 p.m., Friday).

Organizer: **Richard B. Thompson**, University of Arizona

MAA Committee on the Participation of Women Panel Discussion

9:00 AM - 10:20 AM

Improving the persistence of women in graduate school.

Organizers: **Ruth G. Favro**, Lawrence Technological University
Kristen S. Moore, University of Michigan, Ann Arbor
Sarah-Marie Belcastro, Xavier University

Moderator: **Raymond L. Johnson**, University of Maryland, College Park

Panelists: **Abbe H. Herzig**, Rutgers University
Ivelisse M. Rubio, University of Puerto Rico
Judy L. Walker, University of Nebraska

MAA Special Presentation

9:00 AM - 10:20 AM

Proposal writing workshop for grant applications to the NSF Division of Undergraduate Education.

Organizers: **Elizabeth J. Teles**, NSF
Lee L. Zia, NSF

MAA Women and Mathematics Network Poster Session

9:00 AM - 11:00 AM

Special programs to encourage young women in mathematics.

Organizers: **Elizabeth G. Yanik**, Emporia State University
Kathleen A. Sullivan, Seattle University

Exhibits and Book Sales

9:30 AM - 5:30 PM

Math on the Web, III

10:00 AM - 5:20 PM

10:00AM (870) *The case for structured documents in math and science.*
Robert Miner*, Design Science, and **Patrick Ion***, AMS

11:15AM (871) *MathML in the digital library of mathematical functions.*
Bruce Miller, NIST

1:00PM (872) *MathML, OpenMath, and Web services.*
David Carlisle, The Numerical Algorithms Group Ltd.

2:00PM (873) Maple *on the Web: New technologies, products, and applications.*
Tom Lee, Waterloo Maple

3:00PM (874) *Creating mathematical documents for the Web with* Scientific Workplace.
Barry MacKichan, MacKichan, Inc.

4:00PM (875) *Mathematics on the Web.*
Patrick Ion, AMS

5:00PM (876) *TeX to Web conversion.*
Stan Devitt, Stratum Technical Services Ltd.

AMS Invited Address

10:05 AM - 10:55 AM

(877) *Motivic homotopy theory.*
Vladimir Voevodsky, Institute for Advanced Study

ASL Invited Address

10:05 AM - 10:55 AM

(878) *Initial segments of the Turing degrees with a view toward automorphisms.*
Bjorn Kjos-Hanssen, Ruprecht-Karls-Universität Heidelberg

AMS-MAA Invited Address

11:10 AM - NOON

(879) *Some novel uses of lattice reduction.*
Noam D. Elkies, Harvard University (983-11-16)

AMS Colloquium Lectures:Lecture III

1:00 PM - 1:50 PM

(880) *Spectra of hyperbolic surfaces and applications, III.*
Peter Sarnak, Courant Institute and Princeton University

MAA Student Lecture

1:00 PM - 1:50 PM

(881) *What drives mathematics and where is mathematics driving innovation?*
Donna L. Beers, Simmons College

AMS-MAA-SIAM Special Session on Research in Mathematics by Undergraduates, II

1:00 PM - 4:50 PM

Organizers: **Darren A. Narayan**, Rochester Institute of Technology
Carl V. Lutzer, Rochester Institute of Technology

Tamara A. Burton, Rochester Institute of Technology

1:00PM ► (882) *Tournaments with a Transitive Tournament Feedback Arc Set.*
Jennifer L. Baldwin* and **Darren A. Narayan**, Rochester Institute of Technology (983-05-797)

1:30PM ► (883) *When does F_m^L divide F_n? A combinatorial solution.*
Jeremy A Rouse* and **Arthur T Benjamin**, Harvey Mudd College (983-05-605)

2:00PM ► (884) *Random Versions of Seymour's Distance two Conjecture.* Preliminary report.
Elizabeth Wright*, Tulane University, and **Zachary Cohn**, University of Chicago (983-05-1426)

2:30PM ► (885) *Signed Graph Laplacians.*
Mitchel T Keller, North Dakota State University, Fargo, ND (983-05-586)

3:00PM ► (886) *Mathematical Modeling of Cascading Water Clocks.*
Jennifer Goodenow* and **David S. Ross**, Rochester Institute of Technology (983-76-1066)

3:30PM ► (887) *Notes on the structure of $P\Sigma_n$.* Preliminary report.
Rebecca Dolphin*, Mary Washington College, **E Erin Corman**, Keene State College, and **Leonard A VanWyk**, James Madison University (983-20-316)

4:00PM ► (888) *Winning the Most on "The Weakest Link".*
Theresa M Meshes, Dominican University (983-60-752)

4:30PM ► (889) *Contributions to the Coupon Collector's Problem: The Stein-Chen Method and Poisson Process Approximation.* Preliminary report.
Natalie Lents*, Centre College, **Erin LeDell**, Trinity College, and **Alina Nicoleta Badus**, Carleton College (983-60-1431)

AMS-MAA Special Session on The History of Mathematics, II

1:00 PM – 4:55 PM

Organizers: **Joseph W. Dauben**, Lehman College
David E. Zitarelli, Temple University

1:00PM ► (890) *The history of the teaching of mathematics in Mexico in the XIX century.* Preliminary report.
Alejandro R. Garciadiego, Universidad Nacional Autónoma de México (983-01-590)

1:30PM ► (891) *Historical Survey of the Octonions.*
W Harold Davenport, Mesa State College (983-01-76)

2:00PM ► (892) *The First Chinese Translation of the Last Nine Books of Euclid's Elements and its Source.*
Yibao Xu, CUNY Graduate Center (983-01-174)

2:30PM (893) *Reform, Bureaucratic Expansion and Production of Numbers: Statistics in China at the Turn of the 20th Century.* Preliminary report.
Andrea Bréard, CUNY Graduate Center (983-01-184)

3:00PM ► (894) *Reducing imaginary quantities: an episode from the history of the Fundamental Theorem of Algebra.*
Robert E Bradley, Adelphi University (983-01-626)

3:30PM ► (895) *Toward a biography of William A. Granville.* Preliminary report.
George M. Rosenstein, Franklin & Marshall College (983-01-99)

4:00PM ► (896) *Major Percy Alexander MacMahon - the Victorian combinatorialist.* Preliminary report.
Paul Garcia, Open University (983-01-872)

4:30PM ► (897) *Paul Dirac and his Beautiful Mathematics.* Preliminary report.
Shawnee L. McMurran, California State University San Bernardino (983-01-379)

AMS Special Session on Stochastic and Multiscale Problems in the Sciences, II

1:00 PM – 3:20 PM

Organizers: **Weinan E**, Princeton University
Shiyi Chen, Johns Hopkins University
Eric Vanden-Eijnden, New York University-Courant Institute

1:00PM (898) *Cracks and Crazes: Connecting molecular simulations to the macroscopic fracture energy of glassy polymers.*
Mark O Robbins*, **Joerg Rottler** and **Sandra Barsky**, Johns Hopkins University (983-82-1241)

1:30PM (899) *From quantum-mechanics to fracture: atomistic multiscale simulations of silicon.*
Noam Bernstein, Naval Research Laboratory (983-70-1453)

2:00PM ► (900) *A Stochastic Bacterial Transport Model in a Porous Medium.*
Benito M Chen, University of Wyoming, and **Satoko Kurita***, Black Hills State University (983-41-1183)

2:30PM (901) *Heat Flow in a Random Medium and Homogenization.* Preliminary report.
Ian Frederick Pulizzotto, University of Michigan (983-35-79)

3:00PM ► (902) *Rounding Error in Numerical Analysis of Stochastic Differential Equations.* Preliminary report.
Armando Arciniega* and **Edward J. Allen**, Texas Tech University (983-65-637)

AMS Special Session on Wavelets, Frames and Operator Theory, II

1:00 PM – 5:50 PM

Organizers: **Christopher Heil**, Georgia Institute of Technology
Palle Jorgensen, University of Iowa
David Larson, Texas A&M University

1:00PM (903) *Frames in Communications.*
Jelena Kovacevic, Bell Labs (983-94-581)

1:30PM (904) *Operator Parametrization and Tight Frame Approximations.*
Deguang Han, University of Central Florida (983-42-633)

2:00PM (905) *Superwavelets and Generalized Multiresolution Analysis.* Preliminary report.
Eric S Weber, University of Wyoming (983-42-659)

2:30PM (906) *Ellipsoidal Tight Frames.*
Keri Kornelson*, **Ken Dykema**, Texas A&M University, **Dan Freeman**, Guilford College, **Dave Larson**, Texas A&M University, **Marc Ordower**, Randolph-Macon Woman's College, and **Eric Weber**, University of Wyoming (983-47-790)

3:00PM (907) *Wilson bases and Convolution.* Preliminary report.
Mark C Lammers, Western Washington University (983-41-959)

3:30PM (908) *Global structure of the scaling-wavelet variety.*
Ola Bratteli, University of Oslo (983-47-616)

4:00PM (909) *On MRA Riesz Wavelets.*
Richard A. Zalik, Auburn University (983-42-568)

4:30PM (910) *Unitary operators preserving wavelets.*
Ziemowit Rzeszotnik*, University of Texas at Austin, and **Xiaofei Zhang**, Texas A&M University (983-42-978)

5:00PM (911) *A (p,q) weighted version of a theorem of J. Bourgain.*
John J Benedetto and **Alexander M Powell***, University of Maryland (983-42-682)

5:30PM (912) *Generalized Shift-Invariant Systems.*
Amos Ron*, UW-Madison, and **Zuowei Shen**, National University of Singapore (983-42-592)

AMS Special Session on The Many Lives of Lattice Theory and the Theory of Ordered Sets, with Connections to Combinatorics, I

1:00 PM - 5:55 PM

Organizers: **Jonathan D. Farley**, University of Oxford
Stefan E. Schmidt, New Mexico State University
Alex J. Pogel, New Mexico State University

1:00PM (913) *Results and Partial Counterexamples on Order Reconstruction.*
Bernd S. W. Schroeder, Louisiana Tech University (983-06-661)

1:30PM (914) *Monotone Strategies in Games of Incomplete Information.*
David L McAdams, MIT Sloan School of Management (983-06-1031)

2:00PM ► (915) *Stable Communes: a Generalization of Gale and Shapley's Stable Marriages.*
Samuel B. Johnson, Eureka College (983-06-861)

2:30PM ► (916) *Lattice Theory Applied to the Consumer's Problem: Income Effects.*
Richard R Ruble*, Michigan State University, and **Leonard J. Mirman**, University of Virginia (983-06-1479)

3:00PM ► (917) *The algebra of decompositions - applications to physics.*
John R Harding, New Mexico State University (983-06-107)

3:30PM (918) *Sharp and Unsharp elements in Effect algebras: A case for sequential effect algebras as models for quantum logic.*
Dick Greechie, Louisiana Tech University (983-06-1444)

4:00PM (919) *The Poset of Irreducibles and Its Applications.*
George Markowsky, University of Maine (983-06-1398)

4:30PM (920) *Priestley's Duality from Stone's.*
Isidore Fleischer, Centre de recherches mathématiques (983-06-108)

5:00PM (921) *A Priestley duality for bounded distributive residuated lattices.*
Nikolaos Galatos, Vanderbilt University (983-06-1329)

5:30PM (922) *The Priestley separation axiom for scattered spaces.*
Guram Bezhanishvili, **Ray Mines** and **Patrick J Morandi***, New Mexico State University (983-54-784)

AMS Special Session on C-Extensions and Classifications of C*-Algebras, I*

1:00 PM - 4:25 PM

Organizers: **Shuang Zhang**, University of Cincinnati
Huaxin Lin, University of Oregon

1:00PM (923) *Remarks on non-stable K-theory.*
Lawrence G. Brown, Purdue University (983-46-1036)

2:00PM (924) *Quotient Hilbert Modules and C*-Extensions.* Preliminary report.
Ronald G Douglas, Texas A & M University (983-47-565)

2:30PM (925) *A new look at the Universal Coefficient Theorem for Ext.*
Jonathan M. Rosenberg, University of Maryland (983-19-670)

3:00PM (926) *Life After K-Theory.* Preliminary report.
Claude L. Schochet, Wayne State University (983-46-667)

3:30PM (927) *Commutant Algebras of Cowen-Douglas Operators.*
Chunlan Jiang, Hebei Normal University (983-47-1344)

4:00PM (928) *Recent results and questions concerning the classification of amenable C*-algebras.*
George A. Elliott, University of Toronto (983-46-1458)

AMS Special Session on Homotopy Theory, II

1:00 PM - 5:50 PM

Organizers: **Kristine Baxter Bauer**, Johns Hopkins University
J. Michael Boardman, Johns Hopkins University
Nitu Kitchloo, Johns Hopkins University
Jean-Pierre Meyer, Johns Hopkins University
Jack Morava, Johns Hopkins University
W. Stephen Wilson, Johns Hopkins University

1:00PM (929) *The structure of $E(n)_*E(n)$-comodules.* Preliminary report.
Mark Hovey*, Wesleyan University, and **Neil Strickland**, University of Sheffield (983-55-629)

1:30PM (930) *The homology of inverse limits of spectra.*
Hal Sadofsky, University of Oregon (983-55-1467)

2:00PM (931) *A Lyndon-Hochschild-Serre spectral sequence for certain homotopy fixed point spectra.*
Ethan S Devinatz, University of Washington (983-55-751)

2:30PM (932) *The circle-equivariant sigma orientation.*
Matthew Ando, University of Illinois at Urbana-Champaign (983-55-734)

3:00PM (933) *v_1-periodic homotopy groups of compact simple Lie groups.*
Donald M. Davis, Lehigh University (983-55-562)

3:30PM (934) *A new approach to the Landweber exact functor theorem.*
Haynes R Miller, MIT (983-55-1057)

4:00PM (935) *Some odd primary analogs of the Adams-Priddy joker.*
Douglas C Ravenel, University of Rochester (983-55-1157)

4:30PM (936) *Fixity and Group Actions.* Preliminary report.
Alejandro Adem*, University of Wisconsin, **J. Davis**, Indiana University, and **Ozgun Unlu**, University of Wisconsin (983-55-1351)

5:00PM (937) *A polarized view of String Topology.* Preliminary report.
Ralph L Cohen, Stanford University (983-55-713)

5:30PM (938) *The latest? on cohomological physics.* Preliminary report.
Jim Stasheff, University of North Carolina (983-81-1188)

AMS Special Session on Algebraic Topology Based on Knots, II

1:00 PM - 5:50 PM

Organizers: **Mark E. Kidwell**, U.S. Naval Academy
Jozef H. Przytycki, The George Washington University
Yongwu Rong, The George Washington University

1:00PM (939) *Mahler's measure of A-polynomial and hyperbolic volume.* Preliminary report.
Adam S. Sikora, SUNY Buffalo (983-57-1290)

1:30PM (940) *Mahler measure, Lehmer's Question and knot theory.* Preliminary report.
Daniel S. Silver* and **Susan G. Williams**, University of South Alabama (983-57-1242)

2:00PM (941) *Kauffman bracket skein module of quaternionic space.* Preliminary report.
John M. Harris, Louisiana State University (983-57-1463)

2:30PM (942) *The noncommutative generalization of the A-polynomial of the figure eight knot.*
Razvan Gelca*, Texas Tech University, and **Jeremy Sain**, University of California at Berkeley (983-57-866)

3:00PM (943) *String and skein topology of oriented 3-manifolds.* Preliminary report.
Uwe Kaiser, Boise State University (983-57-1200)

3:30PM (944) *Moves on links and Burnside group obstructions.*
Mieczyslaw K. Dabkowski* and **Jozef H. Przytycki**, George Washington University (983-57-1283)

4:00PM (945) *Kauffman Bracket skein modules over the field of rational functions.* Preliminary report.
Patrick M Gilmer, Louisiana State University (983-57-1265)

4:30PM (946) *The Kauffman Bracket Skein Module of a Twist Knot Exterior.* Preliminary report.
Doug Bullock, Boise State University, and **Walter Lo Faro***, University of Wisconsin, Stevens Point (983-57-678)

5:00PM (947) *Detecting torsion in skein modules using Hochschild homology.*
Michael McLendon, Washington College (983-57-1347)

5:30PM (948) *The Kauffman polynomials of genaralized Hopf links.* Preliminary report.
Jianyuan K. Zhong*, Louisiana Tech University, and **Bin Lu**, The University of Arizona (983-57-834)

AMS Special Session on Computational Algebraic and Analytic Geometry for Low-Dimensional Varieties, III

1:00 PM - 5:50 PM

Organizers: **Mika K. Seppälä**, Florida State University
Emil J. Volcheck, Baltimore, Maryland

1:00PM (949) *Numerical computation of modular forms, with applications to Riemann surfaces.* Preliminary report.
Andreas Strombergsson, Princeton University (983-30-924)

1:30PM (950) *Conformal motion by mean curvature for surfaces.* Preliminary report.
Charles R. Collins and **Ken Stephenson***, University of Tennessee (983-30-657)

2:00PM (951) *Calculating explicit elements of prime order in the mapping class group.* Preliminary report.
Peter Turbek, Purdue University Calumet (983-14-1318)

2:30PM (952) *Representations of finite groups on the Riemann-Roch space of a curve.* Preliminary report.
David Joyner* and **Will Traves**, Math Dept, US Naval Academy (983-14-656)

3:00PM (953) *Redset and Singset of a Plane Curve.*
Shreeram S Abhyankar, Purdue University (983-14-154)

3:30PM (954) *Holography principle and arithmetic of algebraic curves.*
Yuri I Manin and **Matilde Marcolli***, MPI-Bonn (983-14-732)

4:00PM (955) *Complex Multiplication for Abelian Manifolds of Arbitrary Genus.* Preliminary report.
Harvey Cohn, Center for Communications Research, La Jolla (983-11-140)

4:30PM (956) *Computational Geometry via the Dixon Resultant.* Preliminary report.
Robert H. Lewis, Fordham University (983-14-986)

5:00PM (957) *Zeros of random polynomials with prescribed Newton polytope.*
Bernard Shiffman* and **Steve Zelditch**, Johns Hopkins University (983-14-736)

5:30PM (958) *A New Method for Decoding Algebraic Geometry Codes.* Preliminary report.
Jeffrey B. Farr* and **Shuhong Gao**, Clemson University (983-13-692)

AMS Special Session on Banach Space Theory and Convex Geometry, III

1:00 PM - 5:55 PM

Organizers: **Teck-Cheong Lim**, George Mason University
Mikhail Ostrovskii, The Catholic University of America

1:00PM (959) *Hilbert space frames, restricted invertibility and the paving conjecture.*
Peter G. Casazza*, University of Missouri - Columbia, **Ole Christensen**, Technical University of Denmark, **Alex Lindner**, Technical University of Munich, and **Roman Vershynin**, University of Alberta (983-46-463)

1:30PM (960) *Spaces with Maximal Projection Constants.*
Bruce L. Chalmers*, Univ. of Calif., Riverside, and **Grzegorz Lewicki**, Jagiellonian Unv., Krakow (983-46-252)

2:00PM (961) *Some questions from the Resume that've survived.* Preliminary report.
Joe Diestel, Kent State University (983-46-439)

2:30PM (962) *Fixed point results for maps defined on closed subsets of Fréchet spaces.*
Marlène Frigon, University of Montréal (983-47-847)

3:00PM (963) *Weak compactness is equivalent to the fixed point property in c_0.*
Paddy Dowling, Miami University, **Chris Lennard***, University of Pittsburgh, and **Barry Turett**, Oakland University (983-46-1044)

3:30PM (964) *The Bishop-Phelps Theorem fails for any uniform non-selfadjoint dual operator algebra.*
Victor I Lomonosov, Kent State University (983-46-1015)

4:00PM (965) *Non-Linear versions of Dvoretzky's Theorem.*
Assaf Naor*, Microsoft Research, **Yair Bartal**, **Manor Mendel** and **Nathan Linial**, Hebrew University (983-52-715)

4:30PM (966) *Some geometric properties of operators acting from L_1.*
Mikhail M. Popov, Chernivtsi National University (983-46-180)

5:00PM (967) *Some problems of convex geometry related to spaces of smooth functions.*
Nahum Zobin, College of William and Mary (983-46-864)

5:30PM (968) *Volumes of projections of convex bodies via Fourier transform.*
Alexander Koldobsky, **Dmitry Ryabogin** and **Artem Zvavitch***, University of Missouri, Columbia (983-52-1178)

AMS Special Session on Mathematical Current Events: Expository Reports

1:00 PM – 4:40 PM

Organizer: **David Eisenbud**, Mathematical Sciences Research Institute

1:00PM (969) *Homotopy Theory of Schemes.*
Michael J Hopkins, MIT (983-19-1428)

2:00PM (970) *Sublinear algorithms for sparse approximations with excellent odds.*
Ingrid Daubechies, Princeton University (983-41-1214)

3:00PM (971) *Recent advances in the Langlands Program.*
Edward Frenkel, University of California, Berkeley (983-14-1260)

4:00PM (972) *The wave maps equation.*
Daniel Tataru, UC Berkeley (983-35-1377)

AMS Special Session on Inverse Problems and Sampling Theory in Signal Analysis, III

1:00 PM – 6:20 PM

Organizer: **M. Zuhair Nashed**, University of Central Florida

1:00PM (973) *Sampling expansions in multivariate unitarily translation invariant reproducing kernel Hilbert spaces.* Preliminary report.
M. Zuhair Nashed, **Cornelis Victor Maria Van Der Mee** and **Sebastiano Seatzu*** (983-34-972)

1:30PM (974) *Discrete Hermite Functions using Wrap-Around Sampling.*
Dale H. Mugler* and **Stuart Clary**, The University of Akron (983-42-1017)

2:00PM (975) *Numerical Solution of a Parabolic Partial Differential Equation with a Trace Type Coefficient.* Preliminary report.
John R. Cannon, University of Central Florida (983-35-841)

2:30PM (976) *Inverse acoustic scattering.*
Ian H. Sloan, University of New South Wales (983-65-1155)

3:00PM (977) *Numerical Approximate Solutions to Generalized Inverse Steklov Problems.*
Mario Ahues* and **Alain Largillier**, University of Saint Etienne, France. (983-65-249)

3:30PM (978) *Well Posed Inversion.*
F. Stenger*, University of Utah, and **R. Ramlau**, University of Bremen (983-35-1381)

4:00PM (979) *Efficient methods for Toeplitz and related equations with applications.* Preliminary report.
Paulo J. S. G. Ferreira, Universidade de Aveiro / Portugal, and **Elena Dominguez***, Universidad Politecnica de Madrid (983-65-992)

4:30PM (980) *Dimensionality reduction in data anslysis (that is, data on diet).*
Umberto Amato, Istituto per le Applicazioni del Calcolo 'Mauro Picone' CNR, Sezione di Napoli (983-62-690)

5:00PM ► (981) *Sampling eigenvalues of fourth order Sturm-Liouville problems.*
Amin Boumenir, State University of West Georgia (983-34-208)

5:30PM ► (982) *Inverse Problems and Sampling Theorems.* Preliminary report.
Ahmed I Zayed, DePaul University (983-42-999)

6:00PM (983) *Inverse Scattering for the Zakharov-Shabat System on the Line.*
Cornelis Van der Mee, University of Cagliari (983-93-943)

MAA Minicourse #13: Part B

1:00 PM – 3:00 PM

Incorporating discrete mathematics in the preparation of K-12 mathematics teachers.
Organizer: **Lolina Alvarez**, New Mexico State University

MAA Minicourse #2: Part B

1:00 PM – 3:00 PM

Java applets in teaching mathematics.
Organizers: **Joe Yanik**, Emporia State University
David M. Strong, Pepperdine University

MAA Minicourse #8: Part B

1:00 PM – 3:00 PM

Mathematical finance.
Organizers: **Walter R. Stromquist**
Alan H. Durfee, Mount Holyoke College

AMS Session on Geometry and Topology, II

1:00 PM – 4:25 PM

1:00PM (984) *Calibers and dense subsets.* Preliminary report.
Istvan Juhasz, MTA Renyi Institute of Mathematics, and **Andrzej Szymanski***, Slippery Rock University of Pennsylavania (983-54-1343)

1:15PM (985) *Properties of Abcohesive Spaces.*
Shing S So*, Central Missouri State University, and **David A John**, Missouri Western State College (983-54-985)

1:30PM (986) *Comparing the Homotopy Types of† $[G, 2]$-Complexes for 2-Knot Groups G.* Preliminary report.
Katherine S Byler, California State University, Fresno (983-55-1396)

1:45PM (987) *A New Magnus Embedding Theorem.* Preliminary report.
Jacqueline A Jensen, Sam Houston State University (983-55-1192)

2:00PM (988) *Simple homotopy for simplicial sets.*
Mehdi Hakim-Hashemi, University of Minnesota (983-55-815)

2:15PM (989) *A counterexample to the 3-dimensional Poincaré conjecture or a simplicial decomposition of the 3-sphere.* Preliminary report.
Francis D Lonergan, none (983-55-286)

2:30PM (990) *Kirby Diagrams from Branched-Covering Descriptions of 3-Manifolds.*
Frank J Swenton, Middlebury College (983-57-759)

2:45PM (991) *A skein theoretic construction of invariants of 3-manifolds associated to the quantum group* $U_q(\mathfrak{g}_2)$. Preliminary report.
Timothy J. O'Brien, Alexandria, VA (983-57-1119)

3:00PM (992) *Examples and Applications of the Consistency Test.* Preliminary report.
Travis R Kelm, St. Edward's University (983-57-1433)

3:15PM ► (993) *Chirality of Alternating Knots in* $S \times I$. Preliminary report.
Thomas Fleming, University of California San Diego (983-57-1268)

3:30PM ► (994) *Upper Bounds for Equilateral Stick Numbers of Knots.*
Eric J Rawdon*, Duquesne University, and **Robert G Scharein**, Simon Frasier University (983-57-631)

3:45PM (995) *A new proof of the Baum-Connes conjecture for a-T-menable groups.* Preliminary report.
Constantin Dorin Dumitraşcu, Dartmouth College (983-19-1469)

4:00PM (996) *Quantum Entanglement, Topological Entanglement and Categorification.* Preliminary report.
Gianfranco Mascari, Italian National Research Council (983-81-655)

4:15PM (997) *Simplified method for classification of entanglement types.*
David W. Lyons* and **Scott N. Walck**, Lebanon Valley College (983-81-114)

AMS Session on Functional Analysis, II

1:00 PM – 4:55 PM

1:00PM (998) *DP1 and Completely Continuous Operators.* Preliminary report.
Elizabeth M Bator*, University of North Texas, and **Dawn R Slavens**, Midwestern State University (983-46-857)

1:15PM (999) *Spaces of Operators,* c_0, *and* ℓ_1.
Elizabeth M. Bator and **Paul W. Lewis***, University of North Texas (983-46-766)

1:30PM (1000) *Sectional representation of Banach modules and their multipliers.*
Terje Hoim and **D. A. Robbins***, Trinity College (983-46-580)

1:45PM (1001) *Hadamard series in Banach spaces with two applications.*
Nicholas N. Vakhania, Institute of Computational Mathematics (983-46-247)

2:00PM (1002) *Some extremal properties of section spaces of Banach bundles and their duals, II.*
Terje Hoim* and **D. A. Robbins**, Trinity College (983-46-202)

2:15PM (1003) *Besov functions and vanishing exponential integrability.*
D. R. Adams, University of Kentucky, and **R. Hurri-Syrjanen***, University of Helsinki (983-46-116)

2:30PM (1004) *Spectrum Preserving Maps of C*-algebras with Real Rank Zero.*
Istvan Kovacs, University of Kentucky (983-46-78)

2:45PM (1005) *Embry truncated complex moment problem.*
Il Bong Jung*, Kyungpook National University, **Eungil Ko**, Ewha Women's University, **Chunji Li**, Northeastern University, and **Sang Soo Park**, Kyungpook National University (983-47-1468)

3:00PM (1006) *Unique solvability and the number of solutions of Hammerstein equations.* Preliminary report.
P. S. Milojevic, New Jersey Institute of Technology, Newark, NJ, 07102 (983-47-1366)

3:15PM (1007) *Operators lambda-commuting with a non-zero compact.* Preliminary report.
Vasile Lauric, Wheeling Jesuit University (983-47-1221)

3:30PM (1008) *Generalized Inverses in Extension Algebras.* Preliminary report.
Lisa A Oberbroeckling, Loyola College in Maryland (983-47-1008)

3:45PM (1009) *On the Solvability of the Cauchy Problem for a unbounded Matrix operator.*
Toka Diagana, Howard University (983-47-23)

4:00PM (1010) *Compactly Bounded Convolutions of Measures.*
Adam W Parr, University of the Virgin Islands (983-43-360)

4:15PM (1011) *Apprximation Operators and Summability.*
Jerry P. King, Lehigh University (983-41-1011)

4:30PM (1012) *Polynomial Approximation with Exponential Weights.*
Michael I. Ganzburg, Hampton University (983-41-90)

4:45PM (1013) *Semi-Regular Multiresolutions Generated by Minimally Supported Scaling Vectors.*
Derek Bruff, Vanderbilt University (983-41-1485)

AMS Session on Algebraic Geometry and Algebra

1:00 PM – 4:55 PM

1:00PM (1014) *The Geometry of a "Generic" Quantum Projective 3-space.* Preliminary report.
Pete D Goetz, University of Oregon (983-14-1441)

1:15PM (1015) *On Ellingsrud and Strømme's explicit description of a cell decomposition of the Hilbert scheme of points of the affine plane.*
Mark E Huibregtse, Skidmore College (983-14-1373)

1:30PM (1016) *Weak Simultaneous Resolution.* Preliminary report.
John J. Iskra, University of Tennessee, Knoxville (983-14-1182)

1:45PM (1017) *The Hopf Algebra of a Uniserial Group.*
Alan Koch, Agnes Scott College (983-14-844)

2:00PM ► (1018) *Translations of Data Points in* $\mathbb{R}^3$. Preliminary report.
Kristofer D Jorgenson, University of the Incarnate Word (983-14-327)

2:15PM (1019) *Equation of Parametric Surfaces with a Single Base Point of Multiplicity k Via Syzygies.* Preliminary report.
Haohao Wang, Louisiana State University (983-14-251)

2:30PM (1020) *Peculiar loci of ample and spanned line bundles.* Preliminary report.
Gian Mario Besana*, DePaul University, **Sandra Di Rocco**, Royal Institute of Technology, and **Antonio Lanteri**, Universita' di Milano (983-14-207)

2:45PM ► (1021) *On computing left eigenvalues of* 3×3 *quaternionic matrix.* Preliminary report.
Wasin So, San Jose State University (983-15-402)

3:00PM (1022) *Structure of the Zero-Divisor Graph of a Non-Commutative Ring.*
Shane P Redmond, Southeastern Louisiana Univ. (983-16-1172)

3:15PM (1023) *Weight spaces of prime characteristic down-up algebras.*
Jeff Hildebrand, Bates College (983-16-1012)

3:30PM (1024) *Primitive and Poisson Spectra of Twists of Polynomial Algebras.*
M. Katherine Brandl, Centenary College (983-16-763)

3:45PM ► (1025) *Primitive ideals of down-up algebras.*
Iwan Praton, Franklin and Marshall College (983-16-280)

4:00PM (1026) *Constructing* $\mathbb{Z}_2$*-graded Lie triple systems.* Preliminary report.
Nora C Hopkins, Indiana State University (983-17-1491)

4:15PM (1027) *Injective Envelopes From Injective Envelopes.* Preliminary report.
Christopher A. Aubuchon, Johnson State College (983-18-1395)

4:30PM (1028) *Minimal Generators and Injective Modules.* Preliminary report.
Naveed Zaman, West Virginia State College (983-18-681)

4:45PM (1029) *The Lower Algebraic* K*-theory of* Γ_3.
Ivonne Ortiz, SUNY Binghamton (983-19-1390)

AMS Session on Combinatorics, II

1:00 PM – 4:55 PM

1:00PM (1030) *Aster Tolerance Representations for Cycles.* Preliminary report.
Mary Ann Barbato*, Fitchburg State College, and **Nancy Eaton**, University of Rhode Island (983-05-1079)

1:15PM ► (1031) *Decomposition of Almost Complete Tripartite Graphs into Two Isomorphic Factors of Fixed Diameter.*
Ellen E Eischen, Princeton University (983-05-1061)

1:30PM (1032) *Centers of tensor products of graphs.*
Richard H. Hammack*, Randolph-Macon College, and **Ghidewon Abay-Asmerom**, Virginia Commonwealth University (983-05-1016)

1:45PM ► (1033) *Notes on a converse to the Sunada theorem for regular graphs.* Preliminary report.
Gregory T Quenell, Mt. Holyoke College (983-05-1009)

2:00PM (1034) *Asymptotics for the distributions of subtableaux in Young and up-down tableaux.*
David J. Grabiner, National Security Agency (983-05-932)

2:15PM (1035) *An Extension of* Q*-Rook Theory to* $C_m \wr S_n$. Preliminary report.
Karen Sue Briggs, University of California, San Diego (983-05-933)

2:30PM ► (1036) *On Economical and Spannable Linear Forests.* Preliminary report.
Curtis Clark*, Morehouse College, **Frank Harary**, New Mexico State University, and **Thomas Storer**, The University of Michigan (983-05-907)

2:45PM ► (1037) *Graph Powers and* k*-Ordered Hamiltonicity.*
Deniss Cebikins, MIT (983-05-885)

3:00PM ► (1038) *The insulation sequence of a graph.*
Elena Grigorescu, Bard College (983-05-871)

3:15PM ► (1039) *Binary Strings with No Odd Runs of Zeros.* Preliminary report.
Ralph P Grimaldi*, Rose-Hulman Institute of Technology, and **Silvia Heubach**, California State University at Los Angeles (983-05-846)

3:30PM (1040) *A Graph Edge-Coloring Problem.*
D. G. Hoffman and **S. A. Clark***, Auburn University (983-05-826)

3:45PM (1041) *Binary Codes from Graphs on Triples.* Preliminary report.
Jamshid Moori*, University of Natal, South Africa, **Jenny D Key**, Clemson University, and **Bernardo Rodrigues**, University of Natal, South Africa (983-05-814)

4:00PM ► (1042) *An Application of Graph Theory to Surface Reconstruction.*
Darren A Narayan, Rochester Institute of Technology (983-05-775)

4:15PM (1043) *The Terwilliger algebras of almost-bipartite* Q*-polynomial distance-regular graphs.* Preliminary report.
John S. Caughman, Portland State University, **Mark S. MacLean***, University of North Carolina - Asheville, and **Paul M. Terwilliger**, University of Wisconsin - Madison (983-05-773)

4:30PM (1044) *A New Construction of Relative Difference Sets with Galois Rings.*
John B. Polhill, Bloomsburg University (983-05-762)

4:45PM ► (1045) *On* K_**-ultrahomogeneous graphs.*
C Jankowski*, University of Notre Dame, **S Proctor**, California State University - Fullerton, and **D C Isaksen**, University of Notre Dame (983-05-761)

MAA Poster Session on Projects Supported by the NSF Division of Undergraduate Education

1:00 PM – 3:00 PM

Organizer: **Jon W. Scott**, Montgomery Community College

1:00PM (1046) *Demos with positive impact.*
David R Hill*, Temple University, and **Lila F Roberts**, Georgia Southern University

1:00PM (1047) *The Probability/Statistics Object Library.*
Kyle Siegrist, University of Alabama in Huntsville

1:00PM (1048) *Project WELCOME.*
James E White*, The Mathwright Library, and **Dan Kalman**, American University

1:00PM (1049) *Visualization Tools for Three Dimensions.*
Daniel L McGee* and **Rafael Martinez-Planell**, University of Puerto Rico Mayaguez

1:00PM (1050) *Mathematics for Future Secondary Teachers.*
James J Madden, Louisiana State University & Agricultural and Mechanical College

1:00PM (1051) *Not Your Usual Liberal Arts Math Course: Electronic Curricula Materials About Fractals for Students Who Never Liked and Never Did Well in Math.*
Larry S Liebovitch, Florida Atlantic University

1:00PM (1052) *A New Approach to College Algebra and Precalculus.*
Davida Fischman* and **Joan Terry Hallett**, California State University-San Bernardino

1:00PM (1053) *Enhancing the Mathematical Understanding of Students in Chemistry.*
Erica Flapan, Pomona College

1:00PM (1054) *Essential Mathematics for Middle School Teachers.*
David Carothers, James Madison University

1:00PM (1055) *Implementation of WeBWorK Delivering Internet-Based Homework In College Algebra Classes.*
Coreen Mett, Radford University

1:00PM (1056) *Discrete Mathematics for Prospective K-8 Teachers.*
Valerie A DeBellis*, East Carolina University, and **Joseph G Rosenstein**, Rutgers University

1:00PM (1057) *A Comprehensive Online Mathematics Assessment, Placement and Exit Testing Program.*
Jerry Johnson*, **Jeff Mortensen** and **Inmaculada Aban**, University of Nevada

1:00PM (1058) *Excellence through Mathematics Communication and Collaboration.*
Jerry Marshall* and **Herbert Riedel**, Tri-County Technical College

1:00PM (1059) *Collaborative Research: A Problem Based Calculus Sequence.*
Charles Allen* and **Carol Browning**, Drury University

1:00PM (1060) *Collaborative Research: A Problem Based Calculus Sequence.*
Ted Mahavier* and **Dale Daniel**, Lamar University

1:00PM (1061) *Collaborative Research: A Problem Based Calculus Sequence.*
Shing So, Central Missouri State University

1:00PM (1062) *Discovery-based Science and Mathematics in an Environmental Context.*
Stephanie Fitchett*, Florida Atlantic University, and **Blake Mellor**, Loyola Marymount University

1:00PM (1063) *Motivating Geometry through Computation and Visualization.*
David Finn, Rose-Hulman Institute of Technology

1:00PM (1064) *Collaborative Research: Adaptation and Implementation of Activity and Web-Based Materials into Post-Calculus Introductory Probability and Statistics Courses.*
Tracy Goodson-Espy, University of Alabama in Huntsville

1:00PM (1065) *Establishing the National Curve Bank.*
Shirley B Gray, California State University Los Angles

1:00PM (1066) *Lexington Collaborative for Reform and Improvement of Middle Mathematics.*
Lillie Crowley*, Lexington Community College, and **Carl Lee**, University of Kentucky

1:00PM (1067) *Collaborative Research: Adaptation and Implementation of Activity and Web-Based Materials into Post-Calculus Introductory Probability and Statistics Courses.*
M. Leigh Lunsford, Athens State University

1:00PM (1068) *Collaborative Research: Adaptation and Implementation of Activity and Web-Based Materials into Post-Calculus Introductory Probability and Statistics Courses.*
Ginger Holmes Rowell* and **Angel E Long**, Middle Tennessee State University

1:00PM (1069) *Web-Based Math Homework.*
John W Jones, Arizona State University

1:00PM (1070) *A Computer Activity Approach to College Geometry.*
Barbara E Reynolds*, Cardinal Stritch University, and **William E Fenton**, Bellarmine University

1:00PM (1071) *Adaptive Teaching and Learning Environments in Science and Mathematics Education.*
Matthew Hudelson* and **Gregory Crouch**, Washington State University

1:00PM (1072) *Multimedia Based Calculus with e-folios.*
Patricia R Wilkinson, Borough of Manhattan Community College

1:00PM (1073) *Statistical Applications for the Mathematics Curriculum.*
George W Cobb, Mount Holyoke College

1:00PM (1074) *WeBWorK in the Mathematics Curriculum.*
Jeffrey J Holt, University of Virginia

1:00PM (1075) *Knot Theory for Preservice and Practicing Secondary Mathematics Teachers.*
Neil Portnoy* and **Thomas Mattman**, California State University, Chico

1:00PM (1076) *Mathematics Across the Curriculum in Washington State.*
Rebecca Hartzler*, **Deann Leoni** and **Jennifer Leveglia**, Edmonds Community College

1:00PM (1077) *CSEMS Scholarship Projects at Edmonds Community College.*
Deann Leoni*, **Rebecca Hartzler** and **Jennifer Leveglia**, Edmonds Community College

1:00PM (1078) *Transforming Biological and Engineering Statistics at Penn State.*
William L Harkness*, **David Hunter**, **Michael Akritas**, Pennsylvania State University, and **Jill Lane**, Schreyer Institute

1:00PM (1079) *Introducing Software Tools into Linear Algebra and Principles of Mathematics.*
Thomas Hagedorn*, **Karen Clark** and **Ed Conjura**, College of New Jersey

1:00PM (1080) *Technical Mathematics for Tomorrow: Recommendations and Exemplary Programs.*
Robert Kimball*, Wake Technical Community College, and **Mary Ann Hovis**, Rhodes State College

1:00PM (1081) *Biomathematics in the Undergraduate Curriculum.*
Raina Robeva*, **Robin Davies**, **James Kirkwood**, Sweet Briar College, **Michael Johnson**, **Boris Kovatchev** and **Marty Straume**, University of Virginia School of Medicine

1:00PM (1082) *Enhancing and Implementing an Internet-Based System for Mathematics Homework Problems.*
William K Ziemer*, **Tangan Gao** and **Angelo Segalla**, California State University Long Beach

1:00PM (1083) *Teaching Improvement Through Mathematics Education at Queensborough Community College: Adapting and Implementing TIME2000 for the Community College.*
Mona Fabricant* and **Sandra Peskin**, Queensborough Community College

1:00PM (1084) *Teacher Preparation, Mathematics and Technology: A National Dialogue.*
Ruth Collins, Delaware Technical and Community College

1:00PM (1085) *The PascGalois Project: Visualizing Abstract Algebra.*
Michael Bardzell* and **Kathleen Shannon**, Salisbury University

1:00PM (1086) *MathThread Partnership: Distance Learning and Outside-of-Class Collaboration for Math.*
Glenn Gordon Smith, State University of New York at Stony Brook

1:00PM (1087) *Sports Modules for Teaching Statistics.*
Jim Albert, Bowling Green State University

1:00PM (1088) *Promoting Active Learning and Collaboration in Calculus with the Investigative Classroom.*
Meighan I Dillon, Southern Polytechnic State University

1:00PM (1089) *Bridging the Vector Calculus Gap.*
Tevian Dray* and **Corinne A Manogue**, Oregon State University

1:00PM (1090) *Making Mathematical Connections in Programs for Prospective Teachers.*
Karen J Graham*, University of New Hampshire, **Neil Portnoy**, California State University, Chico, and **Todd Grunemeier**, University of New Hampshire

1:00PM (1091) *Workshop Precalculus.*
Nancy Baxter Hastings*, Dickinson College, **Kevin Callahan**, California State University, Hayward, **David Hastings**, Shippensburg University, and **Allan Rossman**, California Polytechnic State University, San Luis Obispo

1:00PM (1092) *Pathways through Algebra.*
Terrie Teegarden*, San Diego Mesa College, **Wade Ellis**, West Valley College, and **Wei-Jen Harrison**, American River College

MAA Session on Getting Students to Discuss and to Write About Mathematics, II

1:00 PM - 2:55 PM

Organizer: **Sarah L. Mabrouk**, Framingham State University

1:00PM (1093) *The Use of Student-Authored Study Guides in a Quantitative Reasoning Course.*
Linda McGuire, Muhlenberg College (983-D1-303)

1:15PM ► (1094) *Circling the Desks: A Weekly Discussion in a Liberal Arts Mathematics Course.* Preliminary report.
Joshua D Laison, Colorado College (983-D1-510)

1:30PM ► (1095) *Integrating Writing into a Liberal Arts Mathematics Class.*
Joseph Kirtland, Marist College (983-D1-191)

1:45PM ► (1096) *Electronic Journals for Business Calculus.* Preliminary report.
Kimberly J Presser, Shippensburg University (983-D1-284)

2:00PM ► (1097) *The Use of Modeling and Inquiry Problems in a Single Variable Calculus Course.* Preliminary report.
David A Smith* and **Mike Huber**, United States Military Academy (983-D1-82)

2:15PM ► (1098) *Writing Assignments for Calculus.*
Janet C. Woodland, University of Arkansas (983-D1-466)

2:30PM ► (1099) *Reading Discrete Mathematics: A Semester-long Assignment in Communication.* Preliminary report.
Steven M. Hetzler* and **Robert M. Tardiff**, Salisbury University (983-D1-483)

2:45PM (1100) *Writing Intensive Courses for Prospective Elementary Teachers.* Preliminary report.
Sybilla Beckmann* and **Tawanda Gwena**, University of Georgia (983-D1-530)

MAA Session on Encouraging Underrepresented Groups of Students in Math Contests

1:00 PM - 2:35 PM

Organizers: **Harold B. Reiter**, University of North Carolina
Ruth G. Favro, Lawrence Technological University
David M. Wells, Pennsylvania State University
Susan Schwartz Wildstrom, Walt Whitman High School
Jeff J. Dodd, Jacksonville State University

1:00PM ► (1101) *Reflections on and Visions of Minority Participation in Mathematics Competitions.*
Duane A. Cooper, Morehouse College (983-P1-813)

1:20PM ► (1102) *The Po Leung Kuk Primary Math World Competition and Siemens Science and Technology Competition.* Preliminary report.
Max L Warshauer*, **Terry McCabe** and **Daniela Ferrero**, Southwest Texas State University (983-P1-250)

1:40PM (1103) *The High School Mathematical Contest in Modeling (HiMCM).*
William P Fox, Francis Marion University and COMAP (983-P1-241)

2:00PM ► (1104) *To include more students, don't focus on contests—prepare for mathematics!*
Sarah-Marie Belcastro, Xavier University (983-P1-548)

2:20PM ► (1105) *MMSETS: a competition that prepares students for problem solving oriented global job market.*
Eva J Szillery, Program Director/University of Maine (983-P1-1407)

MAA Session on Mathematical Modeling In and Out of the Classroom

1:00 PM - 4:10 PM

Organizers: **Brian J. Winkel**, United States Military Academy
Tanya L. Leise, Rose-Hulman Institute of Technology
Amy E. Radunskaya, Pomona College

1:00PM ► (1106) *Understanding Models through Dimensional Analysis: the Example of Predator-Prey Interactions.* Preliminary report.
Richard H. Elderkin, Pomona College (983-R1-526)

1:15PM (1107) *Math Modeling Activities for a Variety of Undergraduate Courses.*
Therese Shelton, Southwestern University (983-R1-508)

1:30PM ► (1108) *Mathematical modeling in a liberal arts college: projects to entice and excite students from all majors.*
Ami E Radunskaya, Pomona College (983-R1-525)

1:45PM ► (1109) *Using the Writing Process to Help Teach the Mathematical Modeling Process.*
Steven M Hetzler*, Salisbury University, **Michael A Jones**, Montclair State University, and **Leslie Vitale**, Mott Community College (983-R1-492)

2:00PM ► (1110) *Dirac Attack: The mystical marriage of mathematics and nature.*
Timothy J Pennings, Hope College (983-R1-484)

2:15PM ► (1111) *Environmentally-Focused Modeling Activities.* Preliminary report.
Nancy E Zumoff*, Kennesaw State University, **Christopher Schaufele**, Dineh Coll, and **Paul Latiolais**, Portland State University (983-R1-476)

2:30PM ► (1112) *Modeling AIDS for Dummies.*
L. G. dePillis, Harvey Mudd College (983-R1-394)

2:45PM ► (1113) *A First Course in Mathematical Modeling.*
William P Fox*, Francis Marion University, **Frank Giordano**, NPS, and **Maurice Weir**, Naval Postgraduate School (983-R1-244)

3:00PM *Not just twiddling our thumbs.*
► (1114) **Tanya L. Leise**, Rose-Hulman Institute of Technology (983-R1-179)

3:15PM *How to Solve the "Little Things" in Life.* Preliminary
► (1115) report.
David L. Knellinger*, United States Military Academy, and **Edie E. Knellinger**, Department of English, United States Military Academy (983-R1-170)

3:30PM *Mathematical Modeling in Chemistry - Group*
► (1116) *Theory and Exponential Decay.*
Agnes M Rash, Saint Joseph's University (983-R1-48)

3:45PM *Using a simulation to model a queueing problem.*
► (1117) **Murray H Siegel**, Sam Houston State U (983-R1-46)

4:00PM *Teaching Modeling with Semester-Long*
► (1118) *Student-Generated Projects.*
Bruce Pollack-Johnson* and **Audrey Fredrick Borchardt**, Villanova University (983-R1-38)

MAA Session on Philosophy of Mathematics

1:00 PM - 5:55 PM

Organizer: **Bonnie Gold**, Monmouth University

1:00PM *Why Plato was not a Platonist.*
► (1119) **Thomas Drucker**, University of Wisconsin-Whitewater (983-S1-49)

1:30PM *Peirce, Zeno, Achilles, and the Tortoise.* Preliminary
► (1120) report.
Daniel C Sloughter, Furman University (983-S1-351)

2:00PM *Structuralist Mathematics and Mathematical*
► (1121) *Understanding.* Preliminary report.
Kenneth Manders, University of Pittsburgh (983-S1-544)

2:30PM *Are Mathematical Objects Inside or Outside a*
► (1122) *Human Mind?* Preliminary report.
Roger A. Simons, Rhode Island College (983-S1-546)

3:00PM *What is Mathematics I: The Question.* Preliminary
► (1123) report.
Bonnie Gold, Monmouth University (983-S1-341)

3:30PM *A Conjecture about... Feminist Mathematics?*
► (1124) Preliminary report.
Sarah-marie Belcastro, Xavier University (983-S1-429)

4:00PM *Defining Mathematical Esthetics within the NCTM*
► (1125) *Standards.* Preliminary report.
Michael J. Bossé, Indiana University of Pennsylvania (983-S1-137)

4:30PM *Unfair Gambles in Probability.* Preliminary report.
► (1126) **John E. Beam**, University of Wisconsin Oshkosh (983-S1-482)

5:00PM *Pedagogical challenges of one to one*
► (1127) *correspondence.*
Satish C. Bhatnagar, University of Nevada Las Vegas (983-S1-551)

5:30PM *A Unifying Principle Describing How Mathematical*
► (1128) *Knowledge Unfolds.*
M Anne Dow, Maharishi University of Management (983-S1-545)

MAA Session on Integrating Undergraduate Research with the Mathematics Curriculum

1:00 PM - 3:35 PM

Organizers: **David Brown**, Ithaca College
Osman Yurekli, Ithaca College

1:00PM *Undergraduate Research in Mathematics at Hendrix*
► (1129) *College.*
David C Sutherland, Hendrix College (983-T1-199)

1:20PM *Undergraduate Research at Alma College.*
► (1130) **Aklilu Zeleke**, Alma College (983-T1-442)

1:40PM *Undergraduate Research in Mathematics at Ithaca*
► (1131) *College.* Preliminary report.
Osman Yurekli, Ithaca College (983-T1-693)

2:00PM *The Fusion Method of Traditional, Moore,*
► (1132) *and Constructivism and the Incorporation of Undergraduate Research Through the Mathematics Curriculum.*
M Padraig McLoughlin, Morehouse College (983-T1-363)

2:20PM *Addressing the Needs of Secondary Education*
► (1133) *Students in Undergraduate Research.* Preliminary report.
David A. Brown, Ithaca College (983-T1-577)

2:40PM *Student Research Projects in a Mathematics*
► (1134) *Capstone Course for Secondary Teachers.*
Curtis D. Bennett, Loyola Marymount University (983-T1-218)

3:00PM *The Ins and Outs of Undergraduate Research.*
► (1135) Preliminary report.
Sarah V. Cook* and **Allan Riveland**, Washburn University (983-T1-446)

3:20PM *Explorations with Fibonacci numbers and modular*
► (1136) *arithmetic.* Preliminary report.
Tamara B Veenstra, University of Redlands (983-T1-516)

MAA-University of Arizona Special Presentation

1:00 PM - 3:00 PM

Course in interdisciplinary business mathematics (repeated from 5:00 p.m. to 7:00 p.m., Friday).

Organizer: **Richard B. Thompson**, University of Arizona

MAA Project NExT Panel Discussion

1:00 PM - 2:30 PM

Undergraduate seminars in mathematics.

Organizers: **Jed Herman**, University of St. thomas
Hieu D. Nguyen, Rowan University

Panelists: **William P. Abrams**, Longwood College
Karen D. Bolinger, Clarion University
Philip K. Hotchkiss, Westfield State College
Daniel L. King, Sarah Lawrence College

MAA Panel Discussion

1:00 PM - 2:20 PM

The role of mathematics in the professional work of mathematics educators.

Organizer: **Joan Ferrini-Mundy**, Michigan State University

Moderator: **Gail F. Burrill**, Michigan State University

Panelists: **Christian R. Hirsch**, Western Michigan University
Bradford R. Findell, University of Georgia
Deborah Loewenberg Ball, University of Michigan

MAA Committee on the Undergraduate Program in Mathematics and the CUPM Subcommittee on Mathematics Across the Disciplines Panel Discussion

1:00 PM - 2:20 PM

Mathematics educators, computer science educators: Working together.

Organizer: **William A. Marion**, Valparaiso University

Panelists: **William H. Barker**, Bowdoin College
Susanna S. Epp, DePaul University
Peter B. Henderson, Butler University
Henry M. Walker, Grinnell College

ASL Invited Address

1:20 PM - 2:10 PM

(1137) *Some results concerning strong compactness and supercompactness.*
Arthur W. Apter, Baruch College of the City University of New York

MAA Committee on the Mathematics Education of Teachers-NCTM Panel Discussion

2:00 PM - 3:20 PM

NCATE and the mathematics community.

Organizers: **Judith L. Covington**, Louisiana State University, Shreveport
Marilyn L. Hala, NCTM

Panelists: **Francis Fennell**, Western Maryland College
Judy S. O'Neal, North Georgia College and State University
Connie S. Schrock, Emporia State University

NAM Granville-Brown-Haynes Session of Presentations by Recent Doctoral Recipients in the Mathematical Sciences

2:15 PM - 5:00 PM

Moderator: **William A. Massey**, Princeton University

RMMC Board of Directors

2:15 PM - 4:10 PM

ASL Invited Address

2:25 PM - 3:15 PM

(1138) *F-structures and semiabelian varieties over finite fields.*
Rahim Nazim Moosa, Massachusetts Institute of Technology

AMS-MAA Joint Film Presentation

2:30 PM - 3:30 PM

The Math Life.

Presenters: **Wendy Conquest**, Dartmouth College
Bob Drake, Dartmouth College
Dan Rockmore, Dartmouth College

AMS Committee on Science Policy Special Presentation

2:30 PM - 4:00 PM

A Town Meeting with **William Rundell**, *new Director of the Division of Mathematical Sciences, National Science Foundation.*

MAA Presentations by Teaching Award Winners

2:30 PM - 4:00 PM

The winners of the Deborah and Franklin Tepper Haimo Awards for Distinguished College or University Teaching give the secrets of their success.

Presenters: **Judith V. Grabiner**, Pitzer College
Paul A. Zeitz, University of San Francisco
Ranjan Roy, Beloit College

MAA Minicourse #3: Part B

3:15 PM - 5:15 PM

Optimization of technology in the geometry classroom.

Organizer: **Subhash C. Saxena**, Carolina University

MAA Minicourse #9: Part B

3:15 PM - 5:15 PM

Fair enough? Mathematics of equity.

Organizers: **John C. Maceli**, Ithaca College
Stanley E. Seltzer, Ithaca College

MAA Session on Rethinking the Courses Below Calculus, II

3:15 PM - 5:15 PM

Organizers: **Mary Robinson**, University of New Mexico
Sheldon P. Gordon, SUNY at Farmingdale
Florence S. Gordon, New York Institute of Technology
Arlene H. Kleinstein, SUNY at Farmingdale

3:15PM ► (1139) *Tracking Students through Algebra, Precalculus and Calculus Courses.*
Steven R Dunbar, University of Nebraska-Lincoln (983-M1-380)

3:40PM ► (1140) *Who are our students? Where do they come from? Where do they go?*
Mercedes A. McGowen, William Rainey Harper College (983-M1-556)

4:05PM ► (1141) *Trends in High School Preparation for Calculus and Their Implications for the Transition to College.*
Zalman Usiskin, The University of Chicago (983-M1-432)

4:30PM ► (1142) *Traditional College Algebra/Trig versus a Modeling Approach as Preparation for Calculus.*
Florence S Gordon, New York Institute of Technology (983-M1-538)

4:55PM *Forging a National Initiative to Reform the Courses*
► (1143) *Below Calculus.*
Sheldon P Gordon, SUNY at Farmingdale (983-M1-540)

MAA Panel Discussion

3:30 PM - 4:50 PM

Laptops in the classroom.
Organizer: **Donald B. Small**, U. S. Military Academy
Moderator: **Joseph D. Myers**, U. S. Military Academy
Panelists: **Joseph G. Ecker**, Rensselaer Polytechnic Institute
David L. Finn, Rose-Hulman Institute of Technology
Alex J. Heidenberg, U. S. Military Academy

ASL Contributed Papers

3:30 PM - 5:55 PM

MAA Committee on the Undergraduate Program in Mathematics and the Committee on Student Chapters Undergraduate Poster Session

4:00 PM - 6:30 PM

Organizer: **Mario U. Martelli**, Claremont McKenna College

SIGMAA on Research on Undergraduate Mathematics Education

4:00 PM - 6:00 PM

Business meeting and invited address by Rina Zazkis.
Organizer: **Anne E. Brown**, Indiana University South Bend

MAA General Contributed Paper Session, V

4:15 PM - 6:25 PM

Organizers: **Michael A. Jones**, Montclair State University
Steven M. Hetzler, Salisbury University
Shawnee L. McMurran, California State University at San Bernardino

4:15PM *What do Farey Sequences, Farmer Fred, and*
► (1144) *Chemistry Have in Common?* Preliminary report.
Ioana Mihaila, California State Polytechnic Univ., Pomona (983-Z1-727)

4:30PM *The Center of Population Calculation is Flawed.*
► (1145) **Edward F Aboufadel*** and **David Austin**, Grand Valley State University (983-Z1-67)

4:45PM *The Canadians Should Have Won!?*
► (1146) **Elyn Rykken***, Muhlenberg College, **Maureen Carroll**, University of Scranton, and **Jody Sorensen**, Grand Valley State University (983-Z1-419)

5:00PM *Clasp Moves and Stick Number.* Preliminary report.
► (1147) **Adam O'Connor**, Claremont Graduate School, **Bartlomiej Podlesny**, University of California, Riverside, **Nerissa Soriano**, Cal Poly, Pomona, **Rolland Trapp*** and **Diana Wall**, Cal State, San Bernardino (983-Z1-474)

5:15PM *Generalized Tennis Ball Problem.*
► (1148) **Mahendra Jani*** and **Melkamu Zeleke**, Willaim Paterson University of NJ (983-Z1-1212)

5:30PM *Catalan Numbers In The Fibonacci Sequence.*
► (1149) **Mark Bollman**, Albion College (983-Z1-150)

5:45PM *Degenerate Parabolas are Sharp.*
► (1150) **Bruce O'Neill**, Fairleigh Dickinson University (983-Z1-326)

6:00PM *The Complete Classification of the Pythagorean*
► (1151) *Triples.*
Fat C Lam, Gallaudet University (983-Z1-177)

6:15PM *A Theorem Involving Denominators of Bernoulli*
► (1152) *Numbers.*
Peter Schumer*, Middlebury College, and **Pantelis Damianou**, University of Cyprus (983-Z1-362)

AMS Committee on Science Policy-MAA Science Policy Committee Government Speaker

4:20 PM - 5:10 PM

MAA Minicourse #14: Part B

4:30 PM - 6:30 PM

Teaching a course in the history of mathematics
Organizers: **V. Frederick Rickey**, United States Military Academy
Victor J. Katz, University of District of Columbia

University of Michigan Alumni Reception

4:30 PM - 7:00 PM

BIG SIGMAA Reception

5:00 PM - 6:00 PM

Welcome reception for mathematicians in business, industry, and government.
Organizer: **Philip E. Gustafson**, Mesa State College

MAA-University of Arizona Special Presentation

5:00 PM - 7:00 PM

Course in interdisciplinary business mathematics.
Organizer: **Richard B. Thompson**, University of Arizona

University of Illinois at Urbana-Champaign Department of Mathematics Reception

5:15 PM - 7:15 PM

NAM Reception, Banquet, and Cox-Talbot Address

5:30 PM - 9:30 PM

(1153) *The Maryland experience: Building a community of African American graduate students.*
Raymond L. Johnson, University of Maryland (983-01-187)

University of Wisconsin-Madison Department of Mathematics Reception

5:30 PM - 7:00 PM

Mathematical Reviews Reception

6:00 PM - 7:00 PM

MAA Project NExT Reception

8:30 PM - 10:30 PM

Saturday, January 18

Joint Meetings Registration

7:30 AM - 2:00 PM

AMS-MAA-SIAM Special Session on Research in Mathematics by Undergraduates, III

8:00 AM - 10:50 AM

Organizers: **Darren A. Narayan**, Rochester Institute of Technology
Carl V. Lutzer, Rochester Institute of Technology
Tamara A. Burton, Rochester Institute of Technology

8:00AM ► (1154) *Twinkle, Twinkle, Little Stars: Describing the Limiting Surfaces of Hyperbolic Surfaces Tiled by Quadrilaterals.*
Michael A. Burr*, Tufts University, and **Kathryn Zuhr**, Mount Holyoke College (983-51-585)

8:30AM ► (1155) *Constructing the Moduli Spaces of Riemann Surfaces with Quadrilateral Tilings.* Preliminary report.
Kathryn M Zuhr, Mount Holyoke College (983-54-589)

9:00AM ► (1156) *The Modified Picard-Pade' Approximation Method for Singular Nonlinear Boundary Value Problems.*
Todd A Svitzer* and **Jeff A Evey**, James Madison University (983-65-595)

9:30AM ► (1157) *Crack Identification using the Reciprocity Gap Formula - The 2-Dimensional Case.*
Ronald Ogborne*, SUNY Fredonia, and **Melissa Vellela**, Boston University (983-80-718)

10:00AM ► (1158) *On Roots of Generalized Fibonacci Polynomials.*
Dan Schwegler* and **Aklilu Zeleke**, Alma College (983-40-120)

10:30AM ► (1159) *Irreducible Matrix Solutions for $X^s = 0, Y^t = 0$.* Preliminary report.
Timothy Daley, Tulane University, **Justin Fried***, Brown University, **Brigid Mooney**, Indiana University of Pennsylvania, **Michal Pinkham** and **David Wiygul**, Skidmore College (983-16-582)

AMS-MAA Special Session on The History of Mathematics, III

8:00 AM - 10:55 AM

Organizers: **Joseph W. Dauben**, Lehman College
David E. Zitarelli, Temple University

8:00AM ► (1160) *How it was to study and to teach mathematics in Cornell at the end of 19th century? (Experience from two historical collections).* Preliminary report.
Daina Taimina, Cornell University (983-01-617)

8:30AM ► (1161) *The Curious History of the School Protractor.*
Amy K Ackerberg-Hastings, Rockville, MD (983-01-318)

9:00AM ► (1162) **Giving Direction by Directing a Journal: Thomson, Stokes, Applied Mathematics, and the *Cambridge and Dublin Mathematical Journal*.**
Sloan E Despeaux, Western Carolina University (983-01-566)

9:30AM (1163) *Weierstrass's Foundational Shift in Analysis: His Introduction of the ε-δ Method of Defining Continuity and Differentiability.*
Michiyo Nakane, Seijo University and Rikkyo University (983-01-613)

10:00AM (1164) *On Weierstrass' theory of analytic functions.*
Umberto Bottazzini, University of Palermo, Italy (983-01-456)

10:30AM (1165) *Frédéric Riesz as a pioneer of functional analysis.*
Erwin Kreyszig, Carleton University (983-01-461)

AMS Special Session on Wavelets, Frames and Operator Theory, III

8:00 AM - 10:50 AM

Organizers: **Christopher Heil**, Georgia Institute of Technology
Palle Jorgensen, University of Iowa
David Larson, Texas A&M University

8:00AM (1166) *An analogue of the Bratteli-Jorgensen loop group action for m-systems in the GMRA setting.* Preliminary report.
Judith A Packer, University of Colorado, Boulder (983-46-1069)

8:30AM (1167) *Frames and groups.*
Gestur Olafsson, Louisiana State University (983-43-1004)

9:00AM (1168) *The local trace function of shift invariant subspaces.*
Dorin Ervin E Dutkay, The University of Iowa (983-43-74)

9:30AM (1169) *Non Uniform Sampling and Reconstruction in Irregular Spaces.* Preliminary report.
A Aldroubi and **Armando Rodado***, Vanderbilt University (983-47-795)

10:00AM (1170) *A unified theory of reproducing function systems.*
Eugenio Hernandez, Universidad Autonoma madrid, **Demetrio Labate*** and **Guido Weiss**, Washington University (983-42-700)

10:30AM ► (1171) *A Family of Piecewise-Linear Plane Maps and Associated Nonlinear Difference Operators of Schrödinger Type.*
Jeffrey C. Lagarias*, AT&T Labs-Research, and **Eric Rains**, IDA-CCR (983-58-708)

AMS Special Session on The Many Lives of Lattice Theory and the Theory of Ordered Sets, with Connections to Combinatorics, II

8:00 AM - 10:55 AM

Organizers: **Jonathan D. Farley**, University of Oxford
Stefan E. Schmidt, New Mexico State University
Alex J. Pogel, New Mexico State University

8:00AM (1172) *Progress and problems in the equational theory of lattices.* Preliminary report.
Kirby A. Baker, University of California, Los Angeles (983-06-1489)

8:30AM (1173) *Some Lattice Theory Results and Problems from Yore (with emphasis on nonstandard methods).* **Matt Insall**, University of Missouri - Rolla (983-06-947)

9:00AM ► (1174) *Representation of a Lattice Associated to an Implicational Moore Family by the Direct-Optimal Implicational System.* **Karell Bertet**, University of La Rochelle, France (983-06-944)

9:30AM (1175) *Dual Preorders As Applied In Concurrent Systems Preliminary Report.* Preliminary report. **John S Davis II**, IBM (983-06-1408)

10:00AM (1176) *On lattices of convex sets in $\mathbb{R}^n$.* **George M. Bergman**, University of California (983-06-711)

10:30AM ► (1177) *The Lattice Theory of the Symmetric Group: Is the h-vector of a distributive lattice the f-vector of a poset? Enquiring minds want to know.* Preliminary report. **Jonathan David Farley**, Vanderbilt University (983-06-1486)

AMS Special Session on C-Extensions and Classifications of C*-Algebras, II*

8:00 AM – 10:55 AM

Organizers: **Shuang Zhang**, University of Cincinnati
Huaxin Lin, University of Oregon

8:00AM (1178) *Diagonals of trace-class operators.* **William B. Arveson**, UC Berkeley (983-47-1449)

8:30AM (1179) *Extensions of quasidiagonal C*-algebras.* **Marius Dadarlat***, Purdue University, and **Nate Brown**, Pennsylvania State University (983-46-640)

9:00AM (1180) *Operators observing Jordan structures of C*-algebras.* **Ngai-Ching Wong**, National Sun Yat-sen University (983-46-812)

9:30AM (1181) *The structure of higher dimensional noncommutative toruses.* Preliminary report. **N. Christopher Phillips**, University of Oregon (983-46-1259)

10:00AM (1182) *Which Linear-Fractional Composition Operators are Essentially Normal?* **Sivaram K Narayan**, Central Michigan University (983-47-96)

10:30AM (1183) *On real operator algebras and real operator spaces.* **Zhong-Jin Ruan**, University of Illinois (983-46-1070)

AMS Special Session on Discrete Dynamics and Difference Equations, II

8:00 AM – 10:55 AM

Organizers: **Saber N. Elaydi**, Trinity University
Gerasimos Ladas, University of Rhode Island

8:00AM ► (1184) *Modelling the transmission dynamics of HIV.* Preliminary report. **James A Yorke**, University of Maryland (983-37-1291)

8:30AM (1185) *Generalized Henon equations with delay.* **Judy A Kennedy***, University of Delaware, and **James A Yorke**, University of Maryland (983-37-878)

9:00AM (1186) *Learning About Reality From Observation.* **William Raymond Ott*** and **James A. Yorke**, University of Maryland (983-37-1227)

9:30AM (1187) *Global modeling from time series: difference equations versus differential equations, a possible equivalence.* Preliminary report. **C Letellier***, **T Menard**, University of Rouen, **Aziz Alaoui**, University du Havre, **L A Aguirre**, Universidade federal de minas gerais, and **Saber N Elaydi**, Trinity University (983-39-1123)

10:00AM ► (1188) *Chaos controlling in economic models described by nonlinear difference equations.* Preliminary report. **Malgorzata Guzowska**, University of Szczecin (983-39-588)

10:30AM ► (1189) *The effect of step size on stability when discretizing.* **Joan Hoffacker*** and **Tom Gard**, University of Georgia (983-34-235)

AMS Special Session on Homotopy Theory, III

8:00 AM – 10:50 AM

Organizers: **Kristine Baxter Bauer**, Johns Hopkins University
J. Michael Boardman, Johns Hopkins University
Nitu Kitchloo, Johns Hopkins University
Jean-Pierre Meyer, Johns Hopkins University
Jack Morava, Johns Hopkins University
W. Stephen Wilson, Johns Hopkins University

8:00AM (1190) *Homotopical decompositions for algebraic varieties.* Preliminary report. **Daniel K Dugger**, University of Oregon (983-55-1264)

8:30AM (1191) *On TAQ and THH of commutative S-algebras.* **Randy McCarthy** and **Vahagn Minasian***, University of Illinois, Urbana (983-55-1118)

9:00AM (1192) *Toward KK-theory using Quillen model structures.* Preliminary report. **Michael Joachim**, Universitaet Muenster, and **Mark W. Johnson***, Penn State Altoona (983-55-1060)

9:30AM (1193) *Associahedra and Products of Simplices.* Preliminary report. **Satyan L Devadoss**, Williams College (983-55-997)

10:00AM (1194) *Permutahedral Sets.* **Samson Saneblidze**, A. Razmadze Mathematical Institute, and **Ronald Umble***, Millersville University of PA (983-55-974)

10:30AM (1195) *Algebraic Goodwillie Calculus and the Lower Central Series.* **Andrew Mauer-Oats**, Purdue University (983-55-757)

AMS Special Session on Algebraic Topology Based on Knots, III

8:00 AM – 10:50 AM

Organizers: **Mark E. Kidwell**, U.S. Naval Academy
Jozef H. Przytycki, The George Washington University
Yongwu Rong, The George Washington University

8:00AM (1196) *Link Homotopy Invariant Racks (Preliminary Report).* Preliminary report. **James R Hughes**, Elizabethtown College (983-57-364)

8:30AM (1197) *Coloring twist-spin knots by dynamical extensions of quandles.*
J Scott Carter, University of South Alabama (983-57-1181)

9:00AM (1198) *Braids, quandle extensions, and cocycle knot invariants.* Preliminary report.
Masahico Saito, University of South Florida (983-57-876)

9:30AM (1199) *Orderability of knot groups.*
Dale Rolfsen*, University of British Columbia, and **Bernard Perron**, Universite de Bourgogne (983-55-1464)

10:00AM ► (1200) *Virtual Knot Theory.* Preliminary report.
Louis Hirsch Kauffman, University of Illinois at Chicago (983-57-1135)

10:30AM (1201) *Virtual links and involutions.*
Daniel S. Silver and **Susan G. Williams***, University of South Alabama (983-57-1437)

AMS Special Session on Modular Forms, Elliptic Curves, and Related Topics, III

8:00 AM – 10:50 AM

Organizers: **Cristina M. Ballantine**, College of the Holy Cross
Sharon M. Frechette, College of the Holy Cross
Holly J. Rosson, St. Mary's College of Maryland

8:00AM (1202) *Supercongruences Between Truncated ${}_2F_1$ Hypergeometric Functions and Their Gaussian Analogs.*
Eric T Mortenson, University of Wisconsin-Madison (983-11-1312)

8:30AM (1203) *Bounds on Polynomial Exponential Sums.*
Todd Cochrane, **Christopher Pinner** and **Jason Rosenhouse***, Kansas State University (983-11-1191)

9:00AM (1204) *Extensions of elliptic curves over number fields.*
Matthew Papanikolas*, Brown University, and **Niranjan Ramachandran**, University of Maryland (983-11-593)

9:30AM (1205) *Computing the Arithmetic Genus of Hilbert Modular Fourfolds.* Preliminary report.
Helen G. Grundman* and **Lisa E. Lippincott**, Bryn Mawr College (983-11-1049)

10:00AM (1206) *Average Frobenius distributions for elliptic curves with non trivial rational torsion subgroups.*
Kevin L James, Clemson University (983-11-1358)

10:30AM (1207) *Generalized Lipschitz Summation.*
Paul C. Pasles*, Villanova University, and **Wladimir de Azevedo Pribitkin**, Haverford College (983-11-123)

AMS Session on Combinatorics, III

8:00 AM – 10:55 AM

8:00AM ► (1208) *Random Systems of Distinct Representatives.* Preliminary report.
Zachary Cohn, University of Chicago (983-05-1418)

8:15AM (1209) *Multi-restricted numbers.* Preliminary report.
Ji Young Choi, Shippensburg University (983-05-1451)

8:30AM (1210) *Directed Covering With Block size 5 and both v and lambda Odd.* Preliminary report.
Ahmed M. Assaf, Central Michigan University, and **Hasan A. Al-Halees***, Saginaw Valley State University (983-05-1456)

8:45AM ► (1211) *The Longest Common Subsequence Problem.* Preliminary report.
Jonah D Blasiak, Princeton University (983-05-1484)

9:00AM (1212) *"The Structure of 2-Factors in Line Graphs".*
Ronald J. Gould, Emory University, and **Emily A. Hynds***, Samford University (983-05-1245)

9:15AM ► (1213) *Retracts of Cartesian products of (2k + 1)-angulated graphs and the Circular Chromatic Number.* Preliminary report.
Zhongyuan Che* and **Karen L. Collins**, Wesleyan University (983-05-968)

9:30AM ► (1214) *Domination Analysis of Maximum Weight k-Clique Heuristics.* Preliminary report.
Gareth L Bendall, University of Kentucky (983-05-733)

9:45AM ► (1215) *Image partition regularity over the integers, rationals, and reals.*
Neil Hindman*, Howard University, and **Dona Strauss**, University of Hull (983-05-726)

10:00AM (1216) *The splitter theorems for cubic graphs.*
Guoli Ding and **Jinko Kanno***, Louisiana State University (983-05-611)

10:15AM ► (1217) *Probabilities involving sums and intersections of finite vector subspaces.*
Grady D. Bullington, University of Wisconsin-Oshkosh (983-05-340)

10:30AM ► (1218) *The restricted arc-width of a graph.*
David Arthur, Duke University (983-05-253)

10:45AM ► (1219) *A census of prime-order uniform step magic squares.* Preliminary report.
Livinus U. Uko, Universidade Estadual do Norte Fluminenses, Brazil (983-05-194)

MAA Session on Best Statistics Projects/Activities, II

8:00 AM – 10:55 AM

Organizers: **Carolyn K. Cuff**, Westminster College
Mary M. Sullivan, Rhode Island College

8:00AM ► (1220) *Using a student project to investigate binomial distributions.*
Murray H Siegel, Sam Houston State University (983-L1-45)

8:15AM (1221) *A Delicious Data Approach to Teaching Probability.*
Carol E Marchetti, Rochester Institute of Technology (983-L1-317)

8:30AM ► (1222) *Group Projects in Elementary Statistics.*
Frances B. Lichtman, Alma College (983-L1-552)

8:45AM ► (1223) *The Students Voted—Top 3 Statistics Activities in Probability/Statistics for Elementary Math Teachers.* Preliminary report.
Kathleen A Miller, California State University, Long Beach (983-L1-598)

9:00AM ► (1224) *Statistical Activities for a Math ADEPT course: Improving Middle School Teachers Statistical Reasoning.* Preliminary report.
Barbara A Wainwright, Salisbury University (983-L1-266)

9:15AM ► (1225) *A Class Generated Survey that Enhances Student Learning of Study Design.*
Deborah Lurie, Saint Joseph's University (983-L1-272)

9:30AM (1226) *Service Learning In Statistics.*
Gina F Reed, Gainesville College (983-L1-468)

9:45AM ► (1227) *A Semester-Long Survey Project: Science, Technology, Engineering and Math Attitudes.*
Ginger Holmes Rowell* and **Diane G. Perhac**, Middle Tennessee State University (983-L1-494)

10:00AM ► (1228) *Subjective Issues of Survey Items.* Preliminary report.
Mary M Sullivan, Rhode Island College (983-L1-443)

10:15AM ► (1229) *Examining Data Collection and Criteria Selection In Introductory Statistics.*
Jeffrey Clark, Elon University (983-L1-239)

10:30AM ► (1230) *Generating Data Sets With One Value Exceeding Three Standard Deviations.* Preliminary report.
Michael J. Bossé*, Indiana University of Pennsylvania, and **N. R. Nandakumar**, Delaware State University (983-L1-136)

10:45AM ► (1231) *Taking Advantage of Institutional Research Data.* Preliminary report.
Thomas J Pfaff, Ithaca College (983-L1-192)

MAA Session on Rethinking the Courses Below Calculus, III

8:00 AM - 10:40 AM

Organizers: **Mary Robinson**, University of New Mexico
Sheldon P. Gordon, SUNY at Farmingdale
Florence S. Gordon, New York Institute of Technology
Arlene H. Kleinstein, SUNY at Farmingale

8:00AM ► (1232) *Program for Improving Success in the Sciences, Engineering, and Mathematics PRISEM.* Preliminary report.
Claudia M Rankins* and **Lillie S. Calloway**, Hampton University (983-M1-338)

8:15AM ► (1233) *Precalculus: Life without Lectures.*
Lisa Lister* and **John B. Polhill**, Bloomsburg University (983-M1-320)

8:30AM ► (1234) *Removing Math from the Core Curriculum.* Preliminary report.
Eric S Marland, Appalachian State University (983-M1-143)

8:45AM ► (1235) *Pedagogy in Courses Below Calculus at West Point.*
Darryl Langford* and **Darrall Henderson**, United States Military Academy (983-M1-506)

9:00AM ► (1236) *Successes of a Program in Working with Students Moving from High School to College Level Mathematics.*
Antonio Acevedo and **Wayne M. Eby***, Academic Achievement Programs, University of Maryland, College Park (983-M1-447)

9:15AM ► (1237) *College Algebra: A Unified Approach.*
Revathi Narasimhan, Kean University (983-M1-331)

9:30AM ► (1238) *Skills vs. Concepts.*
Richard D. West, Francis Marion University (983-M1-497)

9:45AM ► (1239) *Do Computer Algebra Systems Have a Place in Mathematics Courses Below Calculus?* Preliminary report.
Thomas B Fox, University of Houston-Clear Lake (983-M1-433)

10:00AM (1240) *Elementary Mathematical Models - An entry level mathematics course for the five minute university.*
Dan Kalman, American University (983-M1-421)

10:15AM ► (1241) *From Zero to Hero Five Years Later: A Report on the Transformation of Intermediate Algebra into College Algebra at an Urban Community College.*
Fred Peskoff*, Borough of Manhattan Community College/CUNY, and **Dale Siegel**, Kingsborough Community College/CUNY (983-M1-537)

10:30AM ► (1242) *The Wireless Laptop In The General Mathematics And College Algebra Classrooms.*
Sarah L Mabrouk, Framingham State College (983-M1-584)

SIGMAA on Research in Undergraduate Mathematics Education, II

8:00 AM - 10:55 AM

Organizers: **James F. Cottrill**, Illinois State University
Anne E. Brown, Indiana University South Bend

8:00AM ► (1243) *Qualitative Research with "Mathematics for the Liberal Arts" Students.*
Bruce N. Wahl, Northern Virginia Community College (983-K1-304)

8:20AM ► (1244) *A Learning Theory Study of the Effect of Arithmetic Skills, Logical Reasoning Skills, Learning and Study Strategies, and Gender, on Course Success for Students at the First-Year College Level.*
Joyce Faye Fischer, Southwest Texas State University (983-K1-234)

8:40AM ► (1245) *NCTM-oriented versus Traditional Problem-solving Skills.*
Carmen Marie Latterell, University of Minnesota Duluth (983-K1-827)

9:00AM (1246) *Structural and Functional Issues of Generativity for Theoretical Perspectives in Mathematics Education Research.*
Michael Chad Furnish Oehrtman, Arizona State University (983-K1-557)

9:20AM ► (1247) *Precalculus students' difficulties with mathematical notation: An example.* Preliminary report.
Draga Vidakovic, Georgia State University (983-K1-627)

9:40AM (1248) *A Mathematician is Surprised by a Mathematics Educator: Student (Mis)use of Mathematical Definitions.*
Barbara S Edwards, Oregon State University, and **Michael Ward***, Western Oregon University (983-K1-520)

10:00AM (1249) *The instructor's role in shaping students' approaches to understanding advanced mathematical concepts.* Preliminary report.
Keith Weber, Murray State University (983-K1-511)

10:20AM ► (1250) *Do students perceive, rather than conceive, mathematical objects, thereby limiting their abilities to employ isometries in geometric proof?*
Karen Graham, University of New Hampshire, **Neil Portnoy***, California State University, Chico, and **Todd Grundmeier**, University of New Hampshire (983-K1-400)

10:40AM (1251) *What Are Students And An Instructor Thinking About When They Describe Mathematics Classes?*
Arthur J Clemons, Ashland, OR, **Pao-sheng Hsu***, Columbia Falls, ME, and **Richard D West***, Francis Marion University (983-K1-413)

MAA General Contributed Paper Session, VI

8:00 AM - 10:40 AM

Organizers: **Michael A. Jones**, Montclair State University
Steven M. Hetzler, Salisbury University
Shawnee L. McMurran, California State University at San Bernardino

8:00AM ► (1252) *New Ways of Looking at Old Things: One Case That Combines Mathematics and American History Through a Primary Source of Information.*
James W. Mauch*, Penn State University, and **Elizabeth K. Mauch**, Bloomsburg University (983-Z1-807)

8:15AM ► (1253) *Robert Adrain (1776 -1843) America's Forgotten Mathematician.*
Pat Touhey, College Misericordia (983-Z1-472)

8:30AM (1254) *Epistemological anlysis of problems in historical development of infinitesimal Calculus.*
Lígia Arantes Sad, Universidade Federal do Espírito Santo - UFESo (983-Z1-529)

8:45AM ► (1255) *Mathematics in the Islamic Era.*
Mohammad Moazzam, Salisbury University (983-Z1-465)

9:00AM ► (1256) *Linear Algebra for Circus Workers, Painters, and Printers.* Preliminary report.
Fusun Akman, Coastal Carolina University (983-Z1-201)

9:15AM (1257) *Existence of Solutions and Global Stability of a Rational Difference Equation*

$$x_{n+1} = \frac{ax_{n-1} + bx_n}{cx_{n-1} + dx_n} x_n \quad n = 0, 1, 2, \ldots.$$

Lynn Carole McGrath*, University of San Diego, and **Christopher Teixeira**, Rhode Island College (983-Z1-1110)

9:30AM ► (1258) *Bézier Cubics.*
Kent M. Neuerburg, Southeastern Louisiana University (983-Z1-1364)

9:45AM ► (1259) *Some Not So Usual Groups That Occur In Geometry.*
Mysore S Jagadish, Barry University, Miami Shores (983-Z1-479)

10:00AM (1260) *Quasi-going-up Rings.* Preliminary report.
Andrew J. Hetzel, The University of Tennessee, Knoxville (983-Z1-401)

10:15AM (1261) *Pluralism: a new way to introduce logic.*
Eric Schechter, Vanderbilt University (983-Z1-302)

10:30AM ► (1262) *Distribution of the Fundamental Constants.*
Louis G. Vargo, Trabuco Cyn., CA (983-Z1-271)

AWM Workshop

8:20 AM – 4:10 PM

This session consists of several parts listed separately throughout this program. All meeting participants are invited to attend all presentations.

Organizers: **Catherine A. Roberts**, The College of the Holy Cross
Jodie D. Novak, University of Northern Colorado

AMS Session on Mathematics Education

8:30 AM – 10:55 AM

8:30AM (1263) *Almost periodic neutral stochastic functional differential equations with abstract Volterra operators.* Preliminary report.
Zephyrinus C. Okonkwo, Albany State University (983-34-1370)

8:45AM ► (1264) *Publication patterns in the different areas of mathematics.* Preliminary report.
Jerrold W. Grossman, Oakland University (983-01-723)

9:00AM ► (1265) *A Grading Dilemma.* Preliminary report.
Tracey B McGrail*, Marist College, and **Robert W McGrail**, Bard College (983-00-1406)

9:15AM ► (1266) *Undergraduate Research Projects.* Preliminary report.
Cheryl Olsen* and **Lenny Jones**, Shippensburg University (983-97-1447)

9:30AM Break

9:45AM ► (1267) *On the transition from high school mathematics to unversity mathematics.* Preliminary report.
Richard O. Hill* and **Thomas Parker**, Michigan State University (983-97-1251)

10:00AM ► (1268) *Thinking Outside the box: Classroom Strategies to Keep Students Interested.*
Michael J Johnson, United States Military Academy (983-97-550)

10:15AM ► (1269) *A Model for Introducing Lab Projects into Precalculus.* Preliminary report.
Jerry G Morris, Sonoma State University (983-97-810)

10:30AM (1270) *In Search of Common Ground for Mathematicians and Mathematics Educators: Separating the NCTM Standards from Constructivism.* Preliminary report.
Sybilla Beckmann, University of Georgia (983-97-259)

10:45AM ► (1271) *Calculus Machina: A Computer Algebra System for Teaching and Learning Calculus.* Preliminary report.
Douglas A Quinney, University of Keele, UK (983-97-07)

AWM Workshop: Presentations by Recent Women Ph.D.s, I

8:30 AM – 10:20 AM

8:30AM (1272) *Modeling the Impact of HIV Infection on TB.*
Lih-Ing Wu Roeger, Texas Tech University

9:00AM (1273) *Mathematics in the Nanocell Approach to Molecular Electronics.*
Summer M. Husband, Rice University

9:30AM (1274) *Uniformly Concentric Bilinski Diagrams.*
Jennifer A. Bruce, Maryville College

10:00AM (1275) *Bicircular Matroids.*
Nancy Ann Neudauer, Pacific University

AMS Committee on Education Panel Discussion

8:30 AM – 10:00 AM

Successfully recruiting mathematics majors.

Moderator: **William G. McCallum**, University of Arizona

Panelists: **John C. Mayer**, University of Alabama at Birmingham
Ronald Miech, University of California Los Angeles
Lisa M. Traynor, Bryn Mawr College

MAA Invited Address

9:00 AM – 9:50 AM

(1276) *The Ubiquity of Elliptic Curves.*
Joseph H. Silverman, Brown University (983-A0-10)

ASL Invited Address

9:00 AM – 9:50 AM

(1277) *Hindman's theorem, ultrafilters, and reverse mathematics.*
Jeff L. Hirst, Appalachian State University

MAA Minicourse #10: Part B

9:00 AM – 11:00 AM

Turning a nonscience or developmental course into a capstone mathematical experience.

Organizers: **James T. Sandefur**, Georgetown University
Rosalie A. Dance, University of the Virgin Islands

MAA Minicourse #15: Part B

9:00 AM – 11:00 AM

Real fun exploring basic mathematics.

Organizers: **Shawnee L. McMurran**, California State University San Bernardino
Robert G. Stein, California State University San Bernardino

MAA Minicourse #4: Part B

9:00 AM – 11:00 AM

Visual linear algebra.

Organizers: **Eugene A. Herman**, Grinnell College
Michael D. Pepe, Seattle Community College
Eric P. Schulz, Walla Walla Community College

MAA Session on Assessment of Student Learning: Models and Methodology, II

9:00 AM – 10:55 AM

Organizers: **Jay A. Malmstrom**, Oklahoma City Community College
Linda Martin, Albuquerque-TVI
Mercedes A. McGowen, William Rainey Harper College

9:00AM ► (1278) *Documenting Mathematical Growth.* **Mercedes A. McGowen**, William Rainey Harper College (983-N1-555)

9:20AM ► (1279) *Assessing Introductory Courses in Mathematics.* Preliminary report. **AbdelNaser J Al-Hasan**, Mount Mary College (983-N1-359)

9:40AM ► (1280) *Assessing Geometric Understanding Through Dynamic Visualization.* Preliminary report. **Ferdinand D Rivera*** and **Barbara Pence**, San Jose State University (983-N1-1040)

10:00AM ► (1281) *Developmental Mathematics Assessment: Issues on Alignment with Accreditation Requirements, Fostering Administrative Support, and Compliance with Quantitative Literacy Requirements.* Preliminary report. **Jacqueline Brannon Giles***, HCC Central College, and **Cheryl Peters**, HCC- Central College (983-N1-560)

10:20AM ► (1282) *Analytic and Holistic Rubrics: How to Make them Work for You.* **Catherine M. Miller**, University of Northern Iowa (983-N1-350)

10:40AM ► (1283) *Placement Testing: Is it a Good Idea?* **Carmen M Latterell**, University of Minnesota Duluth (983-N1-19)

MAA Committee for Curriculum Reform Across the First Two Years and the MAA Task Force on the First College-Level Mathematics Course Panel Discussion

9:00 AM – 10:20 AM

Rethinking the courses below calculus.

Organizer: **Sheldon P. Gordon**, SUNY at Farmingdale

Panelists: **Nancy Baxter Hastings**, Dickinson College
Susan L. Ganter, Clemson University
Mercedes A. McGowen, William Rainey Harper College

MAA Panel Discussion

9:00 AM – 10:20 AM

The intersection of the life sciences, mathematical sciences, and computer science: Implications for the undergraduate curriculum.

Organizers: **Elizabeth J. Teles**, NSF
Lee L. Zia, NSF

NAM Panel Discussion

9:00 AM – 10:00 AM

The challenge of African-American women in mathematics.

Moderator: **Sylvia T. Bozeman**, Spelman College

Panelists: **Jacqueline B. Giles-Giron**, Houston Community College System
Dawn A. Lott, New Jersey Institute of Technology
Ulrica Parker, Emory University

Employment Center

9:00 AM – NOON

Math on the Web, IV

9:30 AM – 10:50 AM

9:30AM (1284) *Overview of MathML Markup.* **Bob Mathews**, Design Science

10:30AM (1285) *Creating Interactive Web pages with MathML.* **Robert Miner**, Design Science

Exhibits and Book Sales

9:30 AM – NOON

NAM Business Meeting

10:00 AM – 10:55 AM

MAA Invited Address

10:05 AM – 10:55 AM

(1286) *Is teaching about mathematics the same as teaching mathematics?* **Paul J. Sally, Jr.**, University of Chicago (983-A0-09)

ASL Invited Address

10:05 AM - 10:55 AM

(1287) *Set theoretical aspects of the Fubini theorem and separate continuity.*
Krzysztof Ciesielski, West Virginia University

AWM Workshop: Women Graduate Students Poster Session

10:30 AM - 11:00 AM

10:30AM (1288) *Modularity of Nonarithmetic Curves, a Hilbert Modular Surface for $\mathbb{Q}(\sqrt{5})$ and the Soccer ball.*
Andrea Moreira Bell, Oregon State University

10:30AM (1289) *A P,Q-Analogue of the Classical Hit Numbers.*
Karen S. Briggs, University of California, San Diego

10:30AM (1290) *Convection in a Thermosyphon: Bifurcation and Stability Analysis.*
Elizabeth Burroughs, University of New Mexico

10:30AM (1291) *Detection of Virtual Knot Diagrams.*
H. A. Dye, University of Illinois at Chicago

10:30AM (1292) *Chromatic Numbers of Hypergraphs and the Bohr Topology.*
Berit Nilsen Givens, University of Wisconsin, Madison

10:30AM (1293) *The symplectic geometry of the Gel'fand-Cetlin basis for representations of the symplectic group.*
Megumi Harada, University of California, Berkeley

10:30AM (1294) *The Rees Algebra of a Conormal Module.*
Jooyoun Hong, Rutgers University

10:30AM (1295) *Some Splitter theorems.*
Jinko Kanno, Louisiana State University

10:30AM (1296) *Cross and Join Surfaces in Surface Bundles Over the Circle.*
Elizabeth Klodginski, University of Michigan

10:30AM (1297) *Colorability and 3-string Tangles.*
Junalyn Navarra-Madsen, University of Texas at Dallas

10:30AM (1298) *Class Groups of Global Function Fields.*
Allison M. Pacelli, Brown University

10:30AM (1299) *Multiparameter Isospectral Deformations on SU(n).*
Emily Proctor, Dartmouth College

10:30AM (1300) *A Cellular Automaton Inverse Problem.*
Billie Rinaldi, Rensselaer Polytechnic Institute

10:30AM (1301) *Hilbert's Tenth Problem.*
Kirsten Eisenträger, University of California, Berkeley

10:30AM (1302) *The Skorokhod Problem and Heavy Traffic Limit Theorems.*
Aubin R.K. Whitley, University of California, San Diego

MAA Business Meeting

11:10 AM - 11:40 AM

AMS Business Meeting

11:45 AM - 12:15 PM

NAM Claytor-Woodard Lecture

1:00 PM - 1:50 PM

(1303) *Gorenstein injective, projective, and flat modules.*
Overtoun M. G. Jenda, Auburn University (983-20-206)

AMS-MAA-SIAM Special Session on Research in Mathematics by Undergraduates, IV

1:00 PM - 5:20 PM

Organizers: **Darren A. Narayan**, Rochester Institute of Technology
Carl V. Lutzer, Rochester Institute of Technology
Tamara A. Burton, Rochester Institute of Technology

1:00PM ► (1304) *On the existence of self-conjugate t-core partitions.* Preliminary report.
John A Baldwin, Harvard University, **Abraham B Kunin***, Massachusetts Institute of Technology, and **Lawrence Sze** (983-11-153)

1:30PM ► (1305) *Asymptotic density in combined number systems.*
Karen Yeats, University of Waterloo (983-11-59)

2:00PM ► (1306) *A Crack at the Frobenius Problem.*
Mete Atamel, Gettysburg College (983-11-666)

2:30PM ► (1307) *Generalization of Erdos's Sum-free Sets problem.* Preliminary report.
Nicolae Laza, Gettysburg College (983-11-1304)

3:00PM ► (1308) *Schur-Stability in 2×2 and 3×3 Matrices.* Preliminary report.
Vishal Gupta, Yale University, **Christine Prizeman**, Manhattan College, and **Coral Wheeler***, University of Akron (983-15-105)

3:30PM ► (1309) *Efficient Eigenspace Projections with Compression.* Preliminary report.
Ruben Arenas, **Nathaniel Eldredge*** and **Michael E. Orrison**, Harvey Mudd College (983-15-1424)

4:00PM ► (1310) *Matrices with Elliptical Numerical Ranges.*
Ethan S. Brown*, Massachusetts Institute of Technology, and **Ilya M. Spitkovsky**, College of William and Mary (983-15-601)

4:30PM ► (1311) *Lower bounds for minimal triangulations of n-cubes.*
Adam Bliss* and **Francis Edward Su**, Harvey Mudd College (983-52-600)

5:00PM ► (1312) *On Quadratic Witt Groups of Polynomial Rings.*
Christopher P Porter*, Gonzaga University, **Christina Maher** and **Paul Gibson**, University of Notre Dame (983-08-1293)

AMS Special Session on Wavelets, Frames and Operator Theory, IV

1:00 PM - 5:50 PM

Organizers: **Christopher Heil**, Georgia Institute of Technology
Palle Jorgensen, University of Iowa
David Larson, Texas A&M University

1:00PM (1313) *An iterative algorithm for ill-posed inverse problems where the object has a sparse wavelet expansion.*
Ingrid Daubechies*, Princeton University, **Michel Defrise**, Vrije Universiteit Brussel, and **Christine De Mol**, Universite Libre de Bruxelles (983-41-749)

1:30PM (1314) *Local reconstruction from averages.*
David F Walnut, George Mason University (983-41-1163)

2:00PM (1315) *Wavelets on p-adic fields and related groups.*
John J Benedetto, University of Maryland, and **Robert L Benedetto***, Amherst College (983-43-676)

2:30PM (1316) *Varying the Lattice of Gabor Frames.*
Hans G. Feichtinger and **Norbert Kaiblinger***, University of Vienna, Austria (983-42-849)

3:00PM (1317) *Approximation of linear operators by Gabor multipliers.*
Hans G. Feichtinger, Univ. Vienna, NuHAG (983-42-798)

3:30PM (1318) *Bilinear pseudodifferential operators on modulation spaces.*
Arpad Benyi, University of Massachusetts, and **Kasso A. Okoudjou***, Georgia Institute of Technology (983-47-603)

4:00PM (1319) *Localization of Frames.*
Karlheinz U. Groechenig, University of Connecticut (983-46-624)

4:30PM (1320) *Measure Function and Redundancy of Weyl-Heisenberg Multiframes and Superframes.*
Radu Balan*, Siemens Corporate Research, and **Zeph Landau**, MSRI (983-40-745)

5:00PM (1321) *Densities of Frames.* Preliminary report.
R. Balan, Siemens Corporate Research, **P. Casazza**, University of Missouri, **C. Heil**, Georgia Tech, and **Z. Landau***, Mathematical Sciences Research Institute (983-46-1286)

5:30PM ► (1322) *Existence and Construction of Finite Frames with a given frame operator.*
Peter G. Casazza* and **Manuel Leon**, University of Missouri - Columbia (983-43-469)

AMS Special Session on The Many Lives of Lattice Theory and the Theory of Ordered Sets, with Connections to Combinatorics, III

1:00 PM – 5:25 PM

Organizers: **Jonathan D. Farley**, University of Oxford
Stefan E. Schmidt, New Mexico State University
Alex J. Pogel, New Mexico State University

1:00PM ► (1323) *Lattices in Conceptual Data Systems.* Preliminary report.
Tim Benjamin Kaiser, PSL / Darmstadt University of Technology (983-06-1272)

1:30PM (1324) *Extensions of Lattices and Cover Functions.*
Asamoah Nkwanta* and **Boniface Eke**, Morgan State University (983-06-75)

2:00PM (1325) *Topological properties of active orders for matroid bases.* Preliminary report.
Bruce E Sagan* and **Rieuwert J Blok**, Michigan State University (983-06-50)

2:30PM (1326) *Topological properties of active orders for matroid bases (II).* Preliminary report.
Rieuwert J Blok* and **Bruce E Sagan**, Michigan State University (983-06-190)

3:00PM (1327) *Concordant sets and matchings in finite lattices.*
Joseph P. S. Kung, University of North Texas (983-06-604)

3:30PM (1328) *Equivalent characterizations of lattice supersolvability and their extensions.*
Peter McNamara*, Massachusetts Institute of Technology, and **Hugh Thomas**, Fields Institute (983-06-297)

4:00PM (1329) *An operad of matroids.* Preliminary report.
Andreas R Blass, University of Michigan (983-05-1342)

4:30PM ► (1330) *Results on Non-Unit Free Triangle Orders.*
Barry A Balof* and **Kenneth P. Bogart**, Dartmouth College (983-06-175)

5:00PM (1331) *Counting the number of bottlenecks in a poset.*
Gary P Gordon, Lafayette College (983-06-1197)

AMS Special Session on C-Extensions and Classifications of C*-Algebras, III*

1:00 PM – 3:55 PM

Organizers: **Shuang Zhang**, University of Cincinnati
Huaxin Lin, University of Oregon

1:00PM (1332) *Analytic and geometric properties of discrete groups.*
Jerome Kaminker, IUPUI (983-46-1378)

1:30PM (1333) *Traces, ideals and arithmetic means.*
Victor Kaftal* and **Gary Weiss**, University of Cincinnati (983-46-835)

2:00PM (1334) *Spans and sums of unitary and similarity orbits of a single operator.*
Kenneth R Davidson* and **Laurent W. Marcoux**, University of Waterloo (983-47-1357)

2:30PM (1335) *Frame Theory and Hilbert C*-Modules.* Preliminary report.
David Royal Larson, Texas A&M University (983-47-622)

3:00PM (1336) *A class of nuclear C*-algebras associated with continuous graphs.*
Takeshi Katsura, University of Oregon (983-46-645)

3:30PM (1337) *On the homotopy type of the unitary group and the Grassmann space of purely infinite simple C*-algebras.*
Shuang Zhang, University of Cincinnati (983-19-1038)

AMS Special Session on Discrete Dynamics and Difference Equations, III

1:00 PM – 5:55 PM

Organizers: **Saber N. Elaydi**, Trinity University
Gerasimos Ladas, University of Rhode Island

1:00PM ► (1338) *A Problem in Time Scales.* Preliminary report.
Allan C Peterson, University of Nebraska-Lincoln (983-39-1207)

1:30PM (1339) *Existence of Three Positive Pseudo-Symmetric Solutions for a One-Dimensional Discrete P-Laplacian.*
Richard Avery, Dakota State University, and **Johnny Henderson***, Baylor University (983-39-36)

2:00PM (1340) *Asymptotic behavior of exponential functions on time scales.*
Sigrun Bodine*, University of Puget Sound, and **D. A. Lutz**, San Diego State University (983-39-185)

2:30PM ► (1341) *On the Asymptotics of the Rational Difference Equation of Third Order.*
S Kalabusic, M. R. S. Kulenovic* and **Carol B Overdeep**, University of Rhode Island (983-39-158)

3:00PM (1342) *Periodic Coefficients Applied to Various Second Order Rational Difference Equations.* Preliminary report.
Carol B Overdeep*, University Of Rhode Island, **M. R. S Kulenovic** and **Gerasimos Ladas**, University of Rhode Island (983-37-149)

3:30PM (1343) *On the Global Character of the Difference Equation* $y_{n+1} = \frac{\alpha+\gamma y_{n-(2k+1)}+\delta y_{n-2l}}{A+y_{n-2l}}$.
E. A. Grove, G. Ladas, M. Predescu*, University of Rhode Island, and **M. Radin**, Rochester Institute of Technology (983-39-290)

4:00PM (1344) *On* $x_{n+1} = \max\left\{\frac{A_n^{(0)}}{x_n}, \frac{A_n^{(1)}}{x_{n-1}}, \ldots, \frac{A_n^{(k)}}{x_{n-k}}\right\}$ *with Periodic Parameters.* Preliminary report.
Candace Marie Kent*, Virginia Commonwealth University, and **Michael A. Radin**, Rochester Institute of Technology (983-37-621)

4:30PM ► (1345) *Oscillation of second order linear and half-linear difference equations with a forcing term.*
O. Došlý, Masaryk University, **John R. Graef***, University of Tennessee at Chattanooga, and **J. Jaroš**, Comenius University (983-39-69)

5:00PM (1346) *Category Theory, Symbolic Dynamics, and Chaos.*
Ralph L Wojtowicz, University of Dallas (983-37-267)

5:30PM (1347) *Symplectic Geometry of Prüfer Transformations.*
Michael K Kinyon*, Indiana University South Bend, and **Calvin D Ahlbrandt**, University of Missouri (983-39-1169)

AMS Special Session on Homotopy Theory, IV

1:00 PM - 5:20 PM

Organizers: **Kristine Baxter Bauer**, Johns Hopkins University
J. Michael Boardman, Johns Hopkins University
Nitu Kitchloo, Johns Hopkins University
Jean-Pierre Meyer, Johns Hopkins University
Jack Morava, Johns Hopkins University
W. Stephen Wilson, Johns Hopkins University

1:00PM (1348) *The Lubin-Tate spectrum* E_n *as a continuous* G_n*-spectrum and its homotopy fixed point spectra.*
Daniel G. Davis, Northwestern University (983-55-113)

1:30PM (1349) $K(s)^*(EG \times_G X^n)$ *for finite abelian groups* G.
Mark A. Pearson, Northwestern University (983-55-133)

2:00PM (1350) *On the Mahowald-Sadofsky conjecture.*
Paul L Shick, John Carroll University (983-55-764)

2:30PM (1351) *Polynomial functors of spectra split after periodic localization.*
Nicholas J Kuhn, University of Virginia (983-55-863)

3:00PM (1352) *Global structure theorems for unstable algebras over the Steenrod algebra.* Preliminary report.
David J Pengelley, New Mexico State University (983-55-97)

3:30PM (1353) *Double Q-rings and homology operations on* E_∞ *rig spaces. This is joint work with André Joyal.* Preliminary report.
Terrence P Bisson*, Canisius College, and **André Joyal**, UQAM (983-55-922)

4:00PM (1354) *Orthogonal calculus, spaces of embeddings and the Fulton-McPherson compactification.*
Gregory Arone, University of Virginia (983-55-1420)

4:30PM (1355) *Tangent 4-fields with finite singularities.*
Duane Randall, Loyola University New Orleans (983-55-1385)

5:00PM (1356) *On the holomorph of a discrete group.*
Maria S. Voloshina, University of Rochester (983-55-1039)

AMS Special Session on Algebraic Topology Based on Knots, IV

1:00 PM - 5:20 PM

Organizers: **Mark E. Kidwell**, U.S. Naval Academy
Jozef H. Przytycki, The George Washington University
Yongwu Rong, The George Washington University

1:00PM (1357) *Perturbative Topological Quantum Field Theory.* Preliminary report.
Thomas Kerler, The Ohio State University (983-57-1494)

1:30PM (1358) *M-Theory and 3-Dimensional Topology.*
Stavros Garoufalidis, Georgia Institute of Technology (983-55-263)

2:00PM (1359) *Reshetikhin-Turaev Invariants from quantum double construction of operator algebra.*
Marta Asaeda, University of Maryland (983-81-1365)

2:30PM (1360) *The Burau and Gassner representations for tangles.* Preliminary report.
Theodore Stanford, New Mexico State University (983-57-1440)

3:00PM (1361) *Quantum Invariants of Knots.* Preliminary report.
Charles D Frohman*, The University of Iowa, and **Joanna M Kania-Bartoszynska**, Boise State University (983-57-1215)

3:30PM (1362) *The effect of mutation on link concordance, 3-manifolds, and the Milnor invariants.*
Jae Choon Cha, Indiana University (983-57-1429)

4:00PM (1363) *A filtration of the knot concordance group and Casson-Gordon invariants.*
Taehee Kim, Indiana University, Bloomington (983-57-1327)

4:30PM (1364) *Bordism Invariants of the Mapping Class Group.* Preliminary report.
Aaron Heap, Rice University (983-55-1278)

5:00PM (1365) *The module of 2-chord diagrams for knots in the solid torus.* Preliminary report.
Khaled Tawfiq Bataineh, New Mexico State University (983-57-1323)

MAA Minicourse #11: Part B

1:00 PM - 3:00 PM

Symmetry for all.
Organizer: **George Baloglou**, SUNY Oswego

MAA Minicourse #16: Part B

1:00 PM - 3:00 PM

Cwatsets: A research experience for undergraduates.
Organizer: **Gary J. Sherman**, Rose-Hulman Institute of Technology

MAA Minicourse #5: Part B

1:00 PM - 3:00 PM

Using and adapting online materials.
Organizers: **David A. Smith**, Duke University
Lang Moore, Duke University
Douglas E. Ensley, Shippensburg University
Franklin A. Wattenberg, U.S. Military Academy

MAA Session on Courses and Projects Addressing the Shortage of K-12 Teachers

1:00 PM – 6:25 PM

Organizers: **Harel Barzilai**, Salisbury University
Maria G. Fung, Western Oregon University
Jay M. Jahangiri, Kent State University

1:00PM (1366) *Addressing K-12 Teachers and Raising Math Standards: What Can We Learn From The Singapore Success Story?*
Om P. Ahuja, Kent State University (983-U1-144)

1:15PM (1367) *Enhancing the Mathematical Core: Activities that Show Future Teachers the Value and Relevance of the Math Courses in their Major.* Preliminary report.
Matt Boelkins* and **Clark Wells**, Grand Valley State University (983-U1-437)

1:30PM (1368) *Western Oregon University's Successful Teacher Preparation Program.*
Laurie Burton and **Maria G. Fung***, Western Oregon University (983-U1-470)

1:45PM (1369) *Increasing Mathematics Preparation for Elementary and Middle School Teachers.*
Robert E Buck, Slippery Rock University (983-U1-279)

2:00PM (1370) *The Contextual, The Mathematical And The Physical How's And Why's Of Arithmetic's Situations: Forcing Future Elementary School Teachers To Understand 'Their' Mathematics.*
Dvora Peretz, Michigan State University (983-U1-92)

2:15PM (1371) *A sequence of mathematics courses designed for teachers.*
Patricia Baggett*, New Mexico State University, and **Andrzej Ehrenfeucht**, University of Colorado (983-U1-369)

2:30PM (1372) *Improving Elementary Level Mathematics Teaching: A World of Opportunity.* Preliminary report.
Gail Kaplan, UMBC and Key School (983-U1-378)

2:45PM (1373) *Number Theory from a Multicultural and Historical Perspective: A Math ADEPT Course.* Preliminary report.
Homer W. Austin, Salisbury University (983-U1-256)

3:00PM (1374) *Connecting Middle School and College Mathematics in Missouri.* Preliminary report.
Asma Harcharras* and **Dorina Mitrea**, University of Missouri (983-U1-434)

3:15PM (1375) *Conceptual Algebra for Teachers: Integrating Algebra into a New Graduate Program for Middle School Teachers.*
Harel Barzilai, Salisbury University (983-U1-261)

3:30PM (1376) *Why Teach Discrete Mathematics to K-8 Teachers?*
Valerie A. DeBellis*, East Carolina University, and **Joseph G. Rosenstein**, Rutgers University (983-U1-387)

3:45PM (1377) *A Collaborative Approach to Mathematics Professional Development for Teachers.* Preliminary report.
Ben Ford* and **Edith Prentice Mendez**, Sonoma State University (983-U1-307)

4:00PM (1378) *Math Teachers without Math: Responses to the Crisis.* Preliminary report.
Joseph R Fiedler, CSU Bakersfield (983-U1-30)

4:15PM (1379) *Connecting Middle School and College Mathematics.* Preliminary report.
Ira J Papick, University of Missouri (983-U1-178)

4:30PM (1380) *Addressing the Shortage of Qualified Middle School Mathematics Teachers.*
Joy Moore, University of Cincinnati (983-U1-273)

4:45PM (1381) *A graduate certificate program in secondary mathematics education.*
M. Elizabeth Mayfield*, **Kira H. Hamman** and **Kimberly K. Tysdal**, Hood College (983-U1-209)

5:00PM (1382) *Design, Implementation, and Results of Professional Development for Early Career Middle and High School Algebra Teachers.*
A. Susan Gay, University of Kansas (983-U1-412)

5:15PM (1383) *Content-Based Induction Programs for New Teachers.*
Joseph G. Rosenstein*, Rutgers University, and **Valerie A. DeBellis**, East Carolina University (983-U1-384)

5:30PM (1384) *Enriching Middle School Mathematics.* Preliminary report.
Pallavi Jayawant* and **Maria K. Robinson**, University of Arizona (983-U1-348)

5:45PM (1385) *Growing Professional Development: A Case Study.*
Barbara Pence, Dept. of Math, San Jose State Univ. (983-U1-332)

6:00PM (1386) *Making Mathematics Teacher Preparation a Priority at a Comprehensive University.* Preliminary report.
David C. Carothers*, **Judith B. Kidd**, **W. Jeanne Fitzgerald** and **J. Robert Hanson**, James Madison University (983-U1-501)

6:15PM (1387) *NGMK12: Integrating Mathematicians and K12 Educators.*
Jennifer "Filly" Fillingim* and **John O'Haver**, University of Mississippi (983-U1-47)

MAA Session on Creative Visualization Labs

1:00 PM – 5:15 PM

Organizers: **Sarah J. Greenwald**, Appalachian State University
Catherine A. Gorini, Maharishi University of Management
Mary L. Platt, Salem State College

1:00PM (1388) *Computer Activities for College Geometry.* Preliminary report.
William E. Fenton*, Bellarmine University, and **Barbara E. Reynolds**, Cardinal Stritch University (983-V1-471)

1:20PM (1389) *Walking, Folding, and Computing to Visualize Geometric Concepts.*
James Morrow, Mount Holyoke College (983-V1-1164)

1:40PM (1390) *Application Based Scripting and Construction for Secondary Education Majors using Geometer's Sketchpad.* Preliminary report.
David R Burns, Western Connecticut State University (983-V1-444)

2:00PM (1391) *A Laboratory Component for Geometry.*
Marsha J Davis, Eastern Connecticut State University (983-V1-535)

2:20PM (1392) *Teaching to See Like a Mathematician.* Preliminary report.
Walter J. Whiteley, York University (983-V1-839)

2:40PM (1393) *Making the Transition from Euclidean to Non-Euclidean Geometry Through Exploration.*
Don Spickler, Salisbury University (983-V1-324)

3:00PM (1394) *Extrinsic and Intrinsic Visualizations.* Preliminary report.
David W. Henderson, Cornell University (983-51-1072)

3:20PM ► (1395) *Spherical Sketchpad: A dynamic java program modeling spherical geometry.* Preliminary report.
David Austin and **William C. Dickinson***, Grand Valley State University (983-V1-740)

3:40PM ► (1396) *Spherical Geometry Project for Elementary Education Students.* Preliminary report.
Jeff Johannes, SUNY Geneseo (983-V1-1234)

4:00PM ► (1397) *Geometry of the Earth and Universe Labs: From the Classroom to Current Research.* Preliminary report.
Sarah J Greenwald, Appalachian State University (983-V1-817)

4:20PM ► (1398) *Paper Models of Surfaces with Curvature.*
Howard Iseri, Mansfield University (983-V1-224)

4:40PM ► (1399) *Using An Acrylic Saddle Surface in Teaching Geometry.*
J. Charles Jacobson, Elmira College (983-V1-229)

5:00PM ► (1400) *The PascGalois Project: Visualization Projects for Abstract Algebra.* Preliminary report.
Michael J. Bardzell, **Kathleen M. Shannon***, Salisbury University, and **Cynthia J. Woodburn**, Pittsburg State University (983-V1-203)

MAA Session on Linking Mathematics with Other Disciplines

1:00 PM – 6:55 PM

Organizers: **Stephanie A. Fitchett**, Honors College, Florida Atlantic University
Blake Mellor, Honors College, Florida Atlantic University
Gavin P. LaRose, University of Michigan

1:00PM ► (1401) *The Connections Curriculum at Western New England College.* Preliminary report.
Marilyn K Pelosi* and **John Willemain**, Western New England College (983-W1-391)

1:15PM (1402) *Mathematics Across the Curriculum in Washington State.*
Deann A Leoni* and **Rebecca Todd Hartzler**, Edmonds Community College (983-W1-225)

1:30PM ► (1403) *Integrated Precalculus and Calculus that Connects with Engineering and Science and Does Some Proofs.* Preliminary report.
Bernd S. W. Schroeder, Louisiana Tech University (983-W1-662)

1:45PM (1404) *Cryptology: A Bridge to Mathematics.*
Chris Christensen, Northern Kentucky University (983-W1-160)

2:00PM ► (1405) *Analysis of Traffic Flows at an Automobile Intersection using MATLAB.* Preliminary report.
Alexander Stanoyevitch, University of Guam (983-W1-186)

2:15PM ► (1406) *Using differentials to bridge the vector calculus gap.*
Tevian Dray* and **Corinne A. Manogue**, Oregon State University (983-W1-330)

2:30PM ► (1407) *Kevin Bacon and a Senior Class.* Preliminary report.
Patti Frazer Lock* and **Aleksandra Portnova**, St. Lawrence University (983-W1-532)

2:45PM ► (1408) *Math in the City: Teacher Professional Development Through Black Historic Sites.*
Irene Duranczyk*, University of Minnesota, **Barbara Leapard**, **Elaine Richards** and **Joanne Caniglia**, Eastern Michigan University (983-W1-182)

3:00PM ► (1409) *Mathematics for Health Sciences: A Model For Interdepartmental Collaboration Resulting in Student Success.*
Fred Peskoff, Borough of Manhattan Community College/CU NY (983-W1-536)

3:15PM ► (1410) *The Haves and the Have-nots: Using Gini's Index of Inequality.*
Karen J Schroeder* and **David H Carhart**, Bentley College (983-W1-63)

3:30PM ► (1411) *Using Projects to Link Mathematics, Statistics, Business, Economics & Other Disciplines in a First-year Course.*
Morteza Shafii-Mousavi* and **Paul Kochanowski**, Indiana University South Bend (983-W1-104)

3:45PM ► (1412) *Risky Business: Connecting Mathematics with Business and Economics.*
Ronald J Harshbarger*, U. of South Carolina Beaufort, and **Lisa S. Yocco**, Georgia Southern Univ (983-W1-72)

4:00PM ► (1413) *Beekeeping Economics: Uniting Beekeeping, Business and Mathematics for High School Students at the Native American Summer Institute.*
Stan T Yoshinobu, Cal State Dominguez Hills (983-W1-292)

4:15PM ► (1414) *A Computational Science Approach for Integrating Mathematics into other Disciplines.* Preliminary report.
Ignatios E Vakalis, Capital University (983-W1-167)

4:30PM ► (1415) *Computational Science as a Motivation for Learning Mathematics.* Preliminary report.
Holly Hirst, Appalachian State University (983-W1-339)

4:45PM ► (1416) *Mathematics Experiences Through Digital Signals.*
Mohamed Allali, Chapman University (983-W1-349)

5:00PM (1417) *Meteorology and Mathematics: A Course Pairing at Clarion University.*
Stephen I. Gendler* and **Anthony J. Vega**, Clarion University (983-W1-24)

5:15PM ► (1418) *Teaching Quantitative Skills in a Geoscience Context.* Preliminary report.
Janet Andersen*, Hope College, **Cathy Manduca**, Carleton College, and **Heather Macdonald**, College of William and Mary (983-W1-410)

5:30PM ► (1419) *Math Projects for Biology and Geoscience Majors Who Don't Like Math.*
Steven D. Leonhardi, Winona State University (983-W1-452)

5:45PM ► (1420) *Applying Mathematics and Technology to Geoscience Problems: Mapping and the Three-Point Problem.*
Vince Schielack, Texas A&M University (983-W1-518)

6:00PM ► (1421) *Use of Linear Algebra in developing Volatile-Organic-Compounds Finger Print of Urban Air: Research with Undergraduate Students.*
Umesh P Nagarkatte* and **Wilbert Hope**, Medgar Evers College, The City University of New York (983-W1-1247)

6:15PM (1422) *Using Critical Thinking to Link Mathematics and Writing Instruction.* Preliminary report.
Ron Taylor* and **Alvin H.F. Smith**, Berry College (983-W1-1452)

6:30PM ► (1423) *An Engineering Project in the Math Classroom: Desalination.*
Ethan Berkove, Lafayette College (983-W1-1493)

6:45PM ► (1424) *Teaching mathematics courses in engineering colleges.*
Wieslaw Marszalek, DeVry College of Technology (983-W1-1399)

MAA Session on Mathematical Connections in Art, Music, and Science

1:00 PM – 5:25 PM

Organizers: **John M. Sullivan**, UIUC
Douglas E. Norton, Villanova Univesity
Reza Sarhangi, Towson University

1:00PM ► (1425) *Optimal Geometry as Art.* Preliminary report.
John M Sullivan, Univ. Illinois (983-X1-811)

1:15PM ► (1426) *Mathematics in Origami.*
Thomas C. Hull, Merrimack College/University of Cincinnati (983-X1-260)

1:30PM ► (1427) *Quilting the Dihedral Group.*
Amy F. Szczepanski, Monmouth University (983-X1-265)

1:45PM ► (1428) *Mathscapes.* Preliminary report.
Anne M. Burns, Long Island University (983-X1-289)

2:10PM ► (1429) *Artistic Mathematics at Timothy Elementary School.* Preliminary report.
Sybilla Beckmann*, University of Georgia, and **Mary Lazzari**, Timothy Elementary School (983-X1-226)

2:25PM ► (1430) *Activities and Computer-Generated Student Masterpieces from a Course Entitled the Mathematics of Artistic Design.*
B. Lynn Bodner, Monmouth University (983-X1-306)

2:40PM ► (1431) *Mathematics in Art and Architecture: A General Education Course.* Preliminary report.
Helmer Aslaksen, Dept. of Mathematics, National University of Singapore (983-X1-450)

2:55PM (1432) *Curve Stitching: Linking Linear and Quadratic Functions.* Preliminary report.
Trisha Bergthold, San Jose State University (983-X1-1404)

3:20PM ► (1433) *A Visual Approach to Mathematics Education: Collaboration for Creating a Textbook Derived from the Interdisciplinary "BRIDGES" Conference Series.* Preliminary report.
Reza Sarhangi, Towson University (983-X1-886)

3:35PM ► (1434) *Paintings, Plane Tilings, and Proofs.*
Roger B. Nelsen, Lewis & Clark College (983-X1-31)

3:50PM ► (1435) *How To Correctly View A Flatland Painting.* Preliminary report.
Mark D Schlatter, Centenary College of Louisiana (983-X1-283)

4:05PM ► (1436) *A Mathematical View of the Four Sacred Mountains of the Navajos.*
Vernon Willie, San Juan College (983-X1-124)

4:20PM Break

4:30PM ► (1437) *Portraits of the Earth: Mathematical Aspects of Cartography.*
Timothy G Feeman, Villanova University (983-X1-312)

4:45PM ► (1438) *Mathematics as Tool and Inspiration in Music.*
Alexandra Kurepa*, North Carolina A&T State University, and **Rodney A. Waschka**, North Carolina State Univeristy (983-X1-426)

5:00PM ► (1439) *Fractal Patterns in Poetry and Mathematics.* Preliminary report.
Marcia Birken* and **Anne C. Coon**, Rochester Institute of Technology (983-X1-173)

5:15PM ► (1440) *Mathematical Connections in Philosophy and Theology: A Brief Tour.*
Douglas E. Norton, Villanova University (983-X1-1301)

MAA Session on Computation Mathematics in Linear Algebra and Differential Equations

1:00 PM – 5:35 PM

Organizers: **Richard J. Marchand**, SUNY Fredonia
Elias Deeba, University of Houston-Downtown
Timothy J. McDevitt, Naval Surface Warfare Center, Dahlgren, VA

1:00PM ► (1441) *Lagrange Polynomials for Data Driven Mathematics Investigations.* Preliminary report.
Michael J. Bossé, Indiana University of Pennsylvania (983-Y1-138)

1:20PM ► (1442) *Effective and efficient numerical techniques for the calculation of the quantity of calcium species during calcium sparks in heart muscle.*
Dawn Alisha Lott*, New Jersey Institute of Technology, **Joshua R. Berlin**, University of Medicine and Dentistry of NJ, and **Miao Li**, New Jersey Institute of Technology (983-Y1-824)

1:40PM ► (1443) *Error Estimates for Approximate Solutions of the Systems of Differential Equations and an Application to the 2-level Atom in the External Electromagnetic Field.* Preliminary report.
Gro Hovhannisyan*, Gannon University, Erie,PA, **Scott Glasgo**, Brigham Young University, and **Michael L. M.L. Ter-Mikaelyan**, Institute for Physical Research, Ashtarak, Armenia (983-Y1-1032)

2:00PM ► (1444) *Shear pleasure.*
Radoslav M. Dimitric, Texas A&M University (983-Y1-596)

2:20PM ► (1445) *The Immersed Interface Method for Elasticity Problems with Interfaces.* Preliminary report.
Xingzhou Yang*, **Zhilin Li**, North Carolina State University, and **Bo Li**, University of Maryland (983-Y1-357)

2:40PM ► (1446) *Graphs which are Laplacian Integral.* Preliminary report.
Jason J. Molitierno*, Sacred Heart University, **Michael Neumann**, University of Connecticut, **Stephen J Kirkland** and **Shaun Fallat**, University of Regina (983-Y1-371)

3:00PM ► (1447) *On falling down a hole through the Earth.*
Andrew J. Simoson, King College (983-Y1-889)

3:20PM ► (1448) *Visualizations in Fractional Calculus.*
Joseph D. Myers*, **Michael J. Jaye** and **Mark S. Gorak**, US Military Academy (983-Y1-455)

3:40PM ► (1449) *Using Inertial Measurements to Estimate Rocket Trajectories.* Preliminary report.
Richard J. Marchand, SUNY College at Fredonia (983-Y1-1297)

4:00PM ► (1450) *The QR Method for Finding Eigenvalues.*
Thomas W. Polaski, Winthrop University (983-Y1-894)

4:20PM (1451) *Getting More Out of Classical ODE Problems.*
Kathleen Pineau, École de technologie supérieure (983-Y1-269)

4:40PM ► (1452) *Graphical Illustration of Numerical Methods for ODE.*
Laurene V. Fausett, Georgia Southern University (983-Y1-440)

5:00PM ► (1453) *Investigating A Predator-Prey Model With a Hand-Held Computer Algebra System.*
Mary Ann Connors, Westfield State College (983-Y1-1050)

5:20PM (1454) *Student Misconceptions in Using Euler's Method in Solving ODEs.*
William P. Fox, Francis Marion University (983-Y1-242)

MAA Interactive Discussion

1:00 PM – 2:20 PM

Forging relationships between professional organizations to improve mathematics learning from kindergarten through graduate school.
Organizers: **Johnny W. Lott**, NCTM and University of Montana
James M. Rubillo, NCTM

MAA Committee on the Undergraduate Program in Mathematics Open Discussion

1:00 PM – 2:20 PM

First college-level mathematics courses.
Organizer: **Donald B. Small**, U. S. Military Academy
Panelists: **Mercedes A. McGowen**, William Harper Rainy College
Sheldon P. Gordon, SUNY at Farmingdale

AMW Workshop: Panel Discussion

1:00 PM – 2:30 PM

Shaping a career in mathematics.
Moderator: **Jodie D. Novak**, University of Northern Colorado
Panelists: **Alessandra O. P. Chiareli**, 3M Company
Mai Gehrke, New Mexico State University
Chawne M. Kimber, Lafayette College
Jennifer McGreevy, U.S. Department of Defense
Margaret M. Robinson, Mount Holyoke College

ASL Invited Address

1:20 PM – 2:10 PM

(1455) *Lower bounds in arithmetic complexity.*
Lou P. van den Dries, University of Illinois, Urbana-Champaign

AMS-MAA Special Session on The History of Mathematics, IV

1:30 PM – 3:55 PM

Organizers: **Joseph W. Dauben**, Lehman College
David E. Zitarelli, Temple University

1:30PM ► (1456) *T.H. Gronwall, Consulting Mathematician in America, 1912-1932.* Preliminary report.
Alan D Gluchoff, Villanova University (983-01-268)

2:00PM ► (1457) *Irene Stegun, the Handbook of Mathematical Functions and the Lingering Mathematical Influence of the Great Depression.*
David Alan Grier, George Washington University (983-01-66)

2:30PM (1458) *Americans in Paris: The Interwar Years.* Preliminary report.
Della D. Fenster, University of Richmond (983-01-615)

3:00PM ► (1459) *Put Notre Dame on the Mathematical Map: Karl Menger 1937-1946.*
Louise A. Golland, Moraine Valley College (983-01-95)

3:30PM ► (1460) *Paul C. Rosenbloom: How one versatile mathematician grappled with mathematics education in mid-20th century America.* Preliminary report.
David Lindsay Roberts, Laurel, Maryland (983-01-602)

ASL Invited Address

2:25 PM – 3:15 PM

(1461) *Automorphisms of the c.e. weak truth-table degrees.*
Timothy H. McNicholl, University of Dallas

AWM Workshop: Presentations by Recent Women Ph.D.s, II

2:30 PM – 4:20 PM

2:30PM (1462) *Prime Ideals of Multiparameter Quantized Coordinate Rings.*
Karen L. Horton, North Dakota State University

3:00PM (1463) *The space of graded traces for holomorphic vertex operator algebras with central charge 24.*
Katherine L. Hurley, University of South Carolina

3:30PM (1464) *Complexity of Computations in Commutative Algebra.*
Amelia Taylor, Rutgers University

4:00PM (1465) *Construction of a 3/4-ideal tetrahedron out of ideal tetrahedra.*
Yana Mohanty, University of California, San Diego

SIGMAA on Statistics Education Panel Discussion

2:45 PM – 4:05 PM

The state of statistics education.
Organizer: **Mary M. Sullivan**, Rhode Island College
Moderator: **Thomas L. Moore**, Grinnell College
Panelists: **Gail F. Burrill**, MSEB
Allan J. Rossman, California Polytechnic State University, San Luis Obispo
Joan B. Garfield, University of Minnesota, Minneapolis

SUMMA Special Presentation

2:45 PM – 4:05 PM

Organizer: **William A. Hawkins, Jr.**, MAA and the University of the District of Columbia

MAA Minicourse #6: Part B

3:15 PM – 5:15 PM

WeBWorK, an internet-based system for generating and delivering homework problems to students.
Organizers: **Arnold K. Pizer**, University of Rochester
Michael E. Gage, University of Rochester

Vicki Roth, University of Rochester

ASL Invited Address

3:30 PM – 4:20 PM

(1466) *Proper forcing revisited.*
Andrzej Roslanowski, University of Nebraska at Omaha and University of Northern Iowa

MAA Informal Session on Actuarial Education

4:15 PM – 6:15 PM

Organizer: **Krzysztof M. Ostaszewski,** Illinois State University

AMS Reception and Banquet

6:30 PM – 10:00 PM

Susan J. Friedlander
AMS Associate Secretary
Chicago, Illinois

James J. Tattersall
MAA Associate Secretary
Providence, Rhode Island

Meetings and Conferences of the AMS

Associate Secretaries of the AMS

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The Meetings and Conferences section of the *Notices* gives information on all AMS meetings and conferences approved by press time for this issue. Please refer to the page numbers cited in the table of contents on this page for more detailed information on each event. Invited Speakers and Special Sessions are listed as soon as they are approved by the cognizant program committee; the codes listed are needed for electronic abstract submission. For some meetings the list may be incomplete. **Information in this issue may be dated. Up-to-date meeting and conference information** at www.ams.org/meetings/.

Meetings:

Important Information regarding AMS Meetings

Potential organizers, speakers, and hosts should refer to page 108 in the January 2003 issue of the *Notices* for general information regarding participation in AMS meetings and conferences.

Abstracts

Several options are available for speakers submitting abstracts, including an easy-to-use interactive Web form. No knowledge of LaTeX is necessary to submit an electronic form, although those who use LaTeX may submit abstracts with such coding, and all math displays and similarily coded material (such as accent marks in text) must be typeset in LaTeX. To see descriptions of the forms available, visit http://www.ams.org/abstracts/instructions.html, or send mail to abs-submit@ams.org, typing help as the subject line; descriptions and instructions on how to get the template of your choice will be e-mailed to you.

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Paper abstract forms may be sent to Meetings & Conferences Department, AMS, P.O. Box 6887, Providence, RI 02940. There is a $20 processing fee for each paper abstract. There is no charge for electronic abstracts. Note that all abstract deadlines are strictly enforced. Close attention should be paid to specified deadlines in this issue. Unfortunately, late abstracts cannot be accommodated.

Conferences: (See http://www.ams.org/meetings/ for the most up-to-date information on these conferences.)

February 13-18, 2003: AAAS Annual Meeting, Denver, Colorado.

June 8 - July 24, 2003: Joint Summer Research Conferences in the Mathematical Sciences, Snowbird, Utah.

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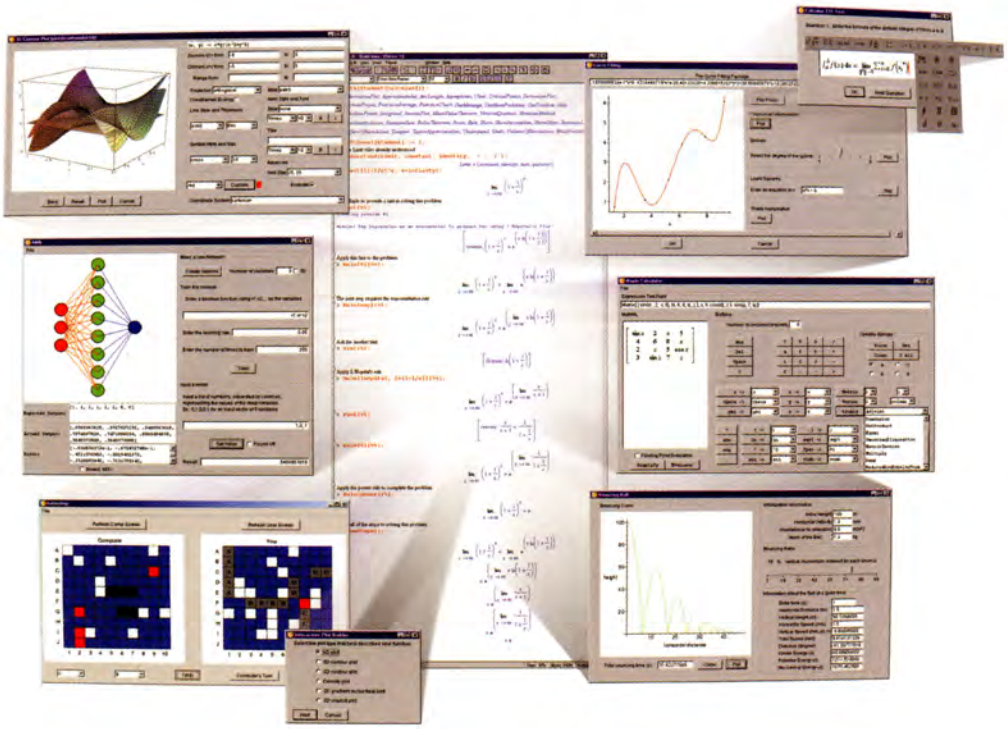

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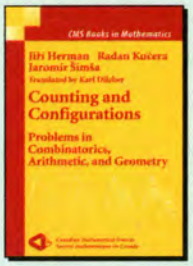
SPRINGER FOR MATHEMATICS

COUNTING AND CONFIGURATIONS

Problems in Combinatorics, Arithmetic, and Geometry

JIŘÍ HERMAN, Gymnazium Brno; **RADAN KUČERA,** Masaryk University; **JAROMÍR ŠIMŠA,** Academy of Sciences of the Czech Republic, all, Brno, Czech Republic; and Translated by **KARL DILCHER,** Dalhousie University, Canada



This book presents methods of solving problems in classical combinatorics, combinatorial number theory, and combinatorial geometry. It can be seen as a continuation of the successful book *Equations and Inequalities* (ISBN 0-387-98942-0) by the same authors. However, it can be read independently or used as a textbook in its own right. The authors' aim is to familiarize the reader with methods for solving problems in elementary mathematics, accessible to beginning university and advanced high-school students. They emphasize basic algebraic operations and other technical skills that are reinforced in numerous examples and exercises.

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CLAUDE P. BRUTER, Université Paris XII, Creteil, France (Ed.)

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L.P. LEBEDEV, Universidad Nacional de Colombia, Bogota, Colombia; and **IOSIF I. VOROVICH,** Rostov State University, Rostov on Don, Russia

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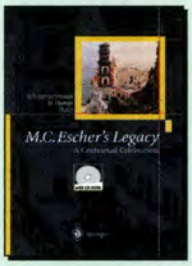
A Centennial Celebration

D. SCHATTSCHNEIDER, Moravian College, Bethlehem, PA; and **M. EMMER,** University of Rome "La Sapienza", Rome, Italy (Eds.)



One of the most popular artists of the 20th century, M. C. Escher, leaves a rich legacy. The centennial celebration of his birth, held in Rome and Ravello in 1998, gave testimony to the keen interest and new insight into his work, and showcased a number of contemporary artists and scientists whose work is directly inspired by that of Escher. This book contains 40 of their articles, richly illustrated with original art works in addition to well-known and little-known works by Escher. A CD-ROM complements the articles, containing color illustrations of work by contemporary artists, movies, animations, and other demonstrations.

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IGOR R. SHAFAREVICH, Mathematical Institute of the Russian Academy of Sciences, Moscow, Russia

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