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Notices

of the American Mathematical Society

January 2010 Volume 57, Number 1

Creativity Issue (see page 57)

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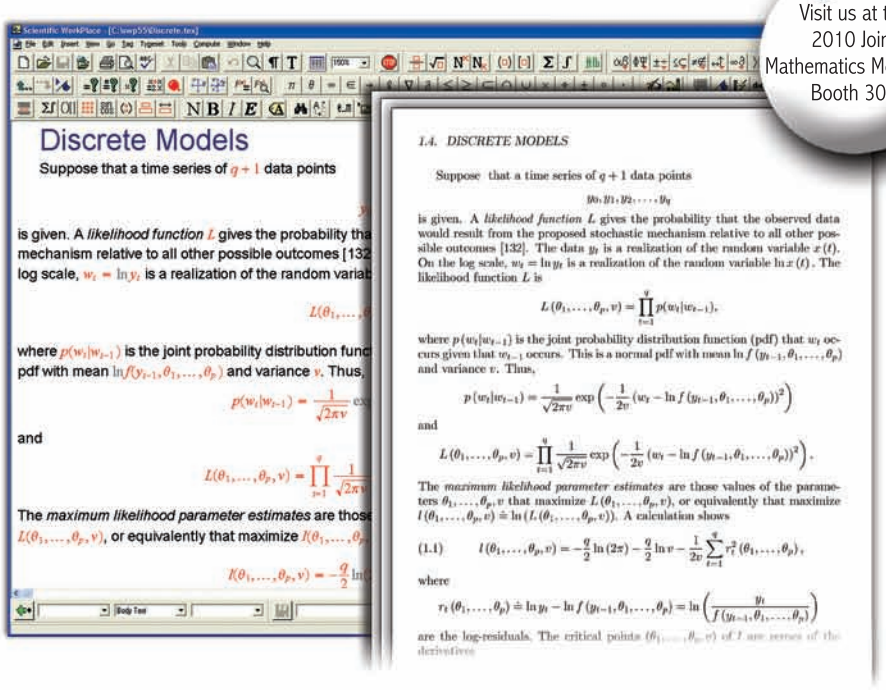

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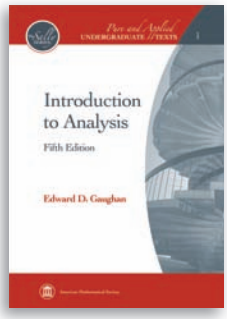

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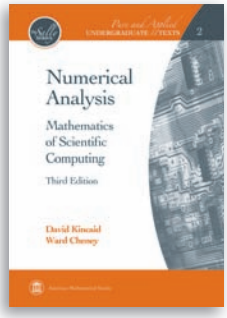

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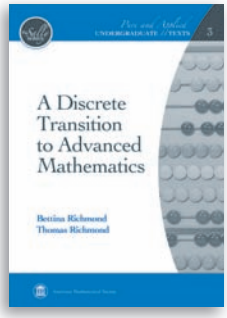

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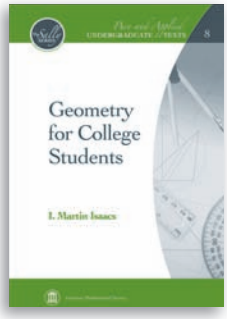

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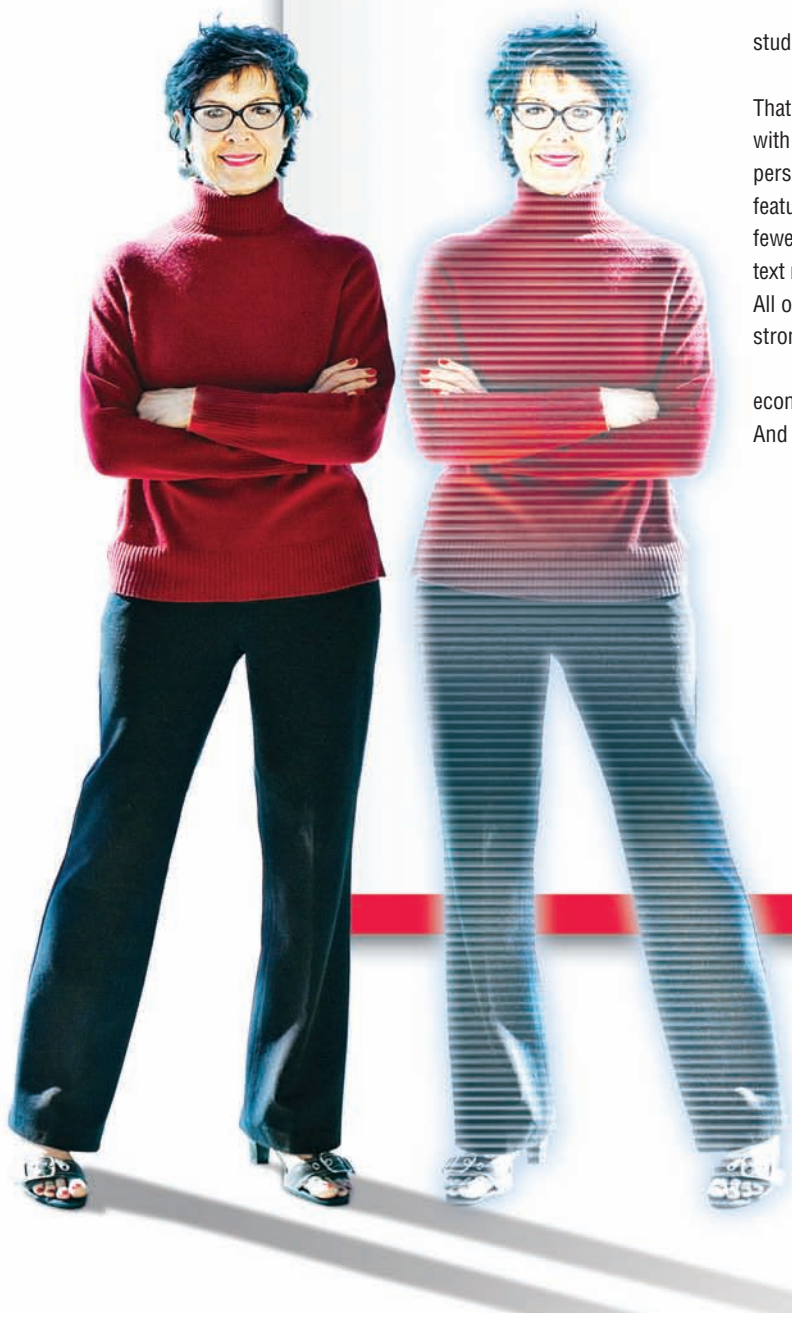

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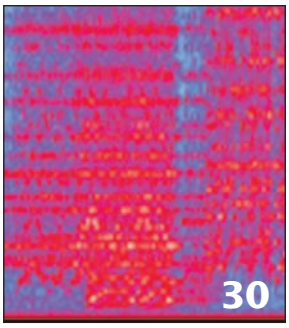

The theme of this issue of the *Notices of the American Mathematical Society* is "Mathematics and the Arts". Even in the time of the ancient Greeks it was generally recognized that mathematics and art are inextricably intertwined. The symbiosis has continued through the ages. Today, with computer graphics and many new artistic media, this interplay has taken startling and enlightening new forms.

We have selected here four articles to showcase different aspects of mathematics and art. We hope that this collection will lead to stimulating discussions and perhaps future contributions to the *Notices of the AMS*.

—Steven G. Krantz
Editor

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Commentary

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Departments

I thank Randi D. Ruden for her splendid editorial work, and for helping to get this issue assembled. She is essential to everything that I do. I thank Marie Taris for editorial contributions.

—Steven G. Krantz
Editor

Opinion

Mathematicians and the Tower of Babel

Mathematics has been flourishing for the last fifty years; classical problems have been solved, many areas have made major progress, and mathematics and physics have rediscovered each other, through the efforts of Atiyah, Singer, Witten, Seiberg, and many others.

At the same time the mathematical community is becoming increasingly fragmented. Looking at the titles on the covers of mathematical journals, or at the topics of lectures at conferences and colloquia, it seems that mathematics has broken into dozens of separate fields. Participation at specialty seminars is growing and attendance at departmental colloquia is dwindling. We are in danger of becoming residents of a Tower of Babel.

This is paradoxical because, to any mathematician who is watching, it is clear that the different branches of mathematics—analysis, algebra, geometry, topology, etc.— are enormously intertwined. Some of the most striking new results occurred at the interface between different areas. Leray's sheaves, beginning as a tool in topology, in the hands of H. Cartan and J. P. Serre revolutionized the study of complex manifolds and had a similar effect on algebraic geometry. Within analysis, a 1949 paper of Arne Beurling brought together Hardy space theory in the disk and the study of operators on Hilbert space, having a profound effect on that subject. Other examples abound.

The departmental colloquium used to be an occasion where individual specialists enlightened their colleagues in other fields about what was happening in their area. Most of the department members came to listen. As a graduate student at Harvard, I regularly attended colloquia. Despite being pretty ignorant, I got a lot out of the talks. I particularly remember, from the late 1940s, a colloquium by Heinz Hopf on almost complex structures on manifolds. I did not know what a complex manifold was, nor know any serious topology, but somehow he managed to explain things, and I found it very interesting. The same happy situation continued for me at Yale, where I was an instructor for some years, and then at Brown for many years.

What has happened? I once heard about a seminar given by Grothendieck, which was described as "A telegram by Grothendieck to Serre". This should not serve as a model for our colloquium speakers. A person giving a colloquium should have a realistic image of the audience in front of him or her. He or she should not generalize from the fact that two people in the front row are asking penetrating questions. This enlivens the lecture, but is misleading about the state of knowledge of the rest of the audience.

The innocent (nonexpert) listener at a mathematics lecture wants certain things: he or she would like an idea of the background of the problem, some of the objectives of the area, to see some simple examples illustrating the problem, and he or she wants to see some of the key steps in the argument. What he or she cannot handle is a massive amount of technical details and so many formulas on the board he or she cannot possibly absorb them.

It comes down to the fact that there are both a transmitter (the speaker) and a receiver (the listener), and the former can send much more information than the latter can absorb.

Here are some things that might improve the situation: more colloquia should inform people outside the field about interesting developments in the field. I remember some excellent talks on the proof of Fermat's Last Theorem which concentrated on explaining main elements in the argument and similar successful talks given about the Seiberg-Witten theory. You may say: "But a speaker traveling to another institution wants to give details of exciting recent developments, especially by him- or herself or coworkers." Of course! But this should be done before and after the colloquium, in the form of a conversation with interested parties.

Also, some schools have programs where speakers are invited for several days, which facilitates the above. In a similar spirit, a mathematician writing an expository article on a subject needs to concentrate on the central issues, and not overwhelm the reader with details. References at the end of the paper can lead the interested reader to continue his or her pursuit of the subject. As well, the writer or lecturer needs to remember that terminology current in his or her field for the last ten years (and in his or her mind part of the English language) may be only fuzzily, or not at all, familiar to the reader or listener.

The problems discussed above have been widely known for many years. It is high time that we tackled them.

—John Wermer
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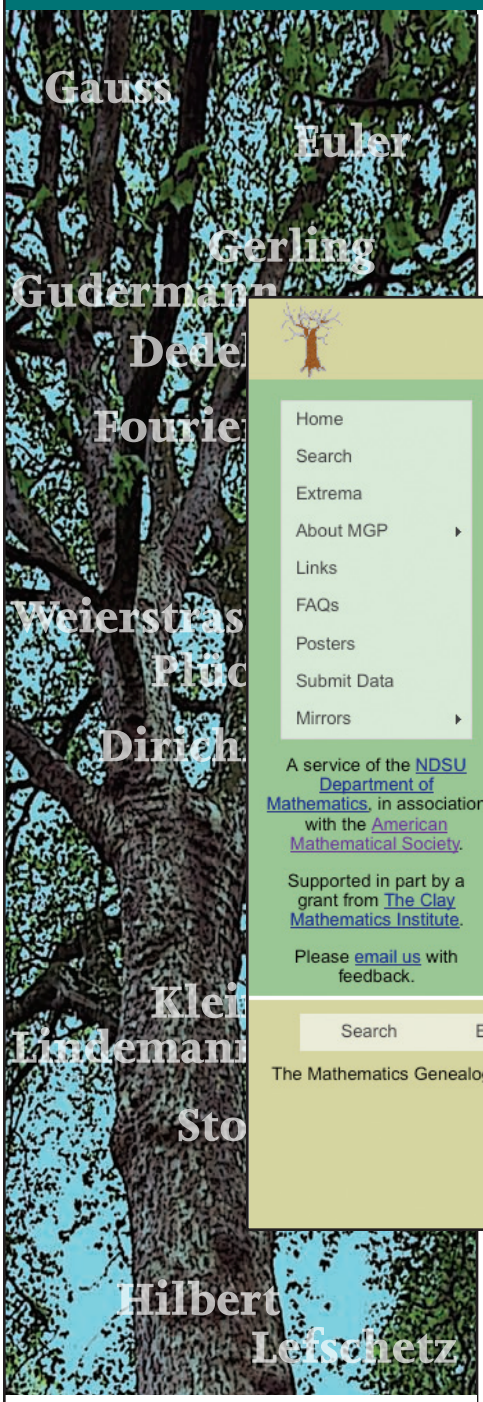

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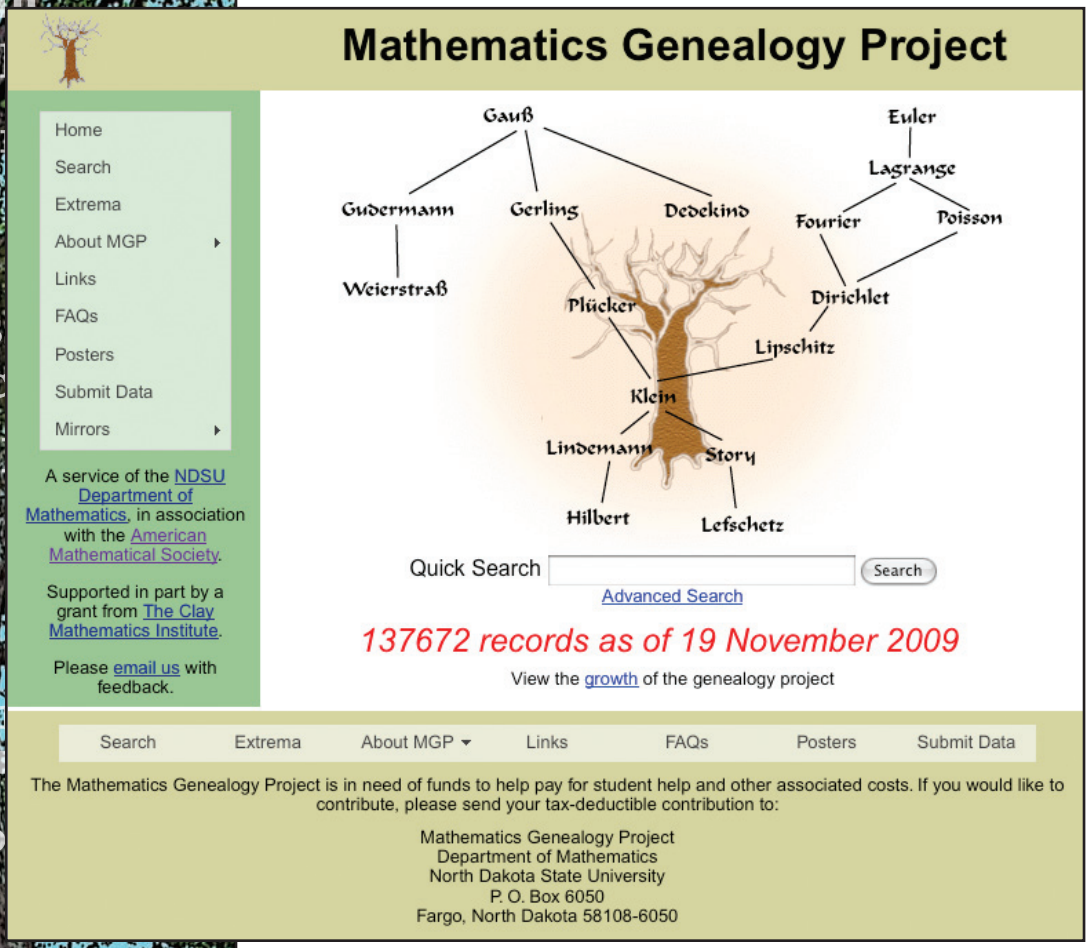

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Letters to the Editor

Hoisting the Black Flag

It is notoriously difficult to publish negative results in other sciences, but the Queen of the Sciences is supposed to be different. Three years ago, in December 2006, the *Notices* published an article containing theorems and mathematical claims for which I found a dozen counterexamples. The *Notices*, however, refused to publish my counterexamples even after I condensed them and their own referee verified them. The editorial solution was a "correction" that not only omitted many of the flaws I had found but also introduced a new mathematical error into the permanent record, in spite of an additional counterexample I had provided them to the new claim. The same errors that appeared in the 2006 *Notices* article continue to be propagated in the literature, including published research articles and a new book. More than two years later, I am still trying to publish the counterexamples and will continue to do so.

In the meantime, however, I have three suggested improvements to the editorial process of the *Notices*:

(1) When AMS editors become aware of serious mathematical errors in a widely publicized paper they published, they should not only correct the record completely in their own journal, but should also notify the relevant media sources and ask for public corrections or retractions (e.g., AMS News Release, *Scientific American,* Discovery Channel, and Mathworld, as in the above case);

(2) AMS editors should not pass judgment on papers or letters that refute articles published under their own watch;

(3) When editors announce a policy that appears to conflict with basic established AMS standards and ethics (e.g., that exposition overrides mathematical correctness), they should first consult the associate editors and AMS officers.

To appreciate the events that motivated this letter, see the diary "How to Publish Counterexamples in 1 2 3 Easy Steps", http://www.scribd.com/doc/19819297/How-to-Publish-Counterexamples-in-1-2-3-Easy-Steps.

It is our duty, as rank-and-file AMS members, to help guide our Society's editors. Our legacy is the scientific culture we leave to the next generation. To paraphrase the inimitable words of H. L. Mencken, "Every normal mathematician must be tempted at times to spit on his hands, hoist the black flag, and begin slitting throats."

—Theodore P. Hill
Georgia Tech

(Received September 24, 2009)

Patents and Mathematics

I am writing to encourage a discussion of whether the AMS should lobby the U.S. Patent and Trademark Office to remove their insulting and counterproductive exclusion of mathematics as evidence of the scientific and technical qualifications required for a lawyer to practice law before USPTO.

In recent years I have been involved as an inventor in patents for molecular diagnostics—one for detecting and identifying mutations using high-resolution DNA melting and another for identifying genes that can be useful for cancer diagnostics and therapies.

In the process I have discovered that there are very few patent attorneys with even a minimal mathematical training, not to mention the level required to understand the math involved in so much of modern science and technology. It was only recently when, in a very pleasant change of circumstances, I was referred to and worked with Thomas M. Bonacci, a patent attorney who had studied mathematics as an undergraduate and graduate student, that I learned why.

He told me that an applicant to practice before USPTO must demonstrate, in accordance with the USPTO's requirements, that he or she possesses scientific and technical proficiency sufficient to address issues that arise in patent law. Notably, however, mathematics is explicitly excluded as a subject for this purpose. I was a bit skeptical until I downloaded the "General Requirements Bulletin for Admission to the Examination for Registration to Practice in Patent Cases Before the United States Patent and Trademark Office" to see for myself. It lists 32 subjects in which bachelor's degrees exhibit adequate proof of the necessary scientific and technical training, as well as 2 1/2 pages of acceptable alternates. Then it states the "Typical Non-Acceptable Course Work: The following typify courses that are not accepted as demonstrating the necessary scientific and technical training:" and in the middle of this paragraph, there appears: "…machine operation (wiring, soldering, etc.), courses taken on a pass/fail basis, correspondence courses, …home or personal independent study courses, high school level courses, mathematics courses, one day conferences, …"

In case you cannot believe where the USPTO places mathematics any more than I could, links to this and related documents are provided at http://www.math.utah.edu/~palais/usptovsmath.html.

Ironically, USPTO requires mathematics coursework for prospective examiners in the computer arts (employees) that it doesn't recognize as qualifying for practitioners.

This is not a debate regarding the appropriateness of patenting mathematics. There have been many such conversations elsewhere. But in these times that mathematics is becoming increasingly visible in valuable patents (e.g., Google's Page Rank, a linear algebra algorithm, was licensed by Stanford for US$336 million) it seems that the USPTO should be encouraging, not discouraging, the mathematical fluency of the lawyers whose work it recognizes.

—Bob Palais
Math Dept., Pathology Dept.
University of Utah

(Received September 24, 2009)

The Art of Mathematics

Michael Atiyah

In the traditional dichotomy between Art and Science, mathematics sits warily between the two. Hermann Weyl said that, in his mathematical work, he always strived after beauty and truth, and we might regard these as being the contrasting characteristics of Art and Science. Mathematicians try to understand the physical world, to unearth the secrets of nature, to search for truth. They do this by creating intellectual edifices of great subtlety and beauty, guided by their aesthetic judgement. Seen this way, mathematics links Art and Science in one great enterprise, the human attempt to make sense of the universe.

We mathematicians can appreciate this grand philosophical unification, but to the layman, unversed in our secrets, Science and Art seem diametrically opposed. Science deals with the hard facts of existence while the Arts exist only in the human mind; "beauty lies in the eye of the beholder." Science is objective, Art is subjective, the two dwell in parallel planes and never meet.

This naïve distinction fails to grasp the nature of science. Poincaré said that science is no more a collection of facts than a house is a collection of bricks. The facts have to be ordered or structured, they have to fit a theory, a construct (often mathematical) in the human mind. The choice of a theory is a human choice; we prefer the theory which appeals to us best, the simplest or most beautiful. We employ Occam's razor, which tells us to make the least assumptions. The success of science seems to indicate that the beauty which we humans search for in mathematical theories does capture aspects of truth, that the universe is indeed built on principles which harmonize with the human mind, that in the words of Keats: "Truth is beauty, beauty truth—that is all ye know on earth and all ye need to know."

While poets have the insight to reach such an understanding, there are few who can see how to reconcile truth and beauty. Mathematics may be art, but to the general public it is a black art, more akin to magic and mystery. This presents a constant challenge to the mathematical community: to explain how art fits into our subject and what we mean by beauty.

In attempting to bridge this divide I have always found that architecture is the best of the arts to compare with mathematics. The analogy between the two subjects is not hard to describe and enables abstract ideas to be exemplified by bricks and mortar, in the spirit of the Poincaré quotation I used earlier.

In architecture one finds a variety of function (from churches to railway stations), a variety of materials (from bricks to glass), and beauty at all levels (from fine detail to great vision). A mathematical theory exhibits similar variety except that the technology is now intellectual rather than physical and the beauty is a more difficult taste to acquire.

Fortunately there are many detailed ways in which art and beauty appear in mathematics, and some of these can be appreciated by the general public. The articles that follow will illustrate this by many specific examples drawn from different areas and show different facets of beauty in mathematics.

Perhaps I can end by reproducing the only poetic passage I have ever written. It is entitled "Dreams" and appears in "The Unravelers",[1] a book produced by the IHES.

> In the broad light of day mathematicians check their equations and their proofs, leaving no stone unturned in their search for rigour. But, at night, under the full moon, they dream, they float among the stars and wonder at the miracle of the heavens. They are inspired. Without dreams there is no art, no mathematics, no life.

Sir Michael Atiyah is Honorary Professor of Mathematics at the University of Edinburgh. His email address is M.Atiyah@ed.ac.uk.

[1] *The French original "Les Déchiffreurs" had a French version which some may prefer. Published by A. K. Peters.*

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The Life and Survival of Mathematical Ideas

Michael F. Barnsley

Nature and evolution provide the notion of a creative system: a core stable form (DNA), a fertile environment, a determination to survive, and random stimuli. Analogously, the mind of a mathematician provides a locus for creative systems, a place where mathematical structures live and evolve.

According to the King James version of Genesis, "On the Fifth day …God created great whales." But Darwin went one better; at the end of his masterwork, in simple beautiful language, he proposes that what was created was a creative system. The last paragraph of *Origin of Species* says:

> It is interesting to contemplate a tangled bank, clothed with many plants of many kinds, with birds singing on the bushes, with various insects flitting about, and with worms crawling through the damp earth, and to reflect that these elaborately constructed forms, so different from each other, and dependent upon each other in so complex a manner, have all been produced by laws acting around us. …There is grandeur in this view of life, with its several powers, having been originally breathed by the Creator into a few forms or into one; and that, whilst this planet has gone circling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being evolved.

Faced with the extraordinary richness and complexity of the physical observable universe, of which we are part, what on earth can a mathematician truly create? The answer is: a vast landscape of lovely constructions, born for the first time, to live on in the realm of ideas. For the realm of ideas belongs to sentient beings such as us: whether or not there was a Creator, it is certain that the system of which we are part is, *by its very nature*, creative. Our genes are creative; they have to be, and they have to allow creative mutations. They must be stable in their creativity. Their creativity is the wellspring of ours. Not only must our genes, through the mechanisms of biology and random mutation, invent new viable forms, but they must also be prone to do so.

Our mathematical creativity may actually be initiated by random events at the deepest level, after deductive reasoning, consistencies, experience, and even intuition, are factored out of the process. But the creative mind contains something much more important than a random idea generator; it provides an environment in which the wild seed of a new idea is given a chance to survive. It is a fertile place. It has its refugias and extinctions. In giving credit for creativity we really praise not random generation but the determination to give life to new forms.

But when does a newly thought up mathematical concept, C, survive? Obviously, C must be consistent with mathematics, true, correct, etc. But I believe that what causes C to survive in the minds and words of mathematicians is that it is, itself, a *creative system.* For now I will resist trying to give a precise definition: for this young notion to survive, it needs to be adaptable. Roughly, I mean that C has the following attributes: (I) C is able to define diverse forms and structures—call them *plants*; (II) *plants* possess DNA; (III) C is stable in several senses; (IV) C can be treated from diverse mathematical positions (e.g., topological, geometrical, measure theoretic, algebraic); (V) C is highly adaptable and can be translated into the languages of various branches of science and

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Figure 1. Pictures of attractors of affine, bilinear, and projective IFSs.

engineering, with real applications; (VI) creative systems beget new creative systems.

For more than two thousand years the key forms of Euclid's *Geometry* have survived, shifted in importance, and evolved. It has all six properties of a creative system; indeed, one could find a number of different ways of defining it as such. Here is the one that I like: the diverse forms and structures are objects such as lines, circles, and other constructions; the DNA of these plants consists of formulas, such as "the equation for a straight line", provided by Descartes' analytic geometry; Euclidean geometry can be treated from geometric, algebraic, and other viewpoints; the topic is stable both in the sense that nearby DNA yields nearby forms and in the sense that small changes in the axioms lead to new viable geometries; it has adapted to many branches of science and engineering, with rich applications; and Euclidean geometry begat projective geometry via the inclusion of the line at infinity. Alternatively one might describe Euclid's geometry more abstractly so that the theorems are its diverse structures and the axioms and definitions are its DNA.

Dynamical systems [19] and *cellular automata* [35] provide two recent examples of creative systems. I mention these topics because each has an obvious visible public aspect, more colorful than lines and circles drawn on papyrus: their depth and beauty are advertised to a broad audience via computer graphic representations of some of their flora. They are alive and well, not only in the minds of mathematicians, but also in many applications.

In your own mind you give local habitation and a name to some special parts of mathematics, your creative system. Because this note is a personal essay, I focus on ideas extracted from my own experience and research. In particular, I discuss *iterated function systems* as a creative system, to illustrate connections with artistic creativity. To sharpen the presentation I focus almost exclusively on point-set topology aspects. While the specifics of iterated function systems may not be familiar to you, I am sure that the mathematical framework is similar to ones that you know.

Iterated Function Systems, Their Attractors, and Their DNA

An *iterated function system (IFS)*,

$$\mathcal{F} := (\mathbb{X}; f_1, \ldots, f_N),$$

consists of a complete metric space $\mathbb{X}$ together with a finite sequence of continuous functions, $\{f_n : \mathbb{X} \to \mathbb{X}\}_{n=1}^{N}$. We say that $\mathcal{F}$ is a *contractive IFS* when all its functions are contractions. A typical *IFS creative system* may consist of all IFSs whose functions belong to a restricted family, such as affine or bilinear transformations acting on $\mathbb{R}^2$.

Let $\mathbb{H}$ denote the set of nonempty compact subsets of $\mathbb{X}$. We equip $\mathbb{H}$ with the Hausdorff metric, so that it is a complete metric space. The Hausdorff distance between two points in $\mathbb{H}$ is the least radius such that either set, dilated by this radius, contains the other set. We define a continuous mapping $\mathcal{F} : \mathbb{H} \to \mathbb{H}$ by

$$\mathcal{F}(B) = \cup f_n(B)$$

for all $B \in \mathbb{H}$. Note that we use the same symbol $\mathcal{F}$ for the IFS and for the mapping.

Let us write $\mathcal{F}^{\circ k}$ to denote the composition of $\mathcal{F}$ with itself k times. Then we say that a set $A \subset \mathbb{X}$ is an *attractor* of the IFS $\mathcal{F}$ when $A \in \mathbb{H}$ and there is an open neighborhood $\mathcal{N}$ of A such that

$$\lim_{k \to \infty} \mathcal{F}^{\circ k}(B) = A$$

for all $B \subset \mathcal{N}$ with $B \in \mathbb{H}$. Since $\mathcal{F} : \mathbb{H} \to \mathbb{H}$ is continuous, we have $\mathcal{F}(A) = A$. Notice that our definition of attractor is topological: in the language of dynamical systems, A is a strongly stable attractive fixed point of $\mathcal{F}$.

Our first theorem provides a sufficient condition for an IFS to possess an attractor, one of the "plants of many kinds" of an IFS creative system.

Theorem 1. [18] *Let $\mathcal{F} = (\mathbb{X}; f_1, \ldots, f_N)$ be a contractive IFS. Then $\mathcal{F} : \mathbb{H} \to \mathbb{H}$ is a contraction, and hence, by Banach's contraction theorem, $\mathcal{F}$ possesses a unique global attractor.*

Attractors of IFSs are our main examples of the diverse forms and structures of an IFS creative system (see Figure 1), as in attribute (I).

An *affine* IFS is one in which the mappings are affine on a Euclidean space. Attractors of affine IFSs

such as Sierpinski triangles, twin-dragons, Koch curves, Cantor sets, fractal ferns, and so on, are the bread-and-butter sets of fractal geometers. The geometries and topologies of these attractors are so rich, fascinating, and diverse that deep papers are written about a single species, or very small families of them!

We define the *DNA* of an IFS attractor to be an explicit formula for the IFS. We refer to the DNA of an IFS attractor as an *IFS code*. The DNA for the canonical Cantor set is $(\mathbb{R}; f_1(x) = x/3, f_2(x) = (x+2)/3)$; these few symbols and their context define a nondenumerable set of Lebesque measure zero. Similarly, the DNA for the Sierpinski triangle is $(\mathbb{R}^2; f_1(x,y) = (x/2, y/2),\ f_2(x,y) = (x/2 + 1/2, y/2),\ f_3(x,y) = (x/2, y/2 + 1/2))$. Here a curve whose points are all branch points is captured in a short strand of symbols. Other simple IFS codes provide DNA for classical objects, such as arcs of parabolas, line segments, triangles, and circles.

How do the individual numbers in IFS codes relate to the properties of the attractors that they define? Similarly, we might ask about the relationship between the DNA of a biological plant and the plant itself, the details of its leaf shapes, the structure of its vascular bundles, and so on.

When Does an Affine IFS Possess an Attractor?

In discussing this seemingly simple question we reveal how IFS theory is subtle and leads into applications, as in attribute (V). We characterize both geometrically and metrically, per attribute (IV), those affine IFSs that possess attribute (I).

Intuition incorrectly suggests that the answer to our question is: if the magnitudes of all of the eigenvalues of the linear parts of the maps of the IFS are less than one, then the affine IFS has an attractor. The situation seems to be analogous to the situation for discrete dynamical systems ([17], Proposition, p. 279), where an affine map has an attractive fixed point if and only if the norm of the linear part is less than one. But the situation is not analogous. Consider for example the IFS

$$(\mathbb{R}^2; f_1(x,y) = (2y, -x/3), f_2(x,y) = (-y/3, 2x)).$$

The point $O = (0,0)$ is an attractive fixed point for both f_1 and f_2, because $f_1^{\circ 2n}(x,y) = f_2^{\circ 2n}(x,y) = (-2/3)^n(x,y)$, $f_1^{\circ(2n+1)}(x,y) = (-2/3)^n f_1(x,y)$, and $f_2^{\circ(2n+1)}(x,y) = (-2/3)^n f_2(x,y)$ for all points (x,y) in $\mathbb{R}^2$. But $\{O\}$ is not an attractor for the IFS because $(f_1 \circ f_2)^n(x,y) = (4^n x, y/9^n)$ implies that O is an unstable fixed point.

The following theorem contains an answer to our question and an affine IFS version of the converse to Banach's contraction theorem [13]. For us, most importantly, it provides both a metric and a geometrical characterization of viable affine IFS codes. See also Berger and Wang [9] and Daubechies and Lagarias [10].

Theorem 2. [1] *If $\mathcal{F} = (\mathbb{R}^M; f_1, \ldots, f_N)$ is an affine IFS, then the following statements are equivalent.*

(1) *$\mathcal{F}$ possesses an attractor.*

(2) *There is a metric, Lipshitz equivalent to the Euclidean metric, with respect to which each f_n is a contraction.*

(3) *There is a closed bounded set $K \subset \mathbb{R}^M$, whose affine hull is $\mathbb{R}^M$, such that $\mathcal{F}$ is nonantipodal with respect to K.*

Briefly, let me explain the terminology. We say that two metrics $d_1(\cdot,\cdot)$ and $d_2(\cdot,\cdot)$ on $\mathbb{R}^M$ are Lipshitz equivalent when there is a constant $C \geq 1$ such that $d_1(x,y)/C \leq d_2(x,y) \leq C d_1(x,y)$ for all $x, y \in \mathbb{R}^M$. Given any closed bounded set K in $\mathbb{R}^M$, whose affine hull is $\mathbb{R}^M$, and any $u \in S^{M-1}$, the unit sphere in $\mathbb{R}^M$, let $\{\mathcal{H}_u, \mathcal{H}_{-u}\}$ be the unique pair of distinct support hyperplanes of K perpendicular to u; see [27], p. 14. Then the set of antipodal pairs of points of K is $K' := \{\{a, a'\} : a \in \mathcal{H}_u \cap \partial K,\ a' \in \mathcal{H}_{-u} \cap \partial K,\ u \in S^{M-1}\}$ where ∂K denotes the boundary of K. We say that an IFS *$\mathcal{F}$ is nonantipodal with respect to K* when each of its functions takes K into itself but maps no antipodal pair of points of K to an antipodal pair of points of K. We denote the latter condition by $\mathcal{F}(K') \cap K' = \emptyset$.

Part of the proof of Theorem 2 relies on the observation that if $\mathcal{K} \subset \mathbb{R}^M$ is a convex body (think of $\mathcal{K}$ as the convex hull of K in (3)), then we can define a metric $d_{\mathcal{K}}(\cdot,\cdot)$ on $\mathbb{R}^M$, Lipshitz equivalent to the Euclidean metric, by

$$d_{\mathcal{K}}(x,y) = \inf\left\{\frac{\|x-y\|}{\|l-m\|} : l, m \in \mathcal{K}, l - m = \alpha(x-y), \alpha \in \mathbb{R}\right\}$$

for all $x \neq y$, where $\|x-y\|$ denotes the Euclidean distance from x to y in $\mathbb{R}^M$. One shows that, if an affine map f_n is nonantipodal with respect to $\mathcal{K}$, then it is a contraction with respect to $d_{\mathcal{K}}$. In fact $d_{\mathcal{K}}$ is, up to a constant factor, a Minkowski metric [30] associated with the symmetric convex body defined by the Minkowski difference $\mathcal{K} - \mathcal{K}$.

Theorem 2 provides a means for defining viable IFS codes (DNA) and is useful in the design of a two-dimensional affine IFS whose attractor approximates a given target set $T \subset \mathbb{R}^2$. Typical IFS software for this purpose exhibits a convex window $\mathcal{K}$, containing a picture of T, on a digital computer display. A set of affine maps is introduced, thereby defining an IFS $\mathcal{F}$. The maps are adjusted using interactive pictures of $\mathcal{F}(\mathcal{K})$ and $\mathcal{F}(T)$. If we ensure that $\mathcal{F}(\mathcal{K}) \subset \mathcal{K}$ and $\mathcal{F}(\mathcal{K}') \cap \mathcal{K}' = \emptyset$, then $\mathcal{F}$ possesses a unique

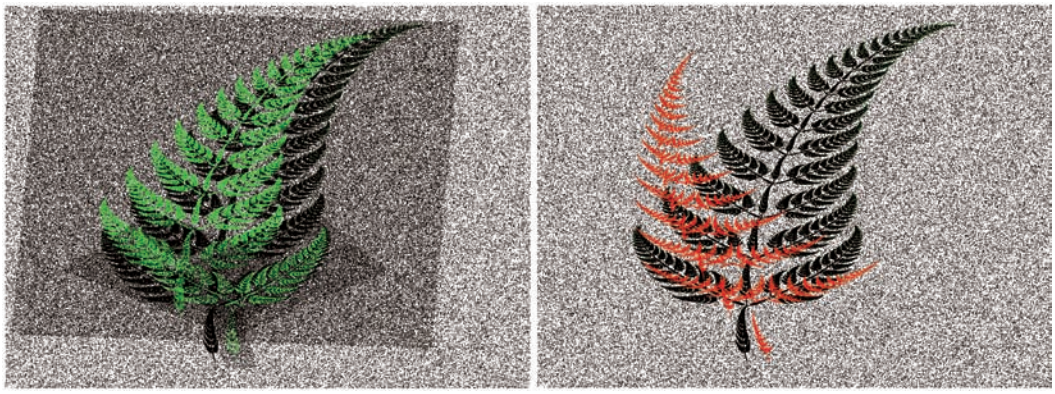

Figure 2. The left-hand panel shows a black fern image within a grimy window; overlayed upon it are four affine transformations of the window and the fern, with the transformed fern images shown in green. The goal has been to approximate the original (black) fern with affinely transformed (green) copies of itself. The rectangular window has been mapped nonantipodally upon itself. So, by Theorem 2, there exists a metric such that the associated affine IFS $\mathcal{F}$ is contractive. The original fern (black) and the attractor (red) of $\mathcal{F}$ are shown in the right-hand panel.

attractor $A \subset \mathcal{K}$. An example is illustrated in Figure 2.

Now we are in a position to explain a stability relationship between IFS codes and attractors and thus to exhibit a form of stability, as in attribute (III). We can control the (Hausdorff) distance $h_{\mathcal{K}}$, which depends on $d_{\mathcal{K}}$, between A and T because it depends continuously on the distance between $\mathcal{F}(T)$ and T. Indeed, the collage theorem [2] states that

$$h_{\mathcal{K}}(A,T) \leq \frac{h_{\mathcal{K}}(\mathcal{F}(T),T)}{1-\lambda},$$

where $0 \leq \lambda < 1$ is a Lipshitz constant for $\mathcal{F} : \mathbb{H} \to \mathbb{H}$, for example the maximum of a set of contractivity factors of the f_ns with respect to $d_{\mathcal{K}}$. Notice that this relationship says nothing about the topological structure of an attractor: it comments only on its approximate shape.

The collage theorem expresses one kind of stability for the IFS creative system, as in attribute (III): small changes in the IFS code of a contractive IFS lead to small changes in the shape of the attractor. Indeed, this realization played a role in the development of fractal image compression [2]. In this development several things occurred. First, affine IFS theory adapted to a digital environment, illustrating a component of attribute (V). Because contractive affine IFSs do not in general translate to contractive discrete operators [28], new theory had to be developed. (See, for example, [16].) This illustrates stability of a second kind, as required in attribute (III): the underlying ideas are robust relative to structural changes in the creative system. Finally, a real application was the result, as required by attribute (V).

Projective and Bilinear IFSs

We will also use both projective and bilinear IFSs for creative applications that control the shape and topology of attractors and transformations between attractors. Both are generalizations of two-dimensional affine IFSs. Both can be expressed with relatively succinct IFS codes yet have more degrees of freedom than affines. Another such family of IFSs is provided by the Möbius transformations on $\mathbb{C} \cup \{\infty\}$. The availability of a rich selection of accessible examples is a valuable attribute for the survival of a mathematical idea.

In two dimensions, the functions of a *projective* IFS are represented in the form

(0.1)
$$f_n(x,y) = \left(\frac{a_n x + b_n y + c_n}{g_n x + h_n y + j_n}, \frac{d_n x + e_n y + k_n}{g_n x + h_n y + j_n}\right),$$

where the coefficients are real numbers. A similar result to Theorem 2 applies to such projective transformations restricted to a judiciously chosen convex body, with the associated Hilbert metric ([12], p. 105), used in place of the generalized Minkowski metric mentioned above. Specifically, let $\mathcal{F}$ denote a projective IFS of the form $(\mathcal{K}^\circ; f_1, \ldots, f_N)$, where $\mathcal{K}^\circ$ is the interior of a convex body $\mathcal{K} \subset \mathbb{R}^2$ such that $\mathcal{F}(\mathcal{K}) \subset \mathcal{K}^\circ$. The associated Hilbert metric d_H is defined on $\mathcal{K}^\circ$ by

$$d_H(x,y) = \ln |\mathcal{R}(x,y;a,b)| \text{ for all } x,y \in \mathcal{K}^\circ \text{ with } x \neq y,$$

where $\mathcal{R}(x,y;a,b) = (|b-x|/|x-a|) / (|b-y|/|y-a|)$ denotes the cross ratio between x, y and the two intersection points a, b of the straight line through x, y with the boundary $\mathcal{K}$. You might like to verify that $\mathcal{F}$ is a contractive IFS with respect to d_H, using the fact that projective transformations

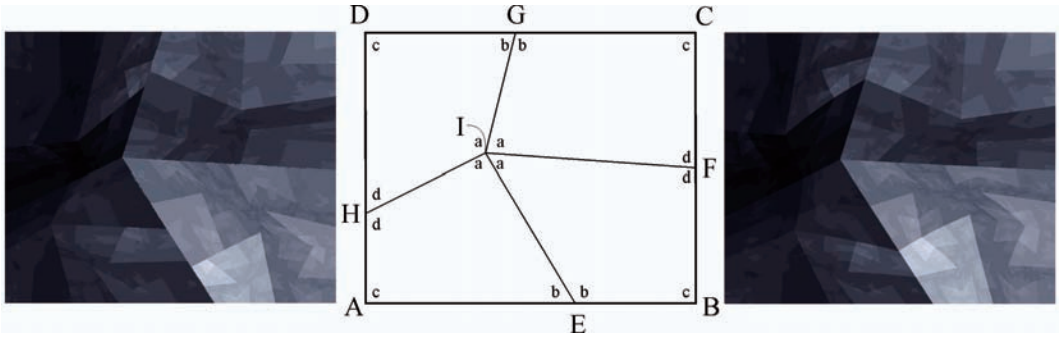

Figure 3. The four quadrilaterals $IEAH$, $IEBF$, $IGCF$, $IGDH$ define both a projective $\mathcal{F}$ and a bilinear IFS $\mathcal{G}$, both of which have a unique attractor, the filled rectangle with vertices at $ABCD$; but the address structures are different. In the left panel and right panels, the attractors of $\mathcal{F}$ and $\mathcal{G}$, respectively, have been rendered, so that points with the same address are the same shade of grey. The address structure is independent of E, F, G, H, I in the bilinear case but not in the projective case. (Hint: compare how lines meet the line IE.)

preserve cross ratios. So projective IFSs can be used in applications in nearly the same way as affine systems.

To describe bilinear transformations, let $\mathcal{R} = [0,1]^2 \subset \mathbb{R}^2$ denote the unit square, with vertices $A = (0,0), B = (1,0), C = (1,1), D = (0,1)$. Let P, Q, R, S denote, in cyclic order, the successive vertices of a possibly degenerate quadrilateral. Then we uniquely define a *bilinear* function $\mathcal{B} : \mathcal{R} \to \mathcal{R}$ such that $\mathcal{B}(ABCD) = PQRS$ by

(0.2)
$$\mathcal{B}(x,y) = P + x(Q-P) + y(S-P) + xy(R+P-Q-S).$$

This transformation acts affinely on any straight line that is parallel to either the x-axis or the y-axis. For example, if $\mathcal{B}|_{AB} : AB \to PQ$ is the restriction of $\mathcal{B}$ to AB, and if $\mathcal{Q} : \mathbb{R}^2 \to \mathbb{R}^2$ is the affine function defined by $\mathcal{Q}(x,y) = P + x(Q-P) + y(S-P)$, then $\mathcal{Q}|_{AB} = \mathcal{B}|_{AB}$. Because of this "affine on the boundary" property, bilinear functions are well suited to the construction of fractal homeomorphisms, as we will see. Sufficient conditions under which there exists a metric with respect to which a given bilinear transformation is contractive are given in [6]. A bilinear IFS has an attractor when its IFS code is close enough (in an appropriate metric) to the IFS code of an affine IFS that has an attractor.

An example of a geometrical configuration of quadrilaterals that gives rise to both a projective and a bilinear IFS is illustrated in Figure 3. In either case we define the IFS to be $(\mathcal{R}; f_1, f_2, f_3, f_4)$ where

$$f_1(ABCD) = IEAH, f_2(ABCD) = IEBF,$$
$$f_3(ABCD) = IGCF, f_3(ABCD) = IGDH,$$

where the first expression means $f_1(A) = I, f_1(B) = E, f_1(C) = A, f_1(D) = H$. With few constraints each IFS is contractive with respect to a metric that is Lipshitz equivalent to the Euclidean metric, with attractor equal to the filled rectangle $ABCD$. But there is an important difference: the bilinear family provides a family of homeomorphisms on $\mathcal{R}$, with applications to photographic art, attribute (V), while the projective family does not, as we will see.

The Chaos Game

How do we compute approximate attractors in a digital environment? Algorithms based on direct discretization of the expression $A = \lim_{k\to\infty} \mathcal{F}^{\circ k}(B)$ have high memory requirements and tend to be inaccurate [28]. The availability of a simple algorithm that is fast and accurate, for the types of IFS that we discuss, has played an important role in the survival of the IFS creative system. The following algorithm, known as the *chaos game*, was described to a wide audience in *Byte* magazine in 1988 (see Figure 4) and successfully dispersed IFS codes to the computer science community. It helped ensure that the IFS creative system would have attribute (V).

Define a *random orbit* $\{x_k\}_{k=0}^{\infty}$ of a point $x_0 \in \mathbb{X}$ under $\mathcal{F} = (\mathbb{X}; f_1, \ldots, f_N)$ by $x_k = f_{\sigma_k}(x_{k-1})$, where $\sigma_k \in \{1, 2, \ldots, N\}$ is chosen, independently of all other choices, by rolling an N-sided die. If the underlying space is two-dimensional and $\mathcal{F}$ is contractive, then it is probable that a picture of the attractor of $\mathcal{F}$, accurate to within viewing resolution, will be obtained by plotting $\{x_k\}_{k=100}^{10^7}$ on a digital display device.

Why does this Markov chain Monte Carlo algorithm work? The following theorem, implicit in [8], tells us how we can think of the attractor of a contractive IFS as being the ω-limit set of almost any random orbit. A direct proof can be found in [31].

Theorem 3. *Let $\{x_k\}_{k=0}^{\infty}$ be a random orbit of a contractive IFS. With probability one*

$$\lim_{K\to\infty} \cup_{k=K}^{\infty} \{x_k\} = A,$$

Figure 4. The original pseudocode from *Byte* magazine (January 1988) for implementing the chaos game algorithm to obtain an image of the attractor of an IFS on $\mathbb{R}^2$. Notice the small number of iterations used! Nowadays, usually, I use 10^7 iterations and discard the first thousand points. On the right is a sketch of a 2–variable tree obtained by a generalization of the chaos game.

Figure 5. From left to right this picture shows: the result of 9000 iterations of the chaos game algorithm applied to a projective IFS; the result of 10^7 iterations; a small picture of a flower; and a rendered close-up of the attractor. In the latter image the colors were obtained with the aid of a fractal transformation from the attractor to the small picture of the yellow flower.

where the limit is taken with respect to the Hausdorff metric.

Pictures, calculated using the chaos game algorithm, of the attractor of a projective IFS $(\mathcal{R}; f_1, f_2, f_3, f_4)$ are shown in the leftmost two panels of Figure 5. You can visualize an approximation to the stationary probability measure of the stochastic process, implicit in the chaos game, in the left-hand image. This measure depends on the strictly positive probabilities associated with the maps, but its support, the attractor, does not! Measure theory aspects of IFS are not considered in this article, but it is nice to see one way in which the topic arises.

Addresses and Transformations Between Attractors

In this section we deepen our understanding of attractors. We discover information about the relationship between IFS codes and the topology of attractors and the relationships between different attractors. This information helps to classify our diverse plants, attribute (I), and leads into real applications in art and biology, attribute (V). Good bookkeeping is the key.

The space $\Omega = \{1, 2, \ldots, N\}^\infty$ with the product topology plays a fundamental role in IFS theory and in this article. We write $\sigma = \sigma_1\sigma_2\ldots$ to denote a typical element of Ω. We will use the notation $f_{\sigma_1\sigma_2\ldots\sigma_k} := f_{\sigma_1} \circ f_{\sigma_2} \circ \cdots \circ f_{\sigma_k}$, $\sigma|k = \sigma_1\sigma_2\ldots\sigma_k$, and $f_{\sigma_1\sigma_2\ldots\sigma_k} = f_{\sigma|k}$ for any $\sigma \in \Omega$ and $k = 1, 2, \ldots$.

The following theorem suggests that our plants can have intricate topological structures and suggests that symbolic dynamics are involved, thereby adding a lusher interpretation of attribute (I).

Theorem 4. [18] *Let $\mathcal{F} = (\mathbb{X}; f_1, \ldots, f_N)$ be a contractive IFS, with attractor A. Let $x \in \mathbb{X}$. A continuous surjection $\pi : \Omega \to A$, independent of x, is well defined by $\pi(\sigma) = \lim_{k\to\infty} f_{\sigma|k}(x)$; the convergence is uniform for $(\sigma, x) \in \Omega \times B$, for any $B \in \mathbb{H}$.*

The set of addresses of a point $x \in A$ is defined to be the set $\pi^{-1}(x)$ and defines an equivalence

Figure 6. Three renderings of a close-up of the attractor in Figure 5 computed using a coupled version of the chaos game and a fractal transformation. On the left the computation has been stopped early, yielding a misty effect. Different aspects of the fractal transformation are revealed by applying it to different pictures.

relation $\sim$ on Ω. For example, the attractor of the IFS $(\mathbb{R}; f_1(x) = x/2, f_2(x) = x/2 + 1/2)$ is the closed interval $[0,1]$. You may check that $\pi^{-1}(0) = \{\overline{1} := 1111\ldots\}$, $\pi^{-1}(1) = \{\overline{2}\}$, $\pi^{-1}(1/2) = \{1\overline{2}, 2\overline{1}\}$, and $\pi^{-1}(1/3) = \{\overline{12}\}$. Some points of an attractor have one address while others have multiple distinct addresses. The topology on A is the identification topology on Ω induced by the continuous map $\pi : \Omega \to A$. In this paper we refer to the set of equivalence classes induced by $\sim$ on Ω as the *address structure* of the IFS. Figure 3 contrasts the address structures of a corresponding pair of bilinear and projective IFSs.

We can think of the topology of an attractor A as being that of Ω with all points in each equivalence class glued together; that is, A is homeomorphic to $\Omega/\sim$. Simple examples demonstrate that the address structure can change in complicated ways when a single parameter is varied: the topologies of attractors, our plants, in contrast to their shapes, do not in general depend continuously on their IFS codes. By restricting to appropriate families of projective or bilinear IFSs, with known address structures, control of the topology of attractors becomes feasible.

A point on an attractor may have multiple addresses. We select the "top" address to provide a unique assignment; the *top address* is the one closest to $\overline{1} = 1111\ldots$ in lexographic ordering. Each element of the address structure of an IFS is represented by a unique point in Ω. This choice is serendipitous, because the resulting set of addresses, called the tops space, is shift invariant and so yields a link between our plants, symbolic dynamics, and information theory attribute (IV), see [5] and references therein.

We define a natural map from an attractor $A_{\mathcal{F}}$ of an IFS $\mathcal{F}$ to the attractor $A_{\mathcal{G}}$ of an IFS $\mathcal{G}$, each with the same number of maps, by assigning to each point of $A_{\mathcal{F}}$ the point of $A_{\mathcal{G}}$ whose set of addresses includes the top address of the point in $A_{\mathcal{F}}$. This provides a map $T_{\mathcal{FG}} : A_{\mathcal{F}} \to A_{\mathcal{G}}$ called a *fractal transformation.* When the address structures of $A_{\mathcal{F}}$ and $A_{\mathcal{G}}$ are the same, this map is a homeomorphism. Since fractal transformations can be readily computed by means of a coupled version of the chaos game, applications to art and geometric modeling become feasible, and the IFS creative system tests new forms and environments, attribute (V).

Let $\mathcal{R} \subset \mathbb{R}^2$ denote a filled unit square. Let $p : \mathcal{R} \to C$ be a *picture (function)*; that is, p is a mapping from $\mathcal{R}$ into a color space C. A *color space* is a set of points each of which is associated with a unique color. In computer graphics a typical color space is $C = \{0, 1, \ldots, 255\}^3$, where the coordinates of a point represent digital values of red, green, and blue. The graph of a picture function may be represented by a colorful picture supported on $\mathcal{R}$. Next time you see a picture hanging on a wall, imagine that it is instead an abstraction, a graph of a picture function. More generally, we allow the domain of a picture function to be an arbitrary subset of $\mathbb{R}^2$.

For example, in the right-hand image in Figure 5 we have rendered the graph of $\tilde{p} : A_{\mathcal{F}} \to C$ obtained by choosing p to correspond to the picture of the yellow flower, $\mathcal{G}$ to be an affine IFS such that $\{g_n(\mathcal{R})\}_{n=1}^4$ is a set of rectangular tiles with $\cup g_n(\mathcal{R}) = \mathcal{R}$, and $\mathcal{F}$ to be the projective IFS whose attractor is illustrated in black. In Figure 6 we show other renderings of a portion of the attractor, obtained by changing the picture p and, in the left-hand image, by stopping the chaos game algorithm early; the pictures are all computed by using a coupled variant of the chaos game. Because $\tilde{p} = p \circ T_{\mathcal{FG}}$ one can infer something about the nature of fractal transformations by looking at

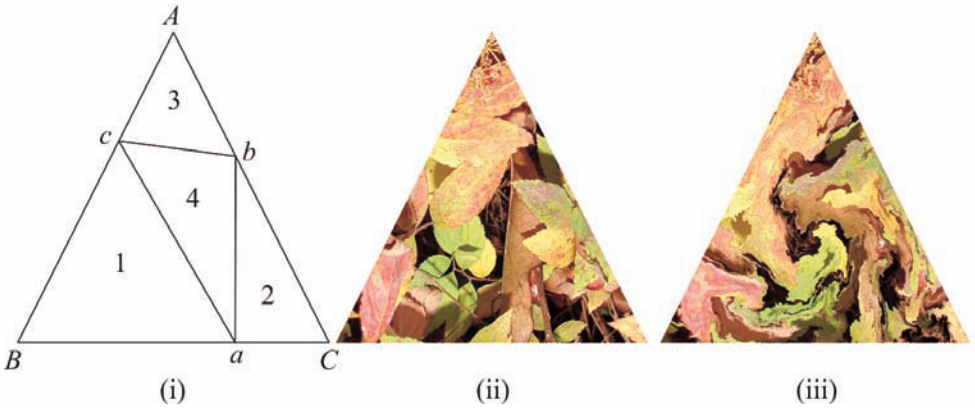

Figure 7. (i) The adjustable points a, b, c used to define a family of affine iterated function systems $\mathcal{F} = (\mathbb{R}^2; f_1, f_2, f_3, f_4)$ with constant address structure; (ii) a picture supported on the attractor of an IFS belonging to the family; (iii) the same picture, transformed under a fractal homeomorphism of the form $T_{\mathcal{FG}} = \pi_{\mathcal{G}} \circ \tau_{\mathcal{F}}$, where $\mathcal{F}$ and $\mathcal{G}$ are two IFSs belonging to the family.

Figure 8. Example of a fractal homeomorphism generated by two IFSs of four bilinear transformations. The attractor of each transformation is the unit square.

such pictures. By panning the source picture p it is possible to make fascinating video sequences of images. You can see some yourself with the aid of *SFVideoShop* [32]. In the present example you would quickly infer that $T_{\mathcal{FG}}$ is not continuous but that it is not far from being so: it may be continuous except across a countable set of arcs.

The Art of Fractal Homeomorphism

Affine and bilinear iterated function systems can be used to provide a wide variety of parameterized families of homeomorphisms on two-dimensional regions with polygonal boundaries such as triangles and quadrilaterals. We use them to illustrate the application of the IFS creative system to a new art form. In effect this application is itself a new creative system for artists. This provides an illustration of attribute (VI): creative systems beget creative systems.

For example, let A, B, and C denote three noncolinear points in $\mathbb{R}^2$. Let c denote a point on the line segment AB, let a denote a point on the line segment BC, and let b denote a point on the line segment CA, such that $\{a, b, c\} \cap \{A, B, C\} = \emptyset$; see Figure 7(i).

Let $\mathcal{F} = (\mathbb{R}^2; f_1, f_2, f_3, f_4)$ be the unique affine IFS such that

$$f_1(ABC) = caB,\ f_2(ABC) = Cab,$$
$$f_3(ABC) = cAb, \text{ and } f_4(ABC) = cab,$$

where we mean, for example, that f_1 maps A to c, B to a, and C to B; see Figure 7(i). For reference, let us write $\mathcal{F} = \mathcal{F}_{\alpha,\beta,\gamma}$ where $\alpha = |Bc|/|AB|$, $\beta = |Ca|/|BC|$, and $\gamma = |Ab|/|CA|$. The attractor of $\mathcal{F}_{\alpha,\beta,\gamma}$ is the filled triangle $\mathcal{T}$ with vertices at A, B, and C. Then $\mathcal{F}_{\alpha,\beta,\gamma}$ is contractive IFS, for each $(\alpha, \beta, \gamma) \in (0, 1)^3$, with respect to a metric that is Lipshitz equivalent to the Euclidean metric, by Theorem 2. Its address structure $C_{\alpha,\beta,\gamma}$ is independent of α, β, γ (see [5], section 8.1).

Figure 7(ii) illustrates a picture $p : \mathcal{T} \to C$; it depicts fallen autumn leaves. Figure 7(iii) illustrates the picture $\tilde{p} = p \circ T_{\mathcal{FG}}$, namely the result of

Figure 9. Before (left) and after a fractal homeomorphism.

Figure 10. Detail from Figure 9 showing not only the vibrant colors of nature but also the wide range of stretching and squeezing achieved in this relatively simple fractal transformation.

applying the homeomorphism $T_{\mathcal{F}\mathcal{G}}$ to the picture p, where $\mathcal{F} = \mathcal{F}_{0.45,0.45,0.45}$ and $\mathcal{G} = \mathcal{F}_{0.55,0.55,0.55}$. The transformation in this example is area-preserving because corresponding tiles have equal areas.

A similar result applies to families of bilinear IFSs. For example, Figure 3 defines a family of bilinear IFSs, $\mathcal{F}_v$, parameterized by the vector of points $v = (E, F, G, H, I)$. This family has constant address structure for all values of v for which $\mathcal{F}_v$ is contractive and can thus be used to provide a family of homeomorphisms $\mathcal{T}_{v,w} : \mathcal{R} \to \mathcal{R}$. An illustration of the action of $\mathcal{T}_{v,w}$ on a picture of Australian heather is given in Figure 8. In this case the parameters v and w both correspond to affine IFSs. What is remarkable in this case, and many like it, is that the transformed picture looks so realistic. Can you tell which is the original?

Figure 9 illustrates a homeomorphic fractal transformation generated by a pair of bilinear IFSs on $\mathcal{R}$. In this case $N = 12$. The original image is a digital photograph of a lemon tree and wallflowers in my garden in Canberra. The final image was printed out on thick acid-free rag paper by a professional printing company, using vivid pigment

inks, at a width of approximately 5 ft. and a height of 3 ft. 6 ins. It represents a fusion of the colors of nature and mathematics; it provokes wonder in me, a sense of the pristine and inviolate, a yearning to look and look ever closer (see Figure 10).

I have used such extraordinary transformations to generate works for three successful (most of the pictures are sold) art shows in Canberra (Australia, July 2008), in Bellingham (Washington State, July 2008), and in Gainesville (Florida, March 2009).

Superfractals

In this section we illustrate attribute (VI). We show how IFS theory begets a new creative system via a higher level of abstraction. The new framework is suitable for mathematical modeling of the geometry of a multitude of naturally occurring, readily observable structures. It also has applications to the visual arts.

The new system has some remarkable properties. Its attractor is a set of interrelated sets that can be sampled by a variant of the chaos game algorithm, as illustrated in Figure 12. This algorithm is born fully formed and is the key to applications. The geometry and topology of the interrelated sets can be controlled when appropriate generalized IFSs are used. In particular, through the concepts of V-variability [7] and superfractals, we are able to form a practical bridge between deterministic fractals (such as some of the IFS attractors in previous sections) and random fractal objects (such as statistically self-similar curves that represent Brownian motion).

V-Variability

Here is a biological way to think of "V-variability". Imagine a tree that grows with this property. If you were to break off all of the branches of any one generation and classify them, you would find that they were of, at most, V different types. By "generation" I mean that you are able to think of the tree as having older and younger branches, that is, some that started to grow during year one, subbranches that began during year two, and so on. The tree is very old. By "type" I mean something like "belongs to a particular conjugacy class". The type may change from generation to generation, but the number V is fixed and as small as possible. Then I will call the imagined tree "V-variable". Figure 4 includes an illustration of a 2-variable tree, where the younger branches start higher up the tree. Again, consider a population of annual plants belonging to a species that admits S distinct possible genotypes. If the number of distinct genotypes in each generation is bounded above by V, then (in circumstances in which V is significantly smaller than S) I would call this population "V-variable". But the mathematical definition relates to a property of attractors of certain IFSs. Figure 11 illustrates a 2-variable fractal subset of the Euclidean plane: it is a union of two tiles of half its size: it is also a union of at most two tiles of a quarter its size, and so on.

Let $\mathcal{F} = (\mathbb{X}; f_1, \ldots, f_N)$ be an IFS of functions f_n that are contractive with respect to the metric d on $\mathbb{X}$. If $\mathcal{G} = (\mathbb{X}; f_{\omega_1}, \ldots, f_{\omega_l})$ for some choice of indices $1 \le \omega_1 < \omega_2 < \cdots < \omega_l \le N$, then we say that $\mathcal{G}$ is a *subIFS* of $\mathcal{F}$.

Given an IFS $\mathcal{G} = (\mathbb{X}; g_1, \ldots, g_M)$ and a sequence of indices $\rho = \rho_1\rho_2 \ldots \rho_M$, where each ρ_m belongs to $\{1, 2, \ldots, V\}$, we can construct a mapping $\mathcal{G}^{(\rho)} : \mathbb{H}^V \to \mathbb{H}$ by defining

$$\mathcal{G}^{(\rho)}(\underline{B}) = \cup_m g_m\left(B_{\rho_m}\right), \text{ for all}$$
$$\underline{B} = (B_1, B_2, \ldots, B_V) \in \mathbb{H}^V.$$

In a similar manner, given a set of subIFSs $\{\mathcal{G}_1, \ldots, \mathcal{G}_L\}$ of $\mathcal{F}$, each consisting of M functions, we can construct mappings from $\mathbb{H}^V$ to itself. Let $\sigma = \sigma_1\sigma_2 \ldots \sigma_V \in \{1, 2, \ldots, L\}^V$, let ρ be a $V \times M$ matrix whose entries belong to $\{1, 2, \ldots, V\}$, and here let ρ_v denote the v^{th} row of ρ. Then we define a mapping $\mathcal{G}^{(\rho,\sigma)} : \mathbb{H}^V \to \mathbb{H}^V$ by

$$\mathcal{G}^{(\rho,\sigma)}(\underline{B}) = (\mathcal{G}_{\sigma_1}^{(\rho_1)}(\underline{B}), \mathcal{G}_{\sigma_2}^{(\rho_2)}(\underline{B}), \ldots, \mathcal{G}_{\sigma_V}^{(\rho_V)}(\underline{B})).$$

We denote the sequence of all such mappings by $\{\mathcal{H}_j : j \in J\}$, where J is the set of all indices (ρ,σ) in some order. We call $\mathfrak{G}^{(V)} = (\mathbb{H}^V; \{\mathcal{H}_j : j \in J\})$ the *V-variable superIFS* associated with the set of subIFSs $\{\mathcal{G}_l\}_{l=1}^L$ of $\mathcal{F}$.

We write B_v to denote the v^{th} component of $B \in \mathbb{H}^V$. If the space $\mathbb{H}^V$ is equipped with the metric $D(B, C) := \max_v \{h(B_v, C_v)\}$, where h is the Hausdorff metric on $\mathbb{H}$, then $(\mathbb{H}^V, D)$ is a complete metric space. The following theorem summarizes basic information about $\mathfrak{G}^{(V)}$. More information is presented in [4] and [7].

Theorem 5. [7] *Let $\mathfrak{G}^{(V)}$ denote the $V-$variable superIFS $(\mathbb{H}^V; \{\mathcal{H}_j : j \in J\})$.*

(i) *If the underlying IFS $\mathcal{F}$ is contractive, then the IFS $\mathfrak{G}^{(V)}$ is contractive.*

(ii) *The unique attractor $\mathbb{A}^{(V)} \in \mathbb{H}(\mathbb{H}^V)$ of $\mathfrak{G}^{(V)}$ consists of a set of V-tuples of compact subsets of $\mathbb{X}$ and $A^{(V)} := \{B_v : B \in \mathbb{A}^{(V)}, v = 1, 2, \ldots, V\} = \{B_v : B \in \mathbb{A}^{(V)}\}$ for all $v = 1, 2, \ldots, V$. (Symmetry of the superIFS with respect to the V coordinates causes this.) Each element of $A^{(V)}$ is a union of transformations, belonging to $\mathcal{F}$, of at most V other elements of $A^{(V)}$.*

(iii) *If $\{\mathbb{A}_k\}_{k=0}^{\infty}$ denotes a random orbit of $\mathbb{A}_0 \in \mathbb{H}^V$ under $\mathfrak{G}^{(V)}$ and $A_k \in \mathbb{H}$ denotes the first component of $\mathbb{A}_k$, then (with probability one) $\lim_{K\to\infty} \cup_{k=K}^{\infty} \{A_k\} = A^{(V)}$ where the limit is taken with respect to the Hausdorff metric on $\mathbb{H}(\mathbb{H}(\mathbb{X}))$.*

Statement (i) implies that $\mathfrak{G}^{(V)}$ possesses a unique attractor $\mathbb{A}^{(V)}$ and that we can describe it in terms of the chaos game. This technique is straightforward to apply, since we need only to

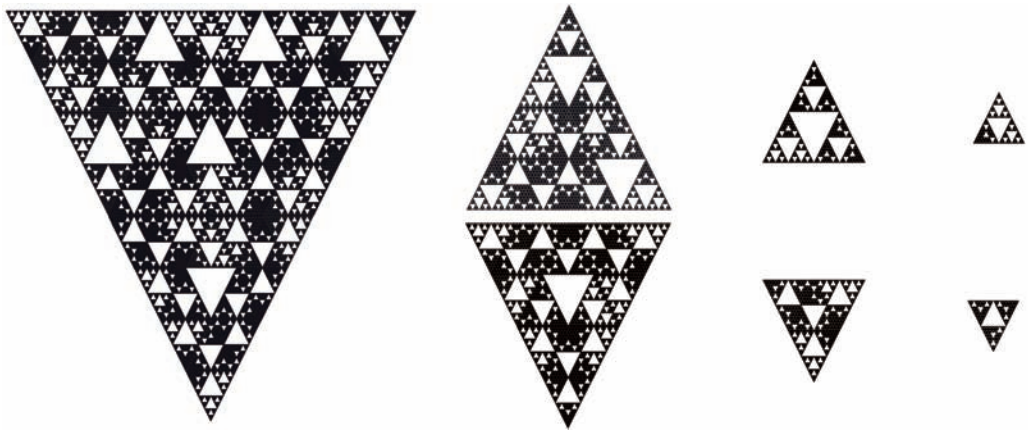

Figure 11. An element of a 2-variable superfractal is shown on the left. If you look closely at it, you will see that it is made of exactly two distinct (up to translation, reflection, and rotation) subobjects of half the linear dimension (the two objects immediately to the right of the first one). And, if you look even closer, you will see that it is made of two subobjects of one-quarter the linear dimension, and so on.

Figure 12. Elements of a 2-variable superfractal, rendered as in Figure 5.

select independently at each step the indices ρ and σ; the functions themselves are readily built up from those of the underlying IFS $\mathcal{F}$.

Statement (ii) tells us that it is useful to focus on the set $A^{(V)}$ of first components of elements of $\mathbb{A}^{(V)}$. It also implies that, given any $A \in A^{(V)}$ and any positive integer K, there exist $A_1, A_2, \ldots, A_V \in A^{(V)}$ such that $A = \cup_{l\in\{1,2,\ldots,V\}} \cup_{\sigma\in\Omega} f_{\sigma|K}(A_l)$. That is, at any depth K, A is a union of contractions applied to V sets, all belonging to $A^{(V)}$, at most V of which are distinct. In view of this property, the elements of $A^{(V)}$ are called *V-variable fractal sets*, and we refer to $A^{(V)}$ itself as a *superfractal*.

Statement (iii) tells us that we can use random orbits $\{\mathbb{A}_k\}_{k=0}^{\infty}$ of $\mathbb{A}_0 \in \mathbb{H}^V$ under $\mathfrak{G}^{(V)}$ to sample the superfractal $A^{(V)}$.

The idea of address structures, tops, and fractal transformations can be extended to the individual sets that comprise $A^{(V)}$; see [4]. We are thus able to render colorful images of sequences of elements of $A^{(V)}$ generated by a more elaborate chaos game involving at each step a $(V+1)$-tuple of sets, one of which is used to define the picture whose colors are used to render the other sets.

Figure 12 illustrates elements taken from such an orbit. In this case a 2-variable superIFS is used: it consists of two subIFSs of a projective IFS $\mathcal{F}$, consisting of five functions, detailed in [4]. The fern-like structure of all elements of the corresponding superfractal is ensured by a generalized version of the collage theorem.

The Problem Solved by Superfractals

The diverse forms that illustrate a successful idea, the plants of a creative system, may change as time goes forward. The ideas of an earlier era of geometry that were popular in applications included cissoids, strophoids, nephroids, and astroids: more recently you would hear about manifolds, Ricci curvature, and vector bundles; today you are just as likely to hear about fractals. Why? As technology advances, some applications become extinct, and new ones emerge.

In *The Fractal Geometry of Nature* [24], Mandelbrot argues that random fractals provide geometrical models for naturally occurring shapes and forms, such as coastlines, clouds, lungs, trees, and Brownian motion. A *random fractal* is a statistically self-similar object with noninteger Hausdorff dimension. Although there are mathematical theories for families of random fractals—see, for example, [25]—they are generally cumbersome to use in geometric modeling applications.

For example, consider the problem of modeling real ferns: ferns look different at different levels of magnification, and the locations of the fronds are not according to some strictly deterministic pattern, as in a geometric series; rather, they have elements of randomness. It seems that a top-down hierarchical description, starting at the coarsest level and working down to finer scales, is needed to provide specific geometrical information about structure at all levels of magnification. This presents a problem: clearly it is time-consuming and expensive in terms of the amount of data needed to describe even a single sample from some statistical ensemble of such objects.

Superfractals solve this problem by restricting the type of randomness to be V-variable. This approach enables the generalized chaos game algorithm, described above, to work, yielding sequences of samples from a probability distribution on V-variable sets belonging to a superfractal. In turn, this means that we can approximate fully random fractals because, in the limit as V tends to infinity, V-variable fractals become random fractals in the sense of [25] (see, for example, [7], Theorem 51).

Thus, we are able to compute arbitrarily accurate sequences of samples of random fractals. Furthermore, we have modeling tools, obtained by generalizing those that belong to IFS theory, such as collage theorem and fractal transformations, which extend in natural ways to the V-variable setting. In some cases the Hausdorff dimension of these objects can also be specified as part of the model. This provides an approach to modeling many naturally occurring structures that is both mathematically satisfying and computationally workable. In particular, we see how the IFS creative system begat a new, even more powerful system, with diverse potential applications. This completes my argument that iterated function systems comprise a creative system.

Further Reading

I would have liked to tell you much more about IFS theory. But this is not a review article, even of some of my own work. It does not touch the full range of the subject, let alone the mathematics of fractal geometry as a whole. The contents were chosen primarily to illustrate the idea of a mathematical creative system.

To survey mathematical fractal geometry, I mention the series of four conference proceedings [36], [37], [38], and [39], carefully edited by Christoph Bandt, Martina Zähle, and others. The books by Falconer, for example [14] and [15], are good textbooks for core material. A recent development has been the discovery of how to construct harmonic functions and a calculus on certain fractal sets; see [20]. This was reported in the *Notices* [33]. A light introduction is [34]. Fractals and number theory is an important area; see, for example, [22], [11], and [23]. The topic of *noncommutative fractal geometry* is another fascinating new area [21]. Fractal geometry is rich with creative possibilities.

Conclusion

In this essay I have illustrated the notion that mathematical ideas that survive are creative systems in their own right, with attributes that parallel some of natural evolution.

Creative systems define, via their DNA, diverse forms and structures. There are three concepts here: seeds, plants, and diversity. Individual plants are products of the system, representatives of its current state and utility. The system itself may remain constant, but the plants evolve, adapting to new generations of minds. The IFS creative system lives in my mind. But mainly I watch its plants: ones that preoccupy me now are not the same as the ones that I looked at years ago; the crucial element is the creative system, not the fractal fern.

Plants provide the first wave of conquest of new environments; an adapted version of the underlying new idea may follow later. The diversity of plants suggests a multitude of possibilities. Their seeds get into the minds of engineers and scientists. Later, the underlying idea, the creative system itself, may take hold.

I think of a good mathematical mind, a strong mathematics department, and a successful conference as each being, like Darwin's bank, a rich ecosystem, a fertile environment where ideas interact and diverse species of plants are in evidence. Some of these plants may be highly visible because they can be represented using computer graphics, while others are more hidden: you may only see them in colloquia, a few glittering words that capture and describe something wonderful, jump from brain to brain, and there take root. (I think of the first time I heard about the Propp-Wilson algorithm.)

A good mathematical idea is a creative system, a source of new ideas, as rich in their own right as the original. The idea that survives is one that takes root in the minds of others: it does so because it is accessible and empowering. Such an idea is likely to lead to applications, but this applicability

is more a symptom that the idea is a creative system rather than being causative. A good idea allows, invites, surprises, simplifies, and shares itself without ever becoming smaller; as generous, mysterious, and bountiful as nature itself.

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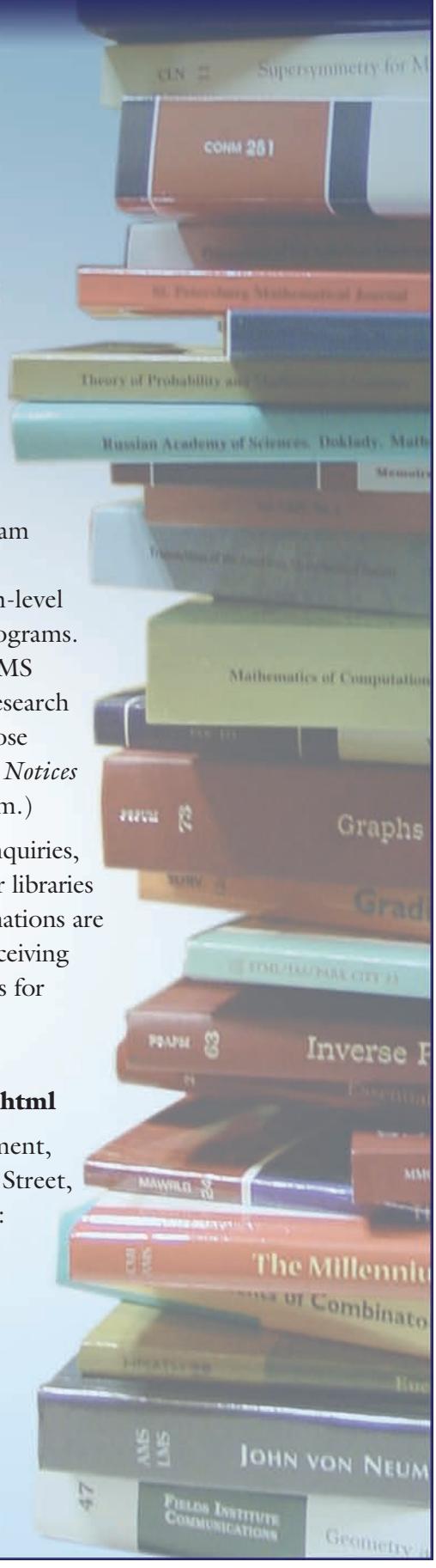

Envisioning the Invisible

Tim Chartier

To Be the Remainder

"What is it like to be the remainder?" I answer this question with a mime sketch in a performance created specifically to motivate thinking about mathematics. I play the part of a clown who, almost compulsively, divides objects into two groups as they emerge from a suitcase. Repeatedly, one object is left: the remainder of the division. The pantomime touches on a universal human experience—being alone. In fact, the dramatic line of the piece relies heavily on a tension between togetherness and separateness.

This sketch guides the audience, mathematicians and nonmathematicians, through a cerebral journey of parity. The mathematical claim is quite simple: division by two of any odd number will result in a remainder of 1, whereas two divides evenly into any even number. The clown, in his simpleminded way, struggles to accept this fact. With increasingly large numbers, he is empathetically saddened by a sole remainder and satisfied when groups divide evenly. Yet, almost tempting mathematical fate, he peers into his suitcase even after forming groups of equal size. This daring spirit results in new, larger sets of objects that he must divide.

The sketch begins with one, then two, and quickly three objects. Even as the set grows to six and seven items, the audience can mentally group the objects to quickly discern the parity of the set. Later in the sketch, the set grows first by three and then by five. At this stage, it is harder to visually anticipate the resulting remainder. Primary school audiences are often heard counting the number of objects in order to calculate whether such aloneness will result. The clown almost always seems to discover his mathematical destiny more slowly than the audience. Children and adults alike often giggle when they compute sets of odd size.

This sketch, like many others that I perform, contextualizes a mathematical idea, enabling an audience to place an abstract concept into a story. This mathematical mime piece presents mathematics in a physical rather than algebraic way. Whether written in formulas or portrayed through the movement of mime, such expressions are pointers to an intellectual experience. This sketch does not offer a proof of the divisibility of odd and even numbers. It does reflect what mathematicians often do prior to writing a proof—analyze simple examples and look for trends in cases of increasing complexity.

This sketch is quite popular with audiences of varying ages. Nonmathematicians enjoy anticipating the clown's ultimate fate with the set of ever-growing size. Mathematicians also enjoy the sketch. The concept it portrays is quite elementary. Mathematicians can be silenced by elegant proofs of simpler concepts and somehow dissatisfied with seemingly clumsy proofs of complex material. The pleasure brought about by a good proof can similarly be evoked through the performing arts—in this case, through a mimetic translation of mathematical thoughts. Why shouldn't we be silenced by an elegant sketch? Completed proofs uncover some truth; we have all experienced the exhilaration of such discoveries. Mathematicians can be quite excited by the mime sketches I perform as they illustrate their abstract world. Regarding this sketch on remainder, a child from a multi-age third- and fourth-grade classroom wrote,

> Thank you for coming to my class to teach and show us some pantomime…. I especially loved the remainder act because it made me laugh. I DID see the remainder.

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Figure 1. Tim Chartier cuts a mime rope of infinite length.

It is natural to ask, "What mathematical ideas can be visualized with mime?" For some, math and mime might seem to exist in disjoint subspaces of the human experience, and thus a list of answers to this question would be an empty set. As for me, mime and math have converged in my life, and as reflected in this article, I see that the set is nonempty and countable. Yet, I sometimes wonder if the set is countably infinite or quite possibly of a finite size of such magnitude that I will never create a one-to-one correspondence between my mime sketches and invisible concepts of math that could be made visible with mime. In this article, I describe some of the ways I use mime to speak about mathematics.

Touching the Infinite

Let's now turn our attention to a mime piece that visualizes the one-dimensional number line as a rope of infinite length. The sketch begins with the lone mime walking toward the audience and suddenly stumbling. Peering down, my character sees an (invisible) object on the floor and proceeds to slowly pick it up. Examining it, he discovers a rope of infinite length in both directions. Wondering what might be at the end of this very long rope, he begins pulling and suddenly is pulled. A tug-of-war results and can prompt questions for the audience about the nature of infinity. My character becomes so frustrated that he pulls a pair of scissors from his back pocket and cuts the rope. Two pieces of the rope remain; one is anchored in his hand while the other portion zips away as if retracted far offstage. The plot continues, but I will refrain from divulging all of its secrets.

It is helpful to note that I, like many mimes, do not wear whiteface. Such a choice enables me to vary the presentation by utilizing masks and props and transition from silence to speaking. Given this, the piece easily provokes discussion on infinity. The portion of the sketch just described leads to the following question for the class or audience:

> There is the moment in the sketch when the mime cuts the rope that goes on forever in both directions. After it is cut, how long is the rope that remains in the mime's hand?

Audiences vary in their responses. My favorite answers generally come from children, which have included, "very long", "half as long", and, of course, "infinitely long". I generally state that the concept of infinite size differs from finite size in that something of infinite size can have some subset (itself possibly infinite in size) removed and remain of infinite size. Audience members have commented after a show, "I had always just thought of infinity as essentially the largest number." The mime sketch challenges this misconception.

Mime speaks in its silence, often leaving echoing, unspoken words in the audience's consciousness. The contents of a clown's suitcase demonstrate a sense of number. An invisible rope left on the performance floor pulls one into struggles regarding cardinality and the infinite.

Math with a Mime Ball

Now, we will touch several arithmetic operators by, first, snatching a mime ball from the air. It has the weight of an orange. We should practice tossing and catching it several times. Of course, we are handling a mime ball, so we can just as easily pick another. Let's do so, and then smash it together with the first and reform the resulting mass into a mime ball with twice the weight as the original. We toss the newly formed ball into the air and catch it with appropriate adjustments for the new weight. Putting this ball aside, we snatch five mime balls from the air, mash them together, and demonstrate the resulting weight with physical changes in our tossing. Now, we smash 100 mime balls into one; the ball has grown so heavy that we cannot lift it. So we reverse the process and divide the ball in half and reform the hemisphere into a mime ball. We can repeat this process, as desired, until we have again produced an invisible object of liftable weight.

The extent to which the illusion of tossing a mime ball looks real depends largely on the ability of the mime to accurately approximate a realistic trajectory of the ball. The mime's body should reflect the force needed to throw a heavier object. The initial velocity of the ball should influence the length and height of the trajectory. Although a mime has the ability to create wildly unrealistic

(a)

(b)

Figure 2. (a) Children hold huge mime balls. (b) This illusion is connected to research in computational fluid dynamics to predict the flight of a soccer ball.

trajectories, an effect that can be quite humorous, such decisions are generally most effective after establishing the illusion of realistic movement.

At this point, audiences are inspired to learn about applications in science that compute trajectories. Predicting an object's trajectory under a set of initial conditions is a question appropriate for mathematical research. For instance, research by the University of Sheffield and Fluent Europe digitized a soccer ball and computed the resulting air flow over a kicked ball. (See Figure 2b.) Researchers found that the shape and surface of the ball, as well as its initial orientation, play a fundamental role in the ball's trajectory through the air. Such research could influence the stitching patterns of future soccer balls [3]. Note, however, that the goal of this scientific research is to accurately predict movement, whereas the goal of our mime movement was to simply seem believable.

Tubular Topology

In a piece with my wife and fellow trained mime, Tanya Chartier, her character interacts with a huge tube, as seen in Figure 3. Throughout the sketch, the tube, or "Slinky" as many audience members name it, contorts into a variety of shapes from small to tall, linear to twisted. The progression of shapes is actually choreographed so as to disorient many viewers as to my orientation. A popular discussion after the sketch involves audience members postulating how my body was positioned in the tube so as to construct different shapes.

Audiences seem ready to tackle mathematical topics that involve the tube. So we present a game. Suppose Slinky begins in the shape of a "$\vee$". Now, Slinky cannot disconnect any part of itself or attach itself to any other part at any time. Following only this simple rule, what letters of the alphabet can Slinky form? Quickly, audiences, from schoolchildren to residents of a retirement community, call out their answers. Note that the validity of one's answer depends, in part, on the style of font that one imagines. Whether this subtlety is mentioned depends largely on the mathematical sophistication of the audience.

This sketch places topology into a fun, nonthreatening setting. Audiences think, risk, and postulate. Isn't mathematics, from a certain viewpoint,

(a)

(b)

Figure 3. A huge Slinky motivates discussion on topology and equivalence of shapes.

Figure 4. Performances by Karl Schaffer (left) and Art Benjamin (right) focus on mathematical topics.

Photo on left by Steve DeBartolomeo and on the right by Anne White. Used with permission.

a cognitive game in which we ramble through our thoughts and options in search of a winning insight? When we "win", we celebrate, even if only momentarily. However, in this game, there is always another challenge, and successes generally lead to greater challenges and bigger rewards.

Being Isaac Newton

Ultimately, audiences, whether in primary, middle, or high schools, large state universities or private colleges, can live mathematics vicariously through my mime performance. In fact, a developing sketch will allow audience members to "meet" a mathematician like Isaac Newton through the use of mask work. I have studied under Marcel Marceau, and I have also trained in other schools of mime and physical theater, resulting in my broad and versatile approach to the art. These sketches on famous mathematicians will use masks constructed from a cast of my face and enable me to speak. Indeed, the sketch combines mime and spoken word. In time, I hope to develop robust sketches to match some tremendous masks, which I commissioned with grant funding, of Isaac Newton, Pierre de Fermat, and Sophie Germain. In performance, the characters will share stories from their lives, which ultimately led each to far-reaching impacts in mathematics. I select stories that reflect the humanity of the person and that may resonate with an audience member's life. Sophie Germain's mask is modeled from pictures of her as a youth. She will enter the stage with a blanket draped over her shoulders, as her parents hid her clothes in the evening in the hope that the cold night air would confine her to bed and stop her studying. Secretly, she will be stepping to her desk to study her beloved mathematics in the dark hours of the night. Pierre de Fermat will tell the tale of that fateful day in which a proof appeared to unfold in his mind but was too long to fit into the margins of his book. He could only write the conjecture, leaving centuries of mathematicians with the challenge of proving it true. Mathematical discovery is a human achievement. Such stories can remind audiences of the personal side and challenges that are all too often hidden behind the mathematical theorems and methods we study and develop.

One Act Among Many

My mathematical mime leans heavily on that performing art's ability to embody the invisible. Other mathematicians with a talent for other performing arts present mathematics in their own interesting and compelling ways [5].

Let me assemble a playbill of performing arts that could easily fill a mathematical variety show. We could begin with Colm Mulcahy (Spelman College) performing magic with a deck of cards. Knowing the mathematical sophistication of this audience, his tricks would lean on a variety of topics from Fibonacci numbers [6] to results of Paul Erdős [7]. After this opening act of magic, Colin Adams (Williams College) could enter as Mel Slugbate, who pitches investments in hyperbolic space for those nervous about the financial risks of buying realty in Euclidean space. Then, an audience member could select a circuit in a graph that would determine a sequence of 5-ball juggling patterns for Greg Warrington (University of Vermont). The lights dim and Karl Schaffer (DeAnza College) and a member of his troupe would begin a dance piece about the prisoner's dilemma. Finally, Art Benjamin (Harvey Mudd College) would enter and befuddle the audience with his outstanding rapid mental arithmetic and mathemagic. Interested in such an evening of entertaining mathematics? While I don't have a venue for such performances, I can lead you to a collection of work that you can read or view. In particular, see [1, 2, 4, 8, 9].

Silent, Closing Confessions

At a recent show in a rural middle school, the throng of early teenagers entered the auditorium with varying levels of interest; some cracked jokes about mimes and others spoke loudly regarding their frustrations with math. As I looked out on the assembled mass, a large proportion of them sat, in various poses, with that characteristic air of distant disdain of a teenage student. In performance,

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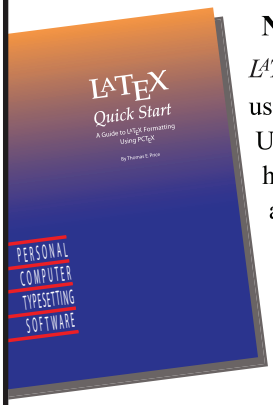

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I generally make a quick judgment call as to how to begin the show. In this case, some well-placed jokes and the use of several convincing mime illusions transformed the atmosphere from quiet and uncertain to laughing and engaged. The show ended in that unmistakable, energetic applause of appreciation.

As I conclude this article and written presentation of my mathematical mime, I wonder what type of audience member you are. What auditorium did I enter as I began this article with the *Notices* readership? More important, have you touched the unseen or heard the unspoken through this narrative of my silent movement?

As mathematicians, our intellectual world is commonly abstract and invisible. We create a narrative of our intellectual thought through our written words. For me, mime is another, quite different but surprisingly similar, way of journeying through this logical field. Best of all, this art creates a road map that invites mathematician and nonmathematician alike to travel alongside me—often in silence, with occasional laughter.

Acknowledgments

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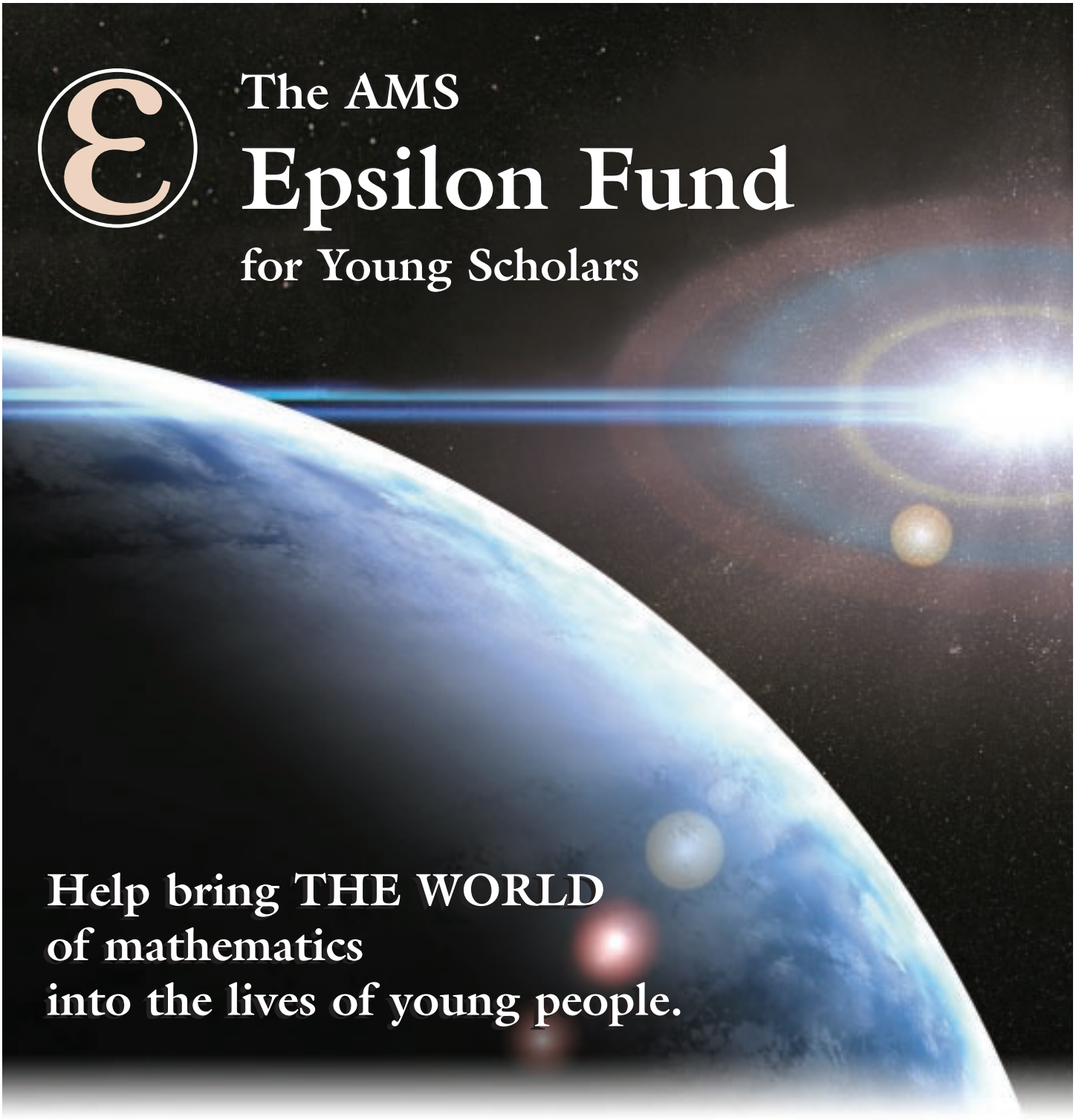

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Music: Broken Symmetry, Geometry, and Complexity

Gary W. Don, Karyn K. Muir, Gordon B. Volk, James S. Walker

The relation between mathematics and music has a long and rich history, including: Pythagorean harmonic theory, fundamentals and overtones, frequency and pitch, and mathematical group theory in musical scores [7, 47, 56, 15]. This article is part of a special issue on the theme of mathematics, creativity, and the arts. We shall explore some of the ways that mathematics can aid in creativity and understanding artistic expression in the realm of the musical arts. In particular, we hope to provide some intriguing new insights on such questions as:

- *Does Louis Armstrong's voice sound like his trumpet?*
- *What do Ludwig van Beethoven, Benny Goodman, and Jimi Hendrix have in common?*
- *How does the brain fool us sometimes when listening to music? And how have composers used such illusions?*
- *How can mathematics help us create new music?*
- *Melody contains both pitch and rhythm. Is it possible to objectively describe their connection?*
- *Is it possible to objectively describe the complexity of musical rhythm?*

In discussing these and other questions, we shall outline the mathematical methods we use and provide some illustrative examples from a wide variety of music.

The paper is organized as follows. We first summarize the mathematical method of Gabor transforms (also known as short-time Fourier transforms, or spectrograms). This summary emphasizes the use of a discrete *Gabor frame* to perform the analysis. The section that follows illustrates the value of spectrograms in providing objective descriptions of musical performance and the geometric time-frequency structure of recorded musical sound. Our examples cover a wide range of musical genres and interpretation styles, including: Pavarotti singing an aria by Puccini [17], the 1982 Atlanta Symphony Orchestra recording of Copland's *Appalachian Spring* symphony [5], the 1950 Louis Armstrong recording of "La Vie en Rose" [64], the 1970 rock music introduction to "Layla" by Duane Allman and Eric Clapton [63], the 1968 Beatles' song "Blackbird" [11], and the Renaissance motet, "Non vos relinquam orphanos", by William Byrd [8]. We then discuss signal synthesis using dual Gabor frames, and illustrate how this synthesis can be used for processing recorded sound and creating new music. Then we turn to the method of continuous wavelet transforms and show how they can be used together with spectrograms for two applications: (1) zooming in on spectrograms to provide more detailed views and (2) producing objective time-frequency

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portraits of melody and rhythm. The musical illustrations for these two applications are from a 1983 Aldo Ciccolini performance of Erik Satie's "Gymnopédie I" [81] and a 1961 Dave Brubeck jazz recording "Unsquare Dance" [94]. We conclude the paper with a quantitative, objective description of the complexity of rhythmic styles, combining ideas from music and information theory.

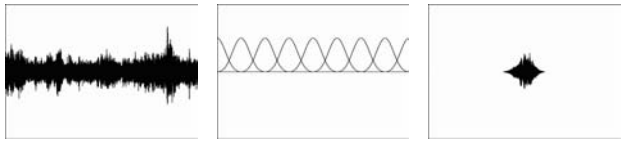
Discrete Gabor Transforms: Signal Analysis

We briefly review the widely employed method of Gabor transforms [53], also known as short-time Fourier transforms, or spectrograms, or sonograms. The first comprehensive effort in employing spectrograms in musical analysis was Robert Cogan's masterpiece, *New Images of Musical Sound* [27] — a book that still deserves close study. A more recent contribution is [62]. In [37, 38], Dörfler describes the fundamental mathematical aspects of using Gabor transforms for musical analysis. Other sources for theory and applications of short-time Fourier transforms include [3, 76, 19, 83, 65]. There is also considerable mathematical background in [50, 51, 55], with musical applications in [40]. Using sonograms or spectrograms for analyzing the music of birdsong is described in [61, 80, 67]. The theory of Gabor transforms is discussed in complete detail in [50, 51, 55] from the standpoint of function space theory. Our focus here, however, will be on its discrete aspects, as we are going to be processing digital recordings.

The sound signals that we analyze are all digital, hence discrete, so we assume that a sound signal has the form $\{f(t_k)\}$, for uniformly spaced values $t_k = k\Delta t$ in a finite interval $[0, T]$. A Gabor transform of f, with window function w, is defined as follows. First, multiply $\{f(t_k)\}$ by a sequence of shifted window functions $\{w(t_k - \tau_\ell)\}_{\ell=0}^{M}$, producing time-localized subsignals, $\{f(t_k)w(t_k - \tau_\ell)\}_{\ell=0}^{M}$. Uniformly spaced time values, $\{\tau_\ell = t_{j\ell}\}_{\ell=0}^{M}$, are used for the shifts (j being a positive integer greater than 1). The windows $\{w(t_k - \tau_\ell)\}_{\ell=0}^{M}$ are all compactly supported and overlap each other; see Figure 1. The value of M is determined by the minimum number of windows needed to cover $[0, T]$, as illustrated in Figure 1(b). Second, because w is compactly supported, we treat each subsignal $\{f(t_k)w(t_k - \tau_\ell)\}$ as a finite sequence and apply an FFT $\mathcal{F}$ to it. This yields the Gabor transform of $\{f(t_k)\}$:

$$\{\mathcal{F}\{f(t_k)w(t_k - \tau_\ell)\}\}_{\ell=0}^{M}. \tag{1}$$

We shall describe (1) more explicitly in a moment (see Remark 1 below). For now, note that because the values t_k belong to the finite interval $[0, T]$, we always extend our signal values beyond the interval's endpoints by appending zeros; hence the full supports of all windows are included.



(a) (b) (c)

Figure 1. (a) Signal. (b) Succession of window functions. (c) Signal multiplied by middle window in (b); an FFT can now be applied to this windowed signal.

The Gabor transform that we employ uses a *Blackman window* defined by

$$w(t) = \begin{cases} 0.42 + 0.5\cos(2\pi t/\lambda) + \\ \qquad 0.08\cos(4\pi t/\lambda) & \text{for } |t| \le \lambda/2 \\ 0 & \text{for } |t| > \lambda/2 \end{cases}$$

for a positive parameter λ equaling the width of the window where the FFT is performed. In Figure 1(b) we show a succession of these Blackman windows. Further background on why we use Blackman windows can be found in [20].

The efficacy of these Gabor transforms is shown by how well they produce time-frequency portraits that accord well with our auditory perception, which is described in the vast literature on Gabor transforms that we briefly summarized above. In this paper we shall provide many additional examples illustrating their efficacy.

Remark 1. To see how spectrograms display the frequency content of recorded sound, it helps to write the FFT $\mathcal{F}$ in (1) in a more explicit form. The FFT that we use is given, for even N, by the following mapping of a sequence of real numbers $\{a_m\}_{m=-N/2}^{m=N/2-1}$:

$$\{a_m\} \xrightarrow{\mathcal{F}} \left\{ A_\nu = \frac{1}{\sqrt{N}} \sum_{m=-N/2}^{N/2-1} a_m\, e^{-i2\pi m\nu/N} \right\}, \tag{2}$$

where ν is any integer. In applying $\mathcal{F}$ in (1), we make use of the fact that each Blackman window $w(t_k - \tau_\ell)$ is centered on $\tau_\ell = j\ell\Delta t$ and is 0 for t_k outside of its support, which runs from $t_k = (j\ell - N/2)\Delta t$ to $t_k = (j\ell + N/2)\Delta t$ and is 0 at $t_k = (j\ell \pm N/2)\Delta t$. So, for a given windowing specified by ℓ, the FFT $\mathcal{F}$ in (2) is applied to the vector $(a_m)_{m=-N/2}^{N/2-1}$ defined by $\left(f(t_k)w([k - j\ell]\Delta t)\right)_{k=j\ell-N/2}^{j\ell+N/2-1}$.

In (2), the variable ν corresponds to frequencies for the discrete complex exponentials $e^{-i2\pi m\nu/N}$ used in defining the FFT $\mathcal{F}$. For real-valued data, such as recorded sound, the FFT values A_ν satisfy the symmetry condition $A_{-\nu} = A_\nu^*$, where A_ν^* is the complex conjugate of A_ν. Hence, no significant information is gained with negative frequencies. Moreover, when the Gabor transform is displayed, the values of the Gabor transform are plotted as

squared magnitudes (we refer to such plots as *spectrograms*). There is perfect symmetry at ν and $-\nu$, so the negative frequency values are not displayed in the spectrograms.

Gabor Frames

When we discuss audio synthesis, it will be important to make use of the expression of Gabor transforms in terms of Gabor frames. An important seminal paper in this field is [92]. A comprehensive introduction can be found in [48]. We introduce Gabor frames here because they follow naturally from combining (1) and (2). If you prefer to see musical examples, then please skip ahead to the next section and return here when we discuss signal synthesis.

Making use of the description of the vector (a_m) given at the end of Remark 1, we can express (1) as

$$(3)\quad \frac{1}{\sqrt{N}} \sum_{k=k_0}^{k_1} f(k\Delta t)\, w([k-j\ell]\Delta t)\, e^{-i2\pi[k-j\ell]\nu/N}.$$

In (1), the values k_0 and k_1 are the lower and upper limits of k that are needed to extend the signal values beyond the endpoints of $[0,T]$. We have also made use of the fact that $w([k-j\ell]\Delta t) = 0$ for $k \le j\ell - N/2$ and for $k \ge j\ell + N/2$.

We now define the functions $\mathbf{G}_{\ell,\nu}(k)$ for $\nu = -N/2,\ldots,N/2-1$ and $\ell = 0,\ldots,M$ as

$$(4)\quad \mathbf{G}_{\ell,\nu}(k) = \frac{1}{\sqrt{N}}\, w([k-j\ell]\Delta t)\, e^{-i2\pi[k-j\ell]\nu/N}$$

and write $C_{\ell,\nu}$ for the Gabor transform values that are computed by performing the computation in (3):

$$(5)\quad C_{\ell,\nu} = \sum_{k=k_0}^{k_1} f(t_k)\, \mathbf{G}_{\ell,\nu}(k).$$

We have suppressed the dependence on j since it is a fixed value, specifying the amount of shifting for each successive window (via $\tau_\ell = t_{j\ell}$). It is set in advance and does not change during the analysis procedure using $\{\mathbf{G}_{\ell,\nu}\}$.

The significance of Equation (5) is that each Gabor transform value $C_{\ell,\nu}$ is expressed as an inner product with a vector $(\mathbf{G}_{\ell,\nu}(k))$. Hence, the entire arsenal of linear algebra can be brought to bear on the problems of analyzing and synthesizing with Gabor transforms. For instance, the vectors $\{\mathbf{G}_{\ell,\nu}\}$ are a discrete *frame*. The theory of frames is a well-established part of function space theory, beginning with the work of Duffin and Schaeffer on nonharmonic Fourier series [45, 99] through applications in wavelet theory [33, 18, 58] as well as Gabor analysis [50, 51, 55, 24].

To relate our discrete Gabor frame to this body of standard frame theory, and to provide an elementary condition for a discrete Gabor frame, we require that the windows satisfy

$$(6)\quad A \le \sum_{\ell=0}^{M} w^2(t_k - \tau_\ell) \le B$$

for two positive constants A and B (the *frame constants*). The constants A and B ensure *numerical stability,* including preventing overflow during analysis and synthesis. The inequalities in (6) obviously hold for our Blackman windows when they are overlapping as shown in Figure 1(b). Using (4) through (6), along with the Cauchy-Schwarz inequality, we obtain (for $K := k_1 - k_0 + 1$):

$$(7)\quad \sum_{\ell=0,\nu=-N/2}^{M,N/2-1} |C_{\ell,\nu}|^2 \le (KB)\ \|f\|^2,$$

where $\|f\|$ is the standard Euclidean norm: $\|f\|^2 = \sum_{k=k_0}^{k_1} |f(t_k)|^2$. When we consider Gabor transform synthesis later in the paper, we shall also find that

$$(8)\quad (A/K)\ \|f\|^2 \le \sum_{\ell=0,\nu=-N/2}^{M,N/2-1} |C_{\ell,\nu}|^2.$$

So we have (using $B_1 := A/K$ and $B_2 := KB$):

$$(9)\quad B_1\|f\|^2 \le \sum_{\ell=0,\nu=-N/2}^{M,N/2-1} |C_{\ell,\nu}|^2 \le B_2\|f\|^2,$$

a discrete version of standard *analysis operator* bounds in function space theory. By *analysis operator,* we mean the Gabor transform $\mathcal{G}$ defined by $\{f(t_k)\} \xrightarrow{\mathcal{G}} \{C_{\ell,\nu}\}$.

Remark 2. (1) It is not necessary to use a single fixed window w to perform Gabor analysis. For example, one could use windows $w_\ell(t_k - \tau_\ell)$ for each ℓ, provided $A \le \sum_{\ell=0}^{M} w_\ell^2(t_k - \tau_\ell) \le B$ is satisfied. Doing so allows for more flexibility in handling rapid events like drum strikes [100], [37, Chap. 3], [39]. (2) The time values $\{t_k\}$ do not need to be evenly spaced (this is called *nonuniform sampling*) [50, 51]. An application using nonuniform sampling is described in Example 12.

Musical Examples of Gabor Analysis

We now discuss a number of examples of using spectrograms to analyze recorded music. Our goal is to show how spectrograms can be used to provide another dimension, a quantitative dimension, to understanding the artistry of some of the great performances in music. For each of the displayed spectrograms, you can view a video of the spectrogram being traced out as the music plays by going to this webpage:

(10) `http://www.uwec.edu/walkerjs/MBSGC/`

Viewing these videos is a real aid to understanding how the spectrograms capture important features of the music. The website also provides an online bibliography and links to the software

we used. Another site with advanced software for time-frequency analysis is [69].

As we describe these examples, we shall briefly indicate how they relate to the art of music and its creation. While spectrograms are extremely useful for quantitative analysis of performance—and performance itself is an act of artistic creation—we shall also point out some ways in which spectrograms can be of use in aiding the creative process of musical composition. When we finish discussing these examples, we will summarize all of these observations on musical creativity.

Example 1 (Pavarotti's vocals)**.** Our first example is a spectrogram analysis of a 1990 recording of the conclusion of Puccini's aria, "Nessun Dorma", featuring a solo by Luciano Pavarotti [17]. See Figure 2. This spectrogram shows the high-amplitude vibrato (oscillations of pitch) that Pavarotti achieves. Using the spectrogram, we can measure quantitatively the amplitudes in the vibrato. This illustrates an interesting *creative application* of spectrograms. Because they can be displayed in real time as the singer is performing, they can be used to help performers to analyze and *improve* their vibrato, both in amplitude and steadiness. One affordable package for real-time spectrogram display can be found at [1]. Notice also that Pavarotti is able to alter the formant structure (the selective amplification of different frequency bands) of the same word in the lyrics, which produces a clearly audible change in brightness (timbre) in the sound. Using spectrograms to study formants is usually the domain of linguistics [75]. But here we see that formants—through a real-time adaptation of selective frequency amplification (selective resonance)—play a role in the magnificent instrumentation that is possible with the human voice.[1]

Example 2 (Contrasting choral and solo voicings)**.** Our second example is another passage from the same recording of "Nessun Dorma" [17], containing a choral passage and the introduction of Pavarotti's concluding solo. See Figure 3. We can see in the spectrogram that there is a notable contrast between the sinuous, blurred vibrato of the chorus in the beginning of the passage versus the clearer vibrato of Pavarotti's solo voice, which is centered on elongated, single pitches. The blurring of the vibrato of the chorus is due to *reverberation* (persistent echoing). We can describe this with the following model:

$$f(t_k) = \sum_{j=0}^{J} g([k - jm]\Delta t)h(j), \tag{11}$$

[1] *There is some speculation that the human vocal apparatus actually evolved first in order to sing, rather than speak* [73].

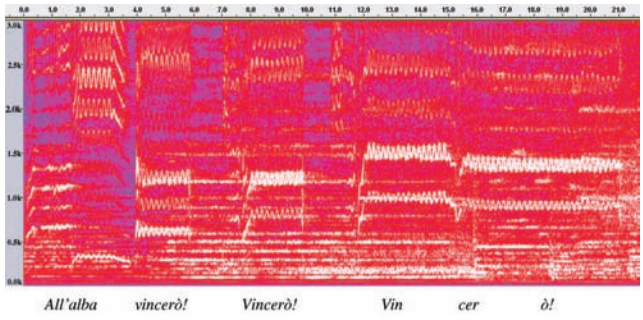


Figure 2. Spectrogram from a recording of "Nessun Dorma" with Luciano Pavarotti. Pavarotti's large-amplitude vibrato is clearly visible *and measurable.* The differing *formants* (selective amplification of different frequency bands) for different vocalizations of the lyrics (printed below the spectrogram) are also clearly displayed. Pavarotti changes the formants for the first two vocalizations of *vincerò,* and this is clearly audible as a change of brightness (timbre) of the sound. In addition, Pavarotti holds the final note, sung as an extended *ò,* with large, constant amplitude vibrato for more than 5 seconds, an amazing feat. (A video for this figure is at (10), a larger graphic is at [101].)

where m is a positive integer, g is the sound that is reverberating, and h is a damping function. The superposition of the slightly damped time-shifted versions of g creates the blurring effect, due to the closeness together in time of almost identical, shifted versions of g. Equation (11) is a discrete *convolution.* Audio engineers frequently employ a model like this, called *convolution reverb,* to simulate the effects of reverberation [44], [7, Sec. 16.7.2]. The function h, called the *impulse response,* is created once through digitally recording the reverberation of a very sharp sound (an impulse). Assuming linearity and shift-invariance properties of reverberation, the reverberation of other sounds is simulated digitally via Equation (11). We shall give an example of using convolution reverb for producing a new musical composition, "Sierpinski Round", in Example 13.

In contrast to the reverberation in the chorus, Pavarotti's vocals—which emerge at high volume from the midst of the chorus, an emotionally moving experience—are much more clearly defined in their vibrato, and his vibrato oscillates around constant pitches. The lack of reverberation in Pavarotti's vocals is probably due to a difference in the way his voice was recorded. The recording was done live at the ruins of the Baths of Caracalla in Rome. Pavarotti sang into a single microphone, while the multiple voices of the chorus were recorded by another microphone (or small set of microphones relative to the large number of

chorus members). Consequently, the recording of the chorus picks up the reverberation off of the walls of the ruins, while Pavarotti's single microphone records his initial voicing without much reverberation. The resounding emergence of Pavarotti's voice from the midst of the chorus is no doubt an artistic choice of Puccini to create a dramatic contrast between the individual and the collective. The blurring of the reverberation of the choral voices versus the clarity of the solo voice serves to further enhance the contrast. This enhanced contrast may also be a creative decision, and with methods such as convolution reverb it can be deliberately produced in creating digital recordings.

Example 3 (Does Louis Armstrong's voice sound like his trumpet?)**.** The classical pianist Edna Stern has answered this question very nicely, with her succinct description of the creative artistry of Louis Armstrong:

> The way he plays trumpet is very similar to his singing, it comes through in the way he is vibrating or marking the expressive moments in the music. Also the timing and the way he is building his phrases are both done in the same declamatory way as his singing. When he is singing, his vibratos are very similar to the trumpet vibratos and I think that there is a clarity in the way he punctuates his syllables, using the exploding ones in a sort of trumpet way. [89]

In Figure 4 we show two spectrograms of clips taken from Armstrong's 1950 recording of "La Vie en Rose" [64] that illustrate perfectly, in a quantitative way, what Stern is talking about. They contain a trumpet solo and vocals of Armstrong. All the vocals exhibit vibrato. The fundamentals for the trumpet notes are in a higher frequency range (around 500 Hz) than the vocals (around 200 Hz). The most prominent trumpet notes exhibiting vibrato are between 0.2 and 1.4 seconds, between 10.5 and 12.2 seconds, and between 14.0 and 15.3 seconds. It is interesting how Armstrong increases the amplitude of the vibrato as these notes progress. This is most evident for the three notes just cited. There is an interesting contrast between these trumpet notes compared with the constant frequency notes of other instruments in the passage (the horizontal bars in the spectrogram that correspond to bass notes at the lowest frequencies, as well as guitar and piano notes at higher frequencies). During the recording, Armstrong also plays notes with constant amplitude vibrato. For example, at the end of the recording, he sustains a note with constant amplitude

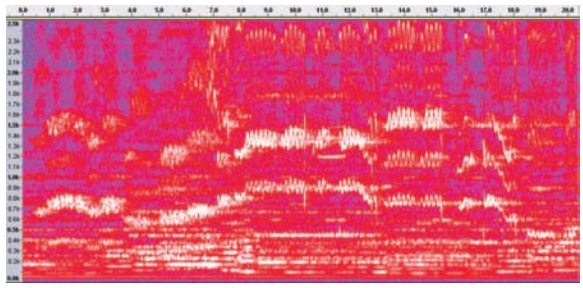


Figure 3. Spectrogram from a recording of "Nessun Dorma" with Luciano Pavarotti. In the first 7.5 seconds, there is a chorus of voices singing. Their lyrics produce several sinuous blurry curves, corresponding to fundamentals and overtones of male and female voices. This chorus is singing with vibrato, but the vibrato is obscured by the blurring (a convolution of reverberating sound). In contrast, Pavarotti's solo emerges from the chorus at about 7.0 seconds. His voicings are with much clearer vibrato and are centered on single, more elongated pitches. (A video for this figure is at (10), a larger graphic is at [101].)

vibrato for about six seconds. The corresponding spectrogram image is similar to the final note for *ò!* held by Pavarotti in Figure 2, so we do not display it.

The exploding syllables that Stern refers to are evident in the very brief, sharply sloped structures that initiate many of the vocals. A particularly prominent one occurs in the vocals spectrogram in Figure 4 at about 14.0 seconds. A similar explosive onset of a trumpet note occurs at about 8.8 seconds in the spectrogram containing the trumpet solo.

Louis Armstrong is well known for both his trumpet playing and his unique vocal style. Here we have shown, in a quantitative way, that it is pointless to try to separate these two aspects of his performance.

Example 4 (Dissonance in rock music)**.** Our next example is a recording of one of the most famous passages in rock music, the introduction to the 1970 recording of "Layla" by Derek and the Dominoes [63]. See Figure 5. The passage begins with the two guitars of Duane Allman and Eric Clapton playing in perfect synchronicity. At around 1.7 seconds, however, a buzzing distortion of the sound occurs. This distortion is due to a beating effect between closely spaced overtones. Although this dissonance may offend some ears, it is most certainly a conscious effect done by the musicians as a prelude to the intense pleading, with a very rough textured voice, of the singer later in the song. It is interesting to contrast this intense dissonance with the more subtle one invoked in "Gymnopédie I" (see Figure 15). When we discuss

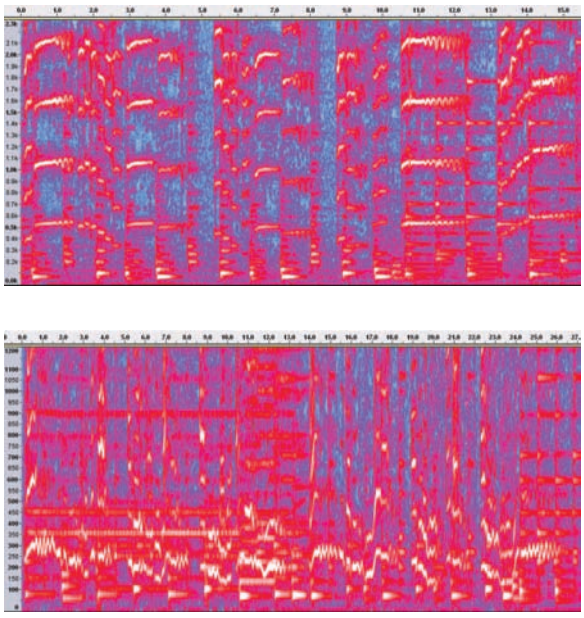


Figure 4. Top: Spectrogram of a trumpet solo by Louis Armstrong. Bottom: Spectrogram of Louis Armstrong vocals. (A video for this figure is at (10), a larger graphic is at [101].)

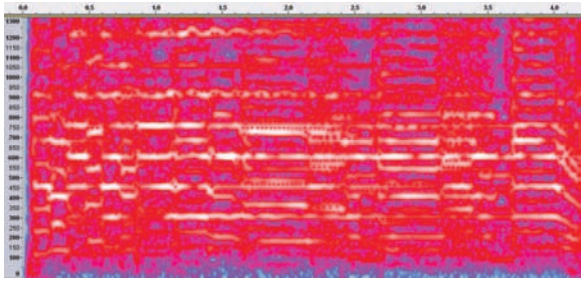


Figure 5. Spectrogram from a recording of "Layla" with Eric Clapton and Duane Allman on guitars. An important feature of the spectrogram is the clear indication of beating between different overtones. For example, for time between 1.7 and 2.2 seconds and frequencies around 450 Hz and 750 Hz, and also for time between 2.2 and 2.4 seconds and frequencies around 300 Hz, 550 Hz, and 700 Hz. The beating appears as sequences of dark points lying between horizontal overtone bands. It is clearly audible as a buzzing sound. (A video for this figure is at (10), a larger graphic is at [101].)

"Gymnopédie I", we will show how this contrast can be characterized quantitatively and how that could be of use in musical composition.

Example 5 (The geometry of *Appalachian Spring*)**.** The use of finite groups in analyzing the structure of notes and chords in musical scores is well established [56, 47, 15]. The work now extends even to the use of highly sophisticated methods from algebraic geometry [70] and orbifold topology [95]. Computer methods are being used as well [21, 12, 7].

One advantage that spectrograms have over analysis of scores, however, is that they provide a way for us to identify these group operations being performed over an extended period of time in a complex musical piece. In such cases, score analysis would be daunting, at least for those without extensive musical training. Spectrograms can help those without score-reading experience to see patterns, and it can help those who do have score-reading experience to connect these group operations to the patterns that they see in the score. Either way, it is valuable. Certainly a solid understanding of these group operations, and how master composers have used them, is an important aspect of learning to create new musical compositions.

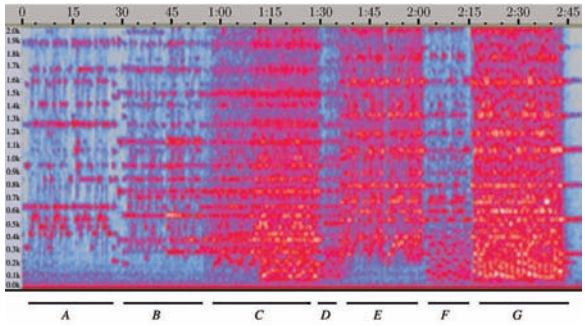


Figure 6. Spectrogram of a passage from *Appalachian Spring* by Aaron Copland. In the time intervals marked by A through G, there is a complex sequence of transpositions and time dilations, played by various instruments, of the basic melody introduced in A. (A video for this figure is at (10), a larger graphic is at [101].)

As an example of analyzing a spectrogram without score references, we look at Section 7 from an Atlanta Symphony recording of Aaron Copland's symphonic suite, *Appalachian Spring* [5]. See Figure 6. Copland uses group-theoretic operations in the time-frequency plane—transposition and dilation—in order to develop the basic melody of the Shaker hymn, "Simple Gifts".

In the spectrogram, within the time interval A and the frequency range of 300 to 600 Hz, there is the initial statement of the melody, played by woodwinds. There is also a transposition and dilation (time shortening) of part of the melody to a much higher frequency range (time range 0:15 to 0:17 and frequency range 900 Hz to 1200

Hz)—a sort of grace note effect, but using an entire melodic motive. In the time interval *B* and the frequency range of 200 to 500 Hz, there is a transposition down to stringed instruments, with a time dilation (shrinkage) of the melody, plus some interpolated notes so that the melody still plays for about 30 seconds. In the time interval *C*, there is a fugue-like development of the melody. It begins with another transposition from *A*'s melody to a lower frequency range than in *B*. Then at about time 1:12 there is an overlay of a transposition of *A*'s melody to a higher frequency range played by horns, and underlying it a very slow-moving time dilation (stretching) of a transposition down to a lower frequency range played by bass strings. In the time interval *D* there is a transition passage, played by woodwinds, of short motives pulled from the melody. The beginning of time interval *E*, from about time 1:37 to time 1:40, contains a rising horn crescendo that leads into a transposition of the melody from *A* to a higher frequency range (also played by horns). Within the time interval *F*, there is a transposition down again, played by woodwinds. Finally, the passage concludes with the time interval *G*, containing a combination of all the previous transpositions: played by strings, horns, and woodwinds at high volume, emphasized by a stately rhythmic pounding of a bass drum.[2] This passage from *Appalachian Spring* is a remarkable example of an extended development of a melodic theme.

Example 6 (What do Ludwig van Beethoven, Benny Goodman, and Jimi Hendrix have in common?)**.** The short answer, of course, is that they all created great music. In Figure 7 we show three spectrograms of recordings of short passages from their music. It is interesting to find the similarities and differences between these spectrograms and the music they reflect. In the Beethoven passage—which is a portion of his Piano Sonata in E (Opus 109) performed by David Añez Garcia [66, Movement 1, Measures 15–17]—we see a descending series of treble notes followed by an ascending series, reflecting an approximate mirror symmetry. The symmetry is broken, however, by an ascending set of bass notes (indicated by the arrow on the spectrogram). The mirror-symmetric pattern is also broken by the gentle rising treble notes trailing off to the right.

The spectrogram of the Goodman recording—a clip from a circa 1943 live broadcast of "Sing, Sing, Sing" [14][3]—also shows a similar, approximate mirror symmetry from time 3.5 seconds to 8.5 seconds, which is also broken by a gently rising scale trailing off to the right. In this case, Goodman is playing a clarinet and *bending the notes* as is commonly done in jazz style. The bending of the notes is clearly displayed in the spectrogram by the connected curved structures (which possess a symmetry of their own). This is a significant contrast to the discretely separated, constant harmonic piano notes in the Beethoven passage.

The spectrogram of the Hendrix passage—a clip from his 1968 recording of "All Along the Watchtower" [46]—exhibits a similar pattern to the other two, an approximately mirror-symmetrical descension and ascension of pitch, followed by a gently rising trailing off of melodic contour. Hendrix, however, illustrates a unique aspect of his music. Rather than using discrete notes, he instead uses his electric guitar to generate a *continuous flow of chords.* The chord progression is continuous rather than a set of discrete tones typically used in most Western music. It is interesting that the electronic sound produced here is surprisingly warm and soft, especially in the later "trailing off" portion. Perhaps this is due to Hendrix's synthesizing continuous chord transitions and vibrato ("wah-wah") within the blues scale, a remarkable achievement.

A more extended spectrogram analysis of the Beethoven piano sonata can be found in [27, pp. 49–56]. For more on jazz *vis-à-vis* classical music, see [16, pp. 106–132]. For incisive comments on Hendrix in particular, see [2, pp. 197 and 203].

Example 7 (Birdsong as a creative spark for music)**.** Birdsong has a long and distinguished history of providing a creative spark for musical composition. Donald Kroodsma, perhaps the world's leading authority on birdsong, has succinctly described this history:

> As early as 1240, the cuckoo's *cuckoo* song appears in human music, in minor thirds. The songs of skylarks, song thrushes, and nightingales debut in the early 1400s. The French composer Olivier Messiaen is my hero, as he championed birdsongs in his pieces. I love Respighi's *Pines of Rome,* too, as the songs of a nightingale accompany the orchestra…I learned recently, too, why I have always especially enjoyed the "Spring" concerto from

[2] *For those listeners familiar with the religious background of the Shaker hymn, the metaphor—external to the music—of the inheritance of the earth is unmistakable in this concluding portion.*

[3] *We hope our discussion of this piece will help to alleviate its undeserved obscurity. At the time of writing,* [14] *is still in print.*

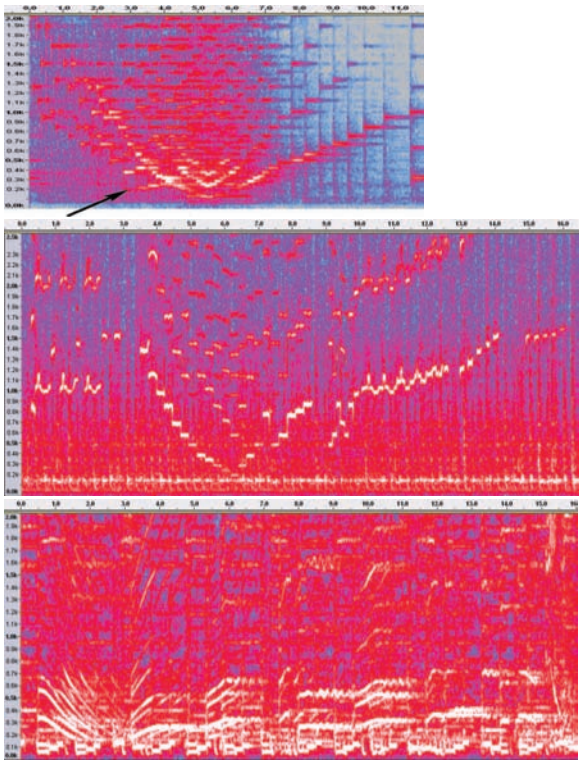


Figure 7. Top: Spectrogram from a recording of Beethoven's Piano Sonata in E (Opus 109). The arrow indicates an ascending bass scale, entering in contrast to the descending treble scale. Middle: Spectrogram from a Benny Goodman recording of "Sing, Sing, Sing". Bottom: Spectrogram from a Jimi Hendrix recording of "All Along the Watchtower". (A video for this figure is at (10), a larger graphic is at [101].)

> Vivaldi's *Four Seasons:* It is the birds and their songs that celebrate the return of spring in this concerto, and now I clearly hear their birdsongs in the brief, virtuoso flourishes by the solo violinist. [61, p. 275]

Kroodsma's book, from which this quote is taken, is full of spectrograms and their use in analyzing the musical qualities of birdsong. There is even a most amusing description on p. 274 of his researching which composers Java sparrows prefer and carrying out musical education with them!

Unfortunately, we do not have space here to do justice to the music of Messiaen. However, there is an excellent discussion, utilizing both spectrograms and scores, of the creative inspiration of birdsong for his music in Rothenberg's book [80]. The website for that book [98] also contains some samples of Messiaen's music and related birdsongs. One technique that Messiaen employed was to slow down the tempo of birdsong to increase its comprehensibility to human ears. He did this based on his own meticulous transcriptions into musical scores of songs he heard in the field. With Gabor transforms, this process can be done digitally with the recorded songs themselves; we will discuss how in Example 12. There is certainly much more to explore in Messiaen's music using the tools of spectrograms. The tools of percussion scalograms for rhythm analysis (which we discuss later) can be employed as well, since Messiaen incorporated the rhythmic styles of birdsong in his music [80, p. 198].

Besides Messiaen, Stravinsky also incorporated elements of birdsong into some of his compositions. In his classic work of musical theory, Mache devotes an entire chapter to studying, via spectrograms, the connections between the music of birds and elements of Stravinsky's music [67, Chap. 5]. Mache uses spectrograms as a kind of *generalized musical notation,* which gets around the very challenging problem of transcribing birdsong into standard musical notation. Mache also discusses other animal music-making in this chapter, which he entitles "Zoomusicology".

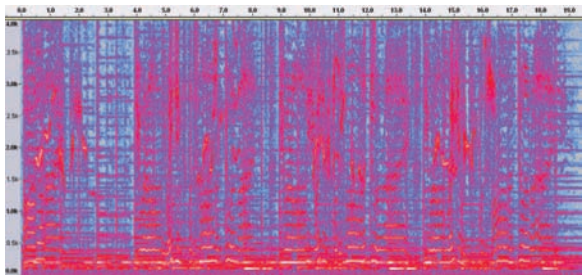


Figure 8. Spectrogram of Paul McCartney's duet with a songbird, from the Beatles' recording "Blackbird". (A video for this figure is at (10), a larger graphic is at [101].)

Besides the world of classical music, or art music, birdsong has been used in more popular music as well. A striking example is from the Beatles, who bridged the worlds of popular song and artistic music. At the end of their 1968 recording of "Blackbird" [11], Paul McCartney literally sings a duet with a blackbird. In Figure 8 we show a spectrogram of this portion of the recording. The blackbird's chirps lie in the upper portion of the time-frequency plane with sharply sloped rapid changes of pitch, while McCartney's vocals lie more in the lower portion (although his overtones often extend into the region where the blackbird is singing). In some places, for instance between 10.0 and 10.5 seconds, McCartney's rapid articulation is quite similar to the blackbird's, as we can see in the similar sharply sloped structures—for McCartney, most prominently between 250 and

1000 Hz, and for the blackbird, most prominently between 1500 and 3000 Hz—whereas in other places, there is a contrast between the longer time-scale rhythm to McCartney's vocals and the shorter time-scale rhythms of the blackbird's chirps.

Example 8 (Do our ears play tricks on us?)**.** In fact, our ears can fool us sometimes. The most famous auditory illusion is due to Shepard [85]. Shepard created electronic tones that seem to rise endlessly in pitch, even though they in fact ascend through just one octave. The tones can also be arranged to create an illusion of endless descent. The website [52] has a nice demonstration of Shepard tones. To hear examples showing that an illusion is actually occurring, go to the URL in (10) and select the topic Example 8: Audio Illusions.

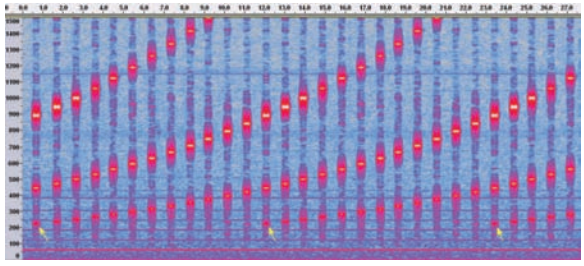


Figure 9. Spectrogram of Shepard's illusion of an endlessly rising series of tones, which in fact stay within just one octave. The arrows indicate where the illusion occurs. (A video for this figure is at (10), a larger graphic is at [101].)

Shepard's illusion is easily explained using spectrograms. Figure 9 practically speaks for itself. The illusion is due to our brain tracking the pitch contour of the fundamentals for the tones and expecting the next fundamental to be exactly one octave higher than where it occurs. The overtones of the electronic tones are all designed in an octave series—the fundamental multiplied by two, four, eight, etc.—to hide the drop in pitch.

Shepard's auditory illusion has been used subsequently by composers in electronic music, the most notable compositions being produced by Risset [7, Chap. 13]. The endlessly rising illusion can be used for expressing moments of infinite, transcendent joy, while the endlessly descending illusion can be used for invoking the opposite emotion.

The special arrangement of only octave spacings in the overtones does not lend itself well to traditional instruments. It is natural to ask, however, whether composers in the past have used illusions like the Shepard tones. Some examples by Bach have been proposed [60, p. 719]. Another

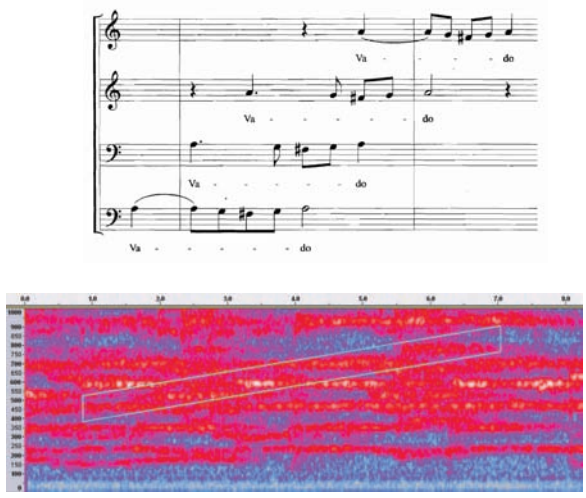


Figure 10. Top: Extract from the score of William Byrd's motet, "Non vos relinquam orphanos". Bottom: Spectrogram of a recording of the passage, with its structures aligned with the vocals in the score above. An ascending series of overtones lies within the parallelogram. (A video for this figure is at (10), a larger graphic is at [101].)

example is pointed out by Hodges in his delightful article on geometry and music [47, Chap. 6]. The illusion occurs in performances of a Renaissance motet by William Byrd, "Non vos relinquam orphanos" ("I will not leave you comfortless"). To describe the illusion, we quote from Hodges's article:

> Jesus is foretelling his ascension into heaven, *Vado* 'I am going'.
>
> The moment passes quickly …The *Vado* motif seems to move steadily upward through the voices, pointing to Jesus' own movement upwards to heaven. …In fact, the movement is not as steady as it sounds; at two of the repetitions there is no movement upwards. …the ear is deceived.

In Figure 10, we show the score and a spectrogram that illustrates the overtones of the voices at the four vocalizations of *Vado* in a 2003 Cambridge Singers recording of the motet [8]. There is clearly a similarity to the Shepard tone arrangement of overtones. As Hodges points out, the effect is subtle. Undoubtedly it is more noticeable when listening to the motet in a locale with long reverberation times contributing to the frequency tracking process in our brains (such as the Great Hall of University College School, London, where this recording was made). As a partial confirmation of this idea, we will amplify the indicated overtones in the

motet's spectrogram in Example 10. This is an example of audio synthesis with Gabor transforms, which we discuss in the next section.

Summary. The musical examples we have discussed were chosen to illustrate that spectrograms enhance our understanding of how great performing artists produce their music and to provide ideas for using Gabor analysis as an aid to creating new music. Our discussion of these examples produced at least these five ideas:

(1) *Perfecting vibrato.* Using spectrograms, either recorded or in real time, to analyze and perfect vibrato. This applies to vibrato in singing and also to vibrato in instrumental music. More generally, this applies to improvements in other musical techniques, such as holding a constant pitch.
(2) *Convolution reverb.* Spectrograms can be used to compare the results, in a quantitative way, of recordings made with different convolution reverb methods.
(3) *Analyzing dissonance.* The beating effect of dissonance can be quantified easily with either spectrograms or scalograms (as we describe in Example 14). This allows for evaluation of creative efforts to employ dissonance in music.
(4) *Visualizing geometric transformations of the time-frequency plane.* Such transformations are regularly used in musical compositions. Spectrograms provide an effective tool for analyzing the patterns of such transformations over longer time scales than score analysis facilitates. Such analyses are valuable for understanding the connection between these patterns and the music they reflect.
(5) *Zoomusicology.* Spectrograms provide a generalized musical notation for capturing the production of sonorities by other species, such as birds. This can yield new ideas for pitch alterations and rhythmic alterations (analyzed with the percussion scalogram method). Also, slowing down the tempo of birdsong, which we discuss later in Example 12, is an important technique (first applied by Messiaen). With Gabor transforms, this slowing down can be performed automatically (without tedious and complicated field transcriptions to standard musical notation).

Discrete Gabor Transforms: Signal Synthesis

The signal $\{f(t_k)\}$ can be reconstructed from its Gabor transform $\{C_{\ell,\nu}\}$. We shall briefly describe this reconstruction and show how it can be expressed in terms of synthesis with a *dual frame,* a frame dual to the Gabor frame $\{\mathbf{G}_{\ell,\nu}\}$. Following this discussion, we apply this synthesis method to audio processing and the creation of new electronic music.

First, we briefly sketch the reconstruction process. The FFT in (2) is invertible, via the formula:

$$a_m = \frac{1}{\sqrt{N}} \sum_{\nu=-N/2}^{N/2-1} A_\nu \, e^{i2\pi m\nu/N}. \tag{12}$$

Hence, by applying such FFT-inverses to the Gabor transform in (1), we obtain a set of discrete signals:

$$\{\{f(t_k)w(t_k-\tau_\ell)\}\}_{\ell=0}^{M}.$$

For each ℓ, we then multiply the ℓth signal by $\{w(t_k-\tau_\ell)\}$ and sum over ℓ, obtaining

$$\{\sum_{\ell=0}^{M} f(t_k)w^2(t_k-\tau_\ell)\} = \{f(t_k)\sum_{\ell=0}^{M} w^2(t_k-\tau_\ell)\}.$$

Multiplying the right side of this last equation by the values

$$\left[\sum_{\ell=0}^{M} w^2(t_k-\tau_\ell)\right]^{-1},$$

which by (6) are no larger than A^{-1}, we obtain our original signal values $\{f(t_k)\}$.

Synthesis Using Dual Frames

We now describe one way in which this reconstruction can be expressed via a dual frame. Alternative ways are described in [23, 25, 57].

We apply inverse FFTs to the Gabor transform values $\{C_{\ell,\nu}\}$ in (5), then multiply by $\{w([k-j\ell]\Delta t)\}$, and sum over ℓ to obtain:

$$\sum_{\ell=0}^{M}\sum_{\nu=-N/2}^{N/2-1} C_{\ell,\nu}\,\frac{w([k-j\ell]\Delta t)}{\sqrt{N}}\,e^{i2\pi(k-j\ell)\nu/N}. \tag{13}$$

We then divide by $\sum_{m=0}^{M} w^2([k-jm]\Delta t)$, obtaining

$$\sum_{\ell=0}^{M}\sum_{\nu=-N/2}^{N/2-1} C_{\ell,\nu}\,\frac{w[(k-j\ell)\Delta t]\,e^{i2\pi(k-j\ell)\nu/N}}{\sqrt{N}\sum_{m=0}^{M} w^2([k-jm]\Delta t)} = f(t_k).$$

Now, define the *dual Gabor frame* $\{\Gamma_{\ell,\nu}\}$ by

$$\Gamma_{\ell,\nu}(k) = \frac{w([(k-j\ell]\Delta t)\,e^{i2\pi(k-j\ell)\nu/N}}{\sqrt{N}\sum_{m=0}^{M} w^2([k-jm]\Delta t)}. \tag{14}$$

We leave it as an exercise for the reader to show that $\{\Gamma_{\ell,\nu}\}$ is, in fact, a discrete frame. Using (14), we obtain

$$f(t_k) = \sum_{\ell=0}^{M}\sum_{\nu=-N/2}^{N/2-1} C_{\ell,\nu}\,\Gamma_{\ell,\nu}(k). \tag{15}$$

Equation (15) is our synthesis of $\{f(t_k)\}$ using the dual frame $\{\Gamma_{\ell,\nu}\}$.

We note that by combining (15) with (6) and using the Cauchy-Schwarz inequality, we obtain Inequality (8).

Remark 3. When there is a high degree of overlapping of windows, then $\sqrt{N}\sum_{m=0}^{M} w^2([k-jm]\Delta t)$ is approximately a constant C, and we have $\Gamma_{\ell,\nu}(k) \approx \mathbf{G}^*_{\ell,\nu}(k)/C$. Hence, the dual Gabor frame is, modulo a constant factor and complex conjugation, approximately the same as the Gabor frame. In any case, (15) shows that we can reconstruct the original signal f as a linear combination of the vectors in the dual Gabor frame, each of which is supported within a single window of the form $w([(k - j\ell]\Delta t)$. These last two statements reveal why we multiplied by the windowings before summing in (13).

The synthesis on the right side of (15) can be expressed independently of the Gabor transform. We shall use S to denote the *synthesis mapping*

$$(16) \quad \{B_{\ell,\nu}\} \xrightarrow{S} \left\{\sigma(t_k) = \sum_{\ell=0}^{M}\sum_{\nu=-N/2}^{N/2-1} B_{\ell,\nu}\,\Gamma_{\ell,\nu}(k)\right\}$$

based on the right side of (15), but now applied to an arbitrary matrix $\{B_{\ell,\nu}\}$.

Musical Examples of Gabor Synthesis

We shall now illustrate Gabor synthesis with musical examples. There are two basic schemes. One scheme, which is used for creating new music, is to use the synthesis mapping S in (16). The input matrix $\{B_{\ell,\nu}\}$ is specified by the composer, and the output $\{\sigma(t_k)\}$ is the new, electronic audio. There is software available for synthesizing music in this way. A beautiful example is the MetaSynth program [71].

Another scheme, which is used for processing audio, can be diagrammed as follows (where P denotes some processing step):

$$(17) \quad \{f(t_k)\} \xrightarrow{G} \{C_{\ell,\nu}\} \xrightarrow{P} \{B_{\ell,\nu}\} \xrightarrow{S} \{\sigma(t_k)\}.$$

The end result $\{\sigma(t_k)\}$ is the processed audio.

Example 9 (Reversing figure and ground)**.** In [38], Dörfler mentions that one application of Gabor transforms would be to select a single instrument, say a horn, from a musical passage. We will illustrate this idea by amplifying the structure **H** shown in the spectrogram on the left of Figure 11, which is from a passage in a 1964 Boston Symphony Orchestra recording of Stravinsky's *Firebird Suite* [93]. The sound corresponding to this structure is a faint sequence of ascending harp notes.

To amplify just this portion of the sound, we multiply the Gabor transform values by a mask of quadratically increasing values from 3.7 to 4.1 within a narrow parallelogram containing **H** and value 1 outside the parallelogram[4] (see the right of Figure 11) and then perform the synthesis mapping S. Notice that the amplified structure **A** stands out more from the background of the remainder of the spectrogram (which is unaltered). Listening to the processed sound file, we hear a much greater emphasis on the harp notes than in the original, and the volume of the rest of the passage is unchanged. We have altered the figure-ground relationship of the music.

The modification we have performed in this example is a *joint time-frequency filtering* of the Gabor transform. With this example, we have touched on an important field of mathematical research known as *Gabor multipliers.* More details can be found in [9, 41, 49, 82, 97].

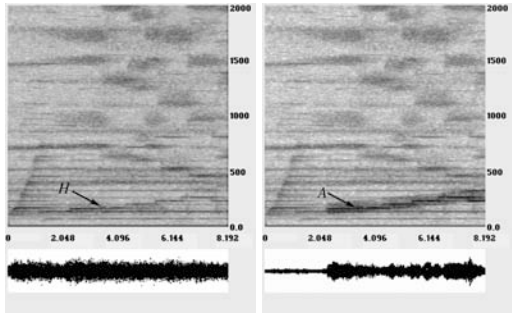


Figure 11. Left: spectrogram of portion of *Firebird Suite.* The structure to be selectively amplified is labeled H. Right: spectrogram with amplified structure labeled A. (A video for this figure is at (10), a larger graphic is at [101].)

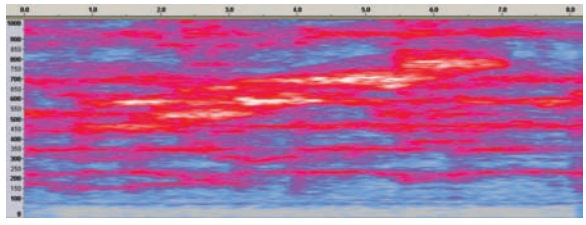


Figure 12. Selective amplification of a region in the spectrogram of a passage from a William Byrd motet, cf. Figure 10. (A video for this figure is at (10), a larger graphic is at [101].)

Example 10 (Amplifying Byrd's illusion)**.** A similar example of Gabor multipliers involves an amplification of a portion of the Gabor transform of the passage from the William Byrd motet considered in Example 8. We again amplify a parallelogram region of the Gabor transform (see Figure 10). This produces the spectrogram shown in Figure 12. After applying the synthesis mapping S to the modified transform, we are better able to hear the illusion. That is because we have selectively amplified the overtones of the vocals that our hearing is "tracking" when we hear the illusion.

Example 11 (Removing noise from audio)**.** One of the most important examples of audio processing with Gabor transforms is in audio denoising. For

[4] *The precise formula can be found at the website in* (10).

reasons of space, we cannot do justice to this vast field. Suffice it to mention that an excellent description of the flexibility of Gabor transform denoising, combining Gabor multipliers with sophisticated Bayesian methods, is given in Dörfler's thesis [37, Sec. 3.3]. An elementary introduction is given in [96, Sec. 5.10]. One advantage of Gabor transforms is that the compact support of the windows allows for *real-time denoising,* including adaptation to changing noise characteristics.

Example 12 (Slowing down sound)**.** In Example 7 we raised the issue of slowing down the tempo of birdsong. This could be done in two ways. The first way is to simply increase the size of the interval Δt between successive signal values when playing back the sound. This has the effect, however, of decreasing the frequencies of the pitches in the sound. For example, if Δt is doubled in size, then the frequencies of all the pitches are halved, and that lowers all the pitches by one octave. The website [98] has examples of this type of slowing down of birdsong.

Another approach to slowing down the birdsong, *while leaving the pitches unchanged,* is to make use of the Gabor transform $\{C_{\ell,\nu}\}$ of the sound. For example, to decrease the sound tempo by a factor of 2, we would first define a matrix $\{B_{\ell,\nu}\}$ as follows. We set $B_{2\ell,\nu} = C_{\ell,\nu}$ for each ℓ, and then interpolate between successive values $B_{2\ell,\nu}$ and $B_{2\ell+2,\nu}$ to define each value $B_{2\ell+1,\nu}$. Finally, we apply the synthesis mapping in (16) to the matrix $\{B_{\ell,\nu}\}$. The windows for this synthesis are all shifts of the original window w, centered at points spaced by the original increment $\Delta\tau$. Now, however, twice as many windowings are done (so as to extend twice as far in time). This method keeps the pitches at the same levels as the original sound, but they now last twice as long.

Slowing down by a factor of 2 is just the easiest method to describe. This latter approach can also be used to slow down (or speed up) the tempo of the sound signal by other factors. Both these methods can also be applied, either separately or in combination, to other digital sound files besides birdsong. For example, the MetaSynth program [71] allows for this sort of morphing of digital sound. It is interesting that the morphing we have described—which via Gabor frames can be done in a localized way on just parts of the signal—requires the extensions of the Gabor transform methodology described in Remark 2.

Example 13 (Granular synthesis of new music)**.** As mentioned above, composers can use the scheme in (16) to create new music. Some good examples can be found at the MetaSynth website [71]. However, we cannot resist showing two of our own compositions, which are really just motifs that still need to be set within larger compositions.

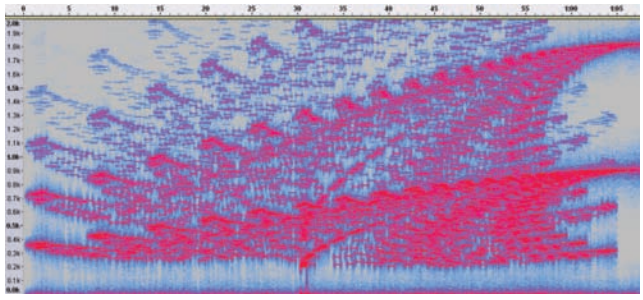


Figure 13. Spectrogram for the fractal music "Fern". (A video for this figure is at (10), a larger graphic is at [101].)

In Figure 13 we show the spectrogram of a granularly synthesized musical passage, "Fern" [35]. The method used for generating the grains $\{B_{\ell,\nu}\}$ was to use the iterated function system (IFS) created by Michael Barnsley for drawing a fractal image of a fern leaf [10, pp. 86–87]. Using the probabilities $p_1 = 0.01$, $p_2 = 0.85$, $p_3 = 0.07$, and $p_4 = 0.07$, one of the corresponding four affine transformations,

$$\mathcal{A}_i \begin{bmatrix} t \\ \nu \end{bmatrix} = \begin{bmatrix} a_i & b_i \\ c_i & d_i \end{bmatrix} \begin{bmatrix} t \\ \nu \end{bmatrix} + \begin{bmatrix} e_i \\ f_i \end{bmatrix}, \quad (i = 1, 2, 3, 4),$$

is applied to a pair of time-frequency coordinates (starting from an initial *seed* pair of coordinates). We shall not list all of the four affine transformations $\mathcal{A}_i$ here. They can be found in [10, Table 3.8.3 on p. 87]. It will suffice to list just one of them:

$$\mathcal{A}_3 \begin{bmatrix} t \\ \nu \end{bmatrix} = \begin{bmatrix} 0.2 & -0.26 \\ 0.23 & 0.22 \end{bmatrix} \begin{bmatrix} t \\ \nu \end{bmatrix} + \begin{bmatrix} 0 \\ 0.07 \end{bmatrix},$$

which is applied with probability $p_3 = 0.07$. Notice that $\mathcal{A}_3$ is not a member of the Euclidean group, since the matrix used for it is not orthogonal.

This IFS is used to draw points of the fern that begin the fundamentals of the notes. An instrumental spectrum generator was then used to generate overtones and time durations for the notes and to generate the actual sound file. Our iterations were done 2500 times using John Rahn's Common Lisp Kernel for music synthesis [78], which converts the generated fractal shape into a file of instrumental tone parameters determining initiation, duration, and pitch. This file of instrumental tone parameters was then converted into a digital audio file using the software C-Sound [30].

An interesting feature of the type of music shown in Figure 13 is that the notes contained in the piece do not exhibit the classical note symmetries (transpositions, reflections, etc.) that are all members of the Euclidean group for the time-frequency plane. That is because some of the affine transformations $\mathcal{A}_i$, such as $\mathcal{A}_3$, are not members of the Euclidean group. Perhaps these non-Euclidean operations on its notes are one source of the eerie quality of its sound.

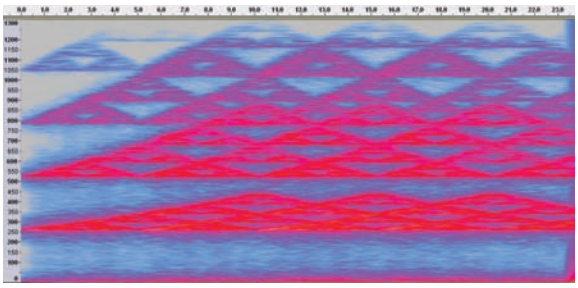


Figure 14. Spectrogram for the granular synthesis music, "Sierpinski Round". (A video for this figure is at (10), a larger graphic is at [101].)

As a second instance of granular synthesis, we applied Barnsley's IFS for the Sierpinski triangle [10, Table 3.8.1 on p. 86]. However, instead of generating only the grains for tones from Sierpinski's triangle, we also superimposed two shiftings in time of all such grains, thus producing three Sierpinski triangles superimposed on each other at different time positions. The spectrogram of the composition, "Sierpinski Round" [36], is shown in Figure 14. Besides having visual artistic value, it is interesting to listen to. It sounds like a ghostly chorus, with a bit of the Shepard rising-pitch-illusion effect.

We have only touched on the vast arena of granular synthesis, fractal music, and electronic music in general. More work is described in [7, 47, 74, 77, 28]. Although electronic music has been developing for about half a century, it is perhaps still in its infancy. Tonal music, based on harmony of one form or another, has been with us for millennia. In his masterful critical history of twentieth-century music, Alex Ross provides a balanced, nuanced view of the development of all forms of new music, including electronic music [79, Part III].

Summary. We have described several uses of Gabor transform synthesis for creating new music. These uses are (1) modifying the intensity of a specific instrument or set of overtones in a musical passage, (2) removing noise, (3) slowing down (or speeding up) the sound, (4) granular synthesis. Although this only scratches the surface of the use of Gabor transform synthesis, we did provide additional references in all of our examples.

Continuous Wavelet Transforms

In this section we briefly review the method of scalograms (continuous wavelet transforms) and then discuss the method of percussion scalograms. Both methods will be illustrated with musical examples.

Scalograms

The theory of continuous wavelet transforms (CWTs) is well established [31, 26, 68]. A CWT differs from a spectrogram in that it does not use translations of a window of fixed width; instead it uses translations of differently sized dilations of a window. These dilations induce a logarithmic division of the frequency axis. The discrete calculation of a CWT that we use is described in detail in [4, Section 4]. We shall only briefly review it here.

Given a function Ψ, called the *wavelet*, the continuous wavelet transform $\mathcal{W}_\Psi[f]$ of a sound signal f is defined as

$$\mathcal{W}_\Psi[f](\tau,s) = \frac{1}{\sqrt{s}}\int_{-\infty}^{\infty} f(t)\overline{\Psi(\frac{t-\tau}{s})}\,dt \tag{18}$$

for *scale* $s > 0$ and *time translation* τ. For the function Ψ in the integrand of (18), the variable s produces a dilation and the variable τ produces a translation.

We omit various technicalities concerning the types of functions Ψ that are suitable as wavelets; see [26, 31, 68]. In [26, 32], Equation (18) is derived from a simple analogy with the logarithmically structured response of our ear's basilar membrane to a sound stimulus f.

We now discretize Equation (18). First, we assume that the sound signal $f(t)$ is nonzero only over the time interval $[0, T]$. Hence (18) becomes

$$\mathcal{W}_\Psi[f](\tau,s) = \frac{1}{\sqrt{s}}\int_{0}^{T} f(t)\overline{\Psi(\frac{t-\tau}{s})}\,dt.$$

We then make a Riemann sum approximation to this last integral using $t_m = m\Delta t$, with uniform spacing $\Delta t = T/N$, and discretize the time variable τ, using $\tau_k = k\Delta t$. This yields

$$\mathcal{W}_\Psi[f](\tau_k,s) \approx \frac{T}{N}\frac{1}{\sqrt{s}}\sum_{m=0}^{N-1} f(t_m)\overline{\Psi([t_m-\tau_k]s^{-1})}. \tag{19}$$

The sum in (19) is a correlation of two discrete sequences. Given two N-point discrete sequences $\{f_k\}$ and $\{\Psi_k\}$, their *correlation* $\{(f:\Psi)_k\}$ is defined by

$$(f:\Psi)_k = \sum_{m=0}^{N-1} f_m\overline{\Psi_{m-k}}\,. \tag{20}$$

[Note: For the sum in (20) to make sense, the sequence $\{\Psi_k\}$ is *periodically extended,* via $\Psi_{-k} := \Psi_{N-k}$.]

Thus Equations (19) and (20) show that the CWT, at each scale s, is approximated by a multiple of a discrete correlation of $\{f_k = f(t_k)\}$ and $\{\Psi_k^s = s^{-1/2}\Psi(t_k s^{-1})\}$. These discrete correlations are computed over a range of discrete values of s, typically

$$s = 2^{-r/J}, \quad r = 0, 1, 2, \ldots, I\cdot J, \tag{21}$$

where the positive integer I is called the number of *octaves* and the positive integer J is called the number of *voices* per octave. For example, the choice of 6 octaves and 12 voices corresponds—based

on the relationship between scales and frequencies described below—to the equal-tempered scale used for pianos.

The CWTs that we use are based on Gabor wavelets.[5] A *Gabor wavelet,* with width parameter ω and frequency parameter ν, is defined as follows:

$$\Psi(t) = \omega^{-1/2} e^{-\pi(t/\omega)^2} e^{i2\pi\nu t/\omega}. \tag{22}$$

Notice that the complex exponential $e^{i2\pi\nu t/\omega}$ has frequency ν/ω. We call ν/ω the *base frequency.* It corresponds to the largest scale $s = 1$. The bell-shaped factor $\omega^{-1/2}e^{-\pi(t/\omega)^2}$ in (22) damps down the oscillations of Ψ, so that their amplitude is significant only within a finite region centered at $t = 0$. (This point is discussed further, with graphical illustrations, in [4, 20].) Because the scale parameter s is used in a reciprocal fashion in Equation (18), it follows that the reciprocal scale $1/s$ will control the frequency of oscillations of the function $s^{-1/2}\Psi(t/s)$ used in Equation (18). Thus frequency is described in terms of the parameter $1/s$, which Equation (21) shows is logarithmically scaled. This point is carefully discussed in [4] and [96, Chap. 6], where Gabor scalograms are shown to provide a method of zooming in on selected regions of a spectrogram. Here we shall provide just one new example.

Example 14 (Subtle dissonance in "Gymnopédie I")**.** On the bottom of Figure 15, we show a spectrogram of the beginning of a 1983 Aldo Ciccolini performance of Erik Satie's "Gymnopédie I" [81]. There is a very subtle dissonance of some of the overtones of the notes in the piece. To see this dissonance we calculated a Gabor scalogram for the first 5.944 seconds of the passage, using 1 octave and 256 voices, a width parameter of 0.1, and frequency parameter 65. The base frequency is therefore 650 Hz, and the maximum frequency is 1300 Hz. This scalogram is shown on the top of Figure 15. The scalogram has zoomed in on the spectrogram enough that we can see several regions where overtones are so closely spaced that beating occurs. This subtle beating is barely evident to our ears, contributing to the haunting quality of the tones in the piece.

Besides Satie, other composers have used subtle dissonance effects in overtones. Debussy was a master of such techniques, including using different types of scales to enhance the interplay of the overtones. The musical history of Ross [79, pp. 43–49] contains a nice synopsis of Debussy's use of overtones, along with the pentatonic scale of much Oriental music (Chinese, Vietnamese, and Javanese gamelan music). The article [34] explores the overtone structures of Debussy in depth and also examines the question of whether

[5] *A CWT with Gabor wavelet is closely related to the Stockwell transform* [91, 54, 43, 90].

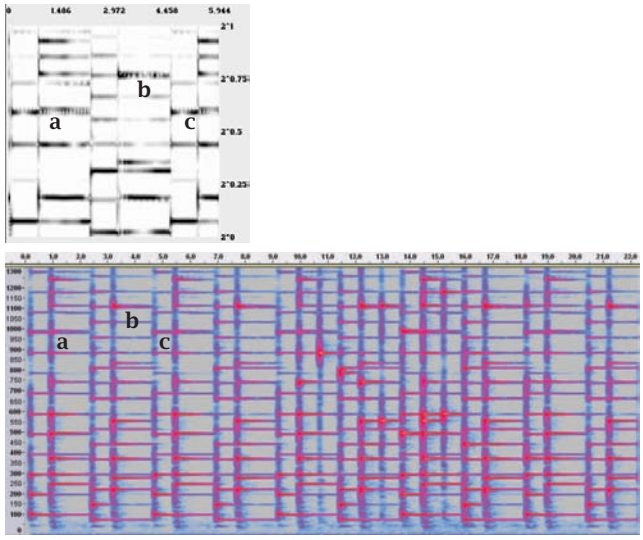


Figure 15. Bottom: Spectrogram of the beginning of "Gymnopédie I" by Erik Satie. Top: A zooming in on the first six seconds for frequencies between 650 Hz and 1300 Hz. There is beating at three places, marked a, b, c in both the scalogram and spectrogram. (A video for this figure is at (10), a larger graphic is at [101].)

the interplay of overtones would be enhanced if the system of *just intonation* were employed.

What Figures 15 and 5 illustrate is that we can use spectrograms and scalograms to produce a *quantitative measure* of the amount of beating in overtones. For example, *beating frequencies* can be easily read off from the spectrogram in Figure 5 and the scalogram in Figure 15. Furthermore, the intensity of the overtones that are "clashing" can be measured from the numerical data that those graphs are displaying. It is an interesting topic for future study: to measure these effects in the music of Debussy, for example, and compare the use of alternative systems of intonation.

The theory that beating in overtones creates a dissonant sound in music originated with Helmholtz [59], [47, Chap. 5]. Sethares's book [84] is an important reference relating Helmholtz's theory to a wide variety of different scales, including the pentatonic scale and Javanese gamelan music.

Percussion Scalograms

As described in [96, Chap. 6] and [20], scalograms can be used in conjunction with spectrograms to produce quantitative portraits of musical rhythm, called percussion scalograms. The theory behind percussion scalograms is described in detail in [20]. It is related to work of Smith [86, 87, 88]. Here we will only state the method. It consists of these two steps:

Step 1. Let $\{|C_{\ell,\nu}|^2\}$ be the spectrogram image. Calculate the average $\mu[|C|^2]$ over all frequencies at each time index ℓ:

$$\mu[|C|^2](\ell) = \frac{1}{N/2} \sum_{\nu=0}^{N/2-1} |C_{\ell,\nu}|^2, \tag{23}$$

and denote the time average of $\mu[|C|^2]$ by A:

$$A = \frac{1}{M+1} \sum_{\ell=0}^{M} \mu[|C|^2](\ell). \tag{24}$$

Then the pulse train $\{\mathcal{P}(\tau_\ell)\}$ is defined by

$$\mathcal{P}(\tau_\ell) = \mathbf{1}_{\{\tau_k : \mu[|C|^2](k) > A\}}(\tau_\ell), \tag{25}$$

where $\mathbf{1}_S$ is the indicator function for a set S ($\mathbf{1}_S(t) = 1$ when $t \in S$ and $\mathbf{1}_S(t) = 0$ when $t \notin S$). The values $\{\mathcal{P}(\tau_\ell)\}$ describe a pulse train whose intervals of 1-values mark off the position and duration of the percussive strikes.

Step 2. Compute a Gabor CWT of the pulse train signal $\{\mathcal{P}(\tau_\ell)\}$ from Step 1. This Gabor CWT provides an objective picture of the varying rhythms within a percussion performance.

When implementing this method, it is sometimes necessary to process the spectrogram by limiting its values to certain frequency bands (intervals of ν values), setting values of the spectrogram to 0 outside of such bands. We now show an example in which this leads to a precise analysis of the relationship between melody and rhythm. (A second example is discussed in [20, Example 6 on p. 355].)

Example 15 (Melody and rhythm in "Unsquare Dance")**.** In the 1961 Dave Brubeck Quartet's recording of "Unsquare Dance" [94], there is an amazing performance involving hand claps, piano notes, and bass notes all played in the unusual time signature of $\frac{7}{4}$. In Figure 16 we show our analysis of the melody and rhythm in a passage from "Unsquare Dance". We used three different frequency ranges from the spectrogram to isolate the different instruments from the passage. The passage begins with a transition from rapid drumstick strikings to hand clappings when the piano enters. The rhythm of the hand clappings plus piano notes has a $\frac{7}{4}$ time signature. Notice that the bass notes are playing with a simple repetition of 4 beats that helps the other musicians play within this unusual time signature. In sum, the analysis shown in Figure 16 provides quantitative evidence for the "tightness" (rhythmic coherence) with which these musicians are performing.

Summary. We gave a couple of examples of the use of scalograms and percussion scalograms in quantitatively analyzing musical performance in the work of Satie and Brubeck. These examples show the value of these techniques for analyzing pitch, rhythm, and overtone structure. We indicated a topic of future research on the music of Debussy, which we hope will yield techniques that can be applied to composition in general.

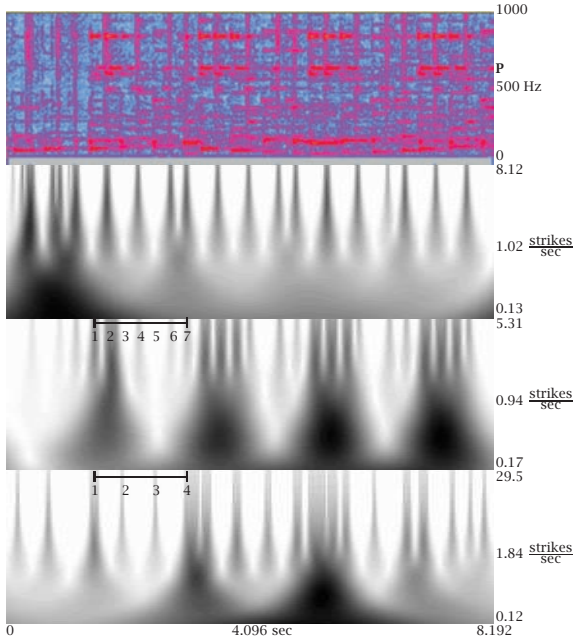


Figure 16. Melody and rhythm in a passage from "Unsquare Dance". *Top:* Spectrogram. P aligns with the piano notes. *Second from top:* Percussion scalogram of frequencies above 3000 Hz. Drumstick and hand clap percussion are emphasized. *Third from top:* Percussion scalogram of frequencies between 400 and 3000 Hz. Piano notes are emphasized. *Bottom:* Percussion scalogram of frequencies below 400 Hz. Bass notes are emphasized. Notice that the hand clapping interlaces with the piano notes—7 beats to a measure of 4 (marked off by the bass notes). (A video for this figure is at (10), a larger graphic is at [101].)

Quantifying Rhythmic Complexity

Article [20] introduced sequences of rest lengths between notes (percussive strikes). See Figure 17. This was done because the rests between notes are at least as important as the notes themselves. As the classical pianist Artur Schnabel said: "The notes I handle no better than many pianists. But the pauses between the notes — ah, that is where the art resides."[6]

We will now attempt to quantify the complexity of a sequence of rests, using ideas from information theory, such as *entropy.* Ideas from

[6] *To hear Artur Schnabel perform, go to the URL in* (10) *and click on the link* Artur Schnabel: Beethoven's Moonlight Sonata.

information theory have been applied extensively to musical analysis. A major landmark in the field is the book by Meyer [72], which, although not providing explicit formulas and quantitative methods, nevertheless set the stage for future work. The field is now vast. One place to search for more material is the online bibliography of Downie [42], which, besides covering the important practical application of using information theory to retrieve musical works from databases, also includes many papers on the general topic of information theory and music. If there is anything new in our approach, it would be the use of percussion scalograms derived from spectrograms of recorded music of extemporaneous, or improvisational, performances (as opposed to score analysis). In any case, we felt this work to be sufficiently interesting to include here, even if it is only a brief introduction to the relations between information theory and music.

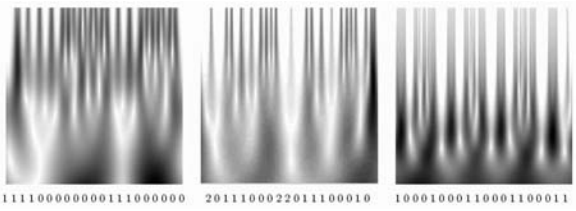


Figure 17. Percussion scalograms. Left: From "Dance Around". Middle: From "Welela". Right: From "Taxman" (bass notes only). Below each scalogram is the sequence of rests for the rhythmic sequence.

First, we review the basic notion of *entropy* from information theory [6, 29]. We assume that we have a stochastic source that emits sequences of symbols from a finite set $S = \{a_0, a_1, \ldots, a_n\}$ and p_k is the probability that the symbol a_k is emitted. The *entropy* E of the source is then measured in *bits* by the formula

$$\mathsf{E} = \sum_{k=0}^{n} p_k \log_2 \left(\frac{1}{p_k}\right). \tag{26}$$

The entropy E provides a greatest lower bound for the average number of bits per symbol that *any* uniquely decipherable encoding method could achieve in encoding the symbols from the source. In practice, a finite sequence of symbols would need to be encoded. By the law of large numbers, the *relative frequencies* of occurrence of the symbols $\{a_k\}$ will be converging to their probabilities, so the relative frequencies can be used in place of the theoretical probabilities $\{p_k\}$.

We will interpret an entropy value as indicating the magnitude of *complexity* of a finite sequence—the idea being that the higher the entropy, the more complex the sequence; hence the more bits it takes to encode the sequence. Using the term *complexity,* rather than *information,* allows us to avoid any connotations of *meaning* to our sequences of rests. Such connotations of *meaning* are generally irrelevant in information theory anyway—something being more complex has nothing to do with whether it is more or less meaningful.

We will now illustrate these ideas with a specific example of a rest sequence, the rest sequence from the "Dance Around" passage shown in Figure 17. The sequence is

(27) 1 1 1 1 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0.

For this sequence, we get relative frequencies of $p_0 = 12/14$ and $p_1 = 2/14$ for the rest symbols 0 and 1, respectively. Hence the entropy is $\mathsf{E} = 0.92$. We leave it as an exercise for the reader to check that for the rest sequence from the "Welela" passage shown in Figure 17, the entropy is $\mathsf{E} = 1.46$. These results seem to confirm our impression that the "Welela" sequence is more complex rhythmically than the "Dance Around" sequence.

However, there is more to it than that. In Table 1 we show our calculations of the entropy E for 10 different rhythmic passages from different genres of music. While the entries for E do seem to be consistent with the fact that African drumming is generally regarded as more rhythmically complex than rock drumming, we do notice that the value of E for "Dance Around" is fairly high. For instance, it is essentially the same as the "Taxman" sequence. But the "Taxman" sequence is

(28) 1 0 0 0 1 0 0 0 1 1 0 0 0 1 1 0 0 0 1 1,

which seems to be more complex than the "Dance Around" sequence in (27). Moreover, using the entropy E would give exactly the same values of $\mathsf{E} = 1$ for the following two sequences:

(29) 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1

(30) 0 0 1 1 1 0 0 0 1 0 0 0 1 1 1 1

Table 1. Complexity Measures E and C for Rhythmic Sequences

Title*	*Genre*	E	C
Wipe Out	*Rock*	0.57	0.54
Dance Around	*Rock*	0.92	0.68
Toad	*Rock*	0.90	0.81
What'd I Say	*R & B*	1.22	0.97
Taxman	*Rock*	0.99	0.98
African Drumming 1	*African*	1.24	1.13
African Drumming 2	*African*	1.42	1.14
Welela	*African*	1.46	1.23
African Drumming 3	*African*	1.46	1.44
Sing, Sing, Sing	*Jazz*	1.52	1.47

*Audio files and discography for these sequences are at the URL in (10).

But it seems clear that the second sequence is more complex rhythmically than the first.

To solve this problem, we introduce a second notion of entropy. The entropy E is based on one type of modeling of a stochastic source: the *memoryless* or Markov-0 source model [29, 13]. We now consider another model, the Markov-1 source model. In the Markov-1 model, we assume that the probabilities of emitting any given symbol will depend on what the previous emitted symbol was. These probabilities will be the *transition probabilities* between *states,* a state being the value of a symbol. The Markov-1 entropy, which we will denote by C, is then calculated by an expected value over all states of the entropies for these transition probabilities. Rather than give a precise formula, it is probably easier to just give an example.

Consider the sequence (29). To do our calculation, we must assume an initial state. Because 0 is the most common rest value in rhythm, we will always assume that the initial state is 0 (this involves appending a dummy symbol 0 to the beginning of the sequence). We then get probabilities of $p_0 = 9/16$ and $p_1 = 7/16$ of being, respectively, in state 0 and state 1 *prior to emitting another symbol.* The transition probabilities are

State 0 ($p_0 = 9/16$)		State 1 ($p_1 = 7/16$)	
$0 \to 0$:	$\frac{8}{9}$	$1 \to 0$:	$\frac{0}{7}$
$0 \to 1$:	$\frac{1}{9}$	$1 \to 1$:	$\frac{7}{7}$

and we then calculate the Markov-1 entropy C by

$$\mathsf{C} = p_0\mathsf{E}_0 + p_1\mathsf{E}_1,$$

where E_0 and E_1 are calculated from the transition probabilities for state 0 and 1, respectively. This yields $\mathsf{C} = (9/16)(.503258) + (7/16)(\log_2 1) = 0.28$, whereas for the sequence (30), we obtain $\mathsf{C} = 0.89$. These Markov-1 entropy values are more consistent with the apparent complexity of the two sequences.

In Table 1 we show our calculations of the Markov-1 entropy C for the 10 different rhythmic passages. These results seem promising. The African drumming sequences are measured as the most complex. That includes the jazz sequence from "Sing, Sing, Sing", which imitates African rhythm—and is one of the most famous drum sequences in jazz history, perhaps because of its complexity. The rock drumming sequences are less complex using this measure.

Obviously we have worked with only a very small sample of music. We intend to continue assembling more data, but we do find the results of interest and hope that this discussion will spur some further work by others as well. Working on other measures of complexity, such as contextual entropy, is another research path. By *contextual entropy* we mean the calculation of entropy based on a non-Markov description of the source. Symbols will be produced with probabilities that depend on what *context* the symbol is in. One set of contexts would be the levels of hierarchy of the rhythm. As discussed in [20], there is a more complete notation for rhythm sequences that includes grouping the notes into hierarchies. The level of hierarchy a symbol belongs to might then be used as the context for that symbol. This idea has the advantage that it may be able to incorporate the fact that *production* of rhythm sequences is *not* a Markov process.[7]

We have done a couple of preliminary calculations with the "Dance Around" and "Welela" rhythmic hierarchies reported in [20, Examples 1 and 2]. We found that this new complexity measure, based on single (memoryless) frequencies of the note lengths as well as contextual (hierarchical) groupings, gives complexities of 1.12 for the "Dance Around" sequence and 1.58 for the "Welela" sequence. The two sequences are now closer in complexity value, and this may reflect the possibility that this new measure may be taking into account some of the speed variations in the "Dance Around" drumming (as discussed in the caption of Figure 5 in [20]). We mention these results only to pique the reader's interest. If our speculations are borne out, then we shall describe our findings in more detail in a subsequent paper.

Summary. We have described some complexity measures for musical rhythm and done an initial study of their value in quantifying the complexity in different rhythmic styles. We will continue working on the relation between entropy measures of complexity and musical rhythm, as that work has just begun.

Concluding Remarks

We have introduced some exciting aspects of the relations between mathematics and music. The methods of Gabor transforms and continuous wavelet transforms were shown to provide a wealth of quantitative methods for analyzing music and creating new music. Readers who wish to learn more can find ample resources in the References.

[7] *The reason is similar to what Chomsky describes for phrase structure in language* [22, p. 22]*: "in English, we can find a sequence* $a + S_1 + b$*, where there is a dependency between* a *and* b*, and we can select as* S_1 *another sequence containing* $c + S_2 + d$*, where there is dependency between* c *and* d*, then select as* S_2 *another sequence of this form, etc." The parallel between English phrases and musical phrases* (*with* $S_1, S_2, \ldots$ *as* bridges) *is obvious.*

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WHAT IS...

an Oka Manifold?

Finnur Lárusson

The prototypical complex manifold is the complex plane $\mathbb{C}$. In three cases out of four we find something interesting by considering the class of complex manifolds X with "many" or "few" holomorphic maps $X \to \mathbb{C}$ or $\mathbb{C} \to X$. The trick, of course, is to come up with a fruitful interpretation of the words "many" and "few".

As undergraduates, most of us take a course in complex analysis on domains in $\mathbb{C}$. Many of the theorems proved in such a course extend to a class of manifolds called *Stein manifolds*. Stein manifolds play a fundamental role in higher-dimensional complex analysis and complex geometry, similar to affine varieties in algebraic geometry.

One of the many equivalent definitions of a Stein manifold X says, roughly speaking, that there are many holomorphic maps $X \to \mathbb{C}$, enough in fact to embed X as a closed complex submanifold of $\mathbb{C}^m$ for some m. Another is the famous Theorem B of H. Cartan that for every coherent analytic sheaf $\mathcal{F}$ on X, the cohomology groups $H^k(X, \mathcal{F})$ vanish for all $k \geq 1$. A third is a convexity property: there is a proper smooth function $X \to [0, \infty)$ which is strictly plurisubharmonic. Plurisubharmonicity is ordinary convexity weakened just enough to make it biholomorphically invariant. The equivalence of any two of these definitions is a deep theorem.

While it is nontrivial to interpret the word "many", the word "few" has a straightforward interpretation as "no nonconstant". A complex manifold X is *Brody hyperbolic* if every holomorphic map $\mathbb{C} \to X$ is constant. It turns out that the notion of Kobayashi hyperbolicity, equivalent to Brody hyperbolicity for compact manifolds but stronger in general, is more important. A complex manifold X is *Kobayashi hyperbolic* if there is a metric (a nondegenerate distance function) d on X such that $d(f(z), f(w)) \leq \delta(z, w)$ for all holomorphic maps f from the open unit disc $\mathbb{D} = \{z \in \mathbb{C} : |z| < 1\}$ to X, and all $z, w \in \mathbb{D}$. Here δ denotes the Poincaré distance on $\mathbb{D}$. Picard's little theorem says that the twice-punctured plane $\mathbb{C} \setminus \{0, 1\}$ is Brody hyperbolic; it is in fact Kobayashi hyperbolic.

Hyperbolicity problems in higher-dimensional complex geometry have been intensively studied in recent years. Many deep problems remain unsolved, some to do with a mysterious connection with arithmetic. S. Lang conjectured that a smooth complex projective variety defined over a number field K is Kobayashi hyperbolic if and only if it has only finitely many rational points over each finite extension of K. In the one-dimensional case, this is a celebrated theorem of G. Faltings.

It is only recently that a good notion of a complex manifold X having "many" holomorphic maps $\mathbb{C} \to X$ has emerged. The new notion has its origins in a seminal paper of M. Gromov, the 2009 Abel laureate, published in 1989 [2]. Gromov's ideas and results have been developed further over the past ten years, primarily by F. Forstnerič, partly in joint work with J. Prezelj. Forstnerič has proved the equivalence of over a dozen properties, saying, in one way or another, that a complex manifold is the target of many holomorphic maps from $\mathbb{C}$ [1]. He has named such manifolds *Oka manifolds*, after K. Oka, a pioneer in several complex variables. In the remainder of this article, we will motivate the definition of an Oka manifold, sketch what is known about them, and mention two major applications of the ambient theory.

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(What about the fourth class, of complex manifolds with "few" holomorphic maps to $\mathbb{C}$? Even if we interpret "few" as "no nonconstant", this class seems too big to be of interest. It contains all compact manifolds and a whole lot more.)

Runge and Weierstrass. The story begins with two well-known theorems of nineteenth-century complex analysis concerning a domain Ω in $\mathbb{C}$. The *Runge approximation theorem* says that if K is a compact subset of Ω with no holes in Ω, then every holomorphic map $K \to \mathbb{C}$ can be approximated, uniformly on K, by holomorphic maps $\Omega \to \mathbb{C}$. (By a holomorphic map $K \to \mathbb{C}$ we mean a holomorphic function on some open neighborhood of K.) The *Weierstrass theorem* says that if T is a discrete subset of Ω, then every map $T \to \mathbb{C}$ extends to a holomorphic map $\Omega \to \mathbb{C}$.

In the formative years of modern complex analysis, in the mid-twentieth century, these theorems were extended to higher dimensions, generalizing Ω to a Stein manifold S. The *Oka-Weil approximation theorem* replaces the topological condition that K have no holes in S with the subtle, nontopological condition that K be *holomorphically convex* in S. This means that for every $x \in S \setminus K$, there is a holomorphic function f on S with $|f(x)| > \sup_K |f|$. The *Cartan extension theorem*, on the other hand, generalises T to a closed complex subvariety of S and says that every holomorphic map $T \to \mathbb{C}$ extends to a holomorphic map $S \to \mathbb{C}$.

We usually consider these theorems as results about Stein manifolds, and of course they are, but we can also view them as expressing properties of the target $\mathbb{C}$. We can then formulate them for a general target. To avoid topological obstructions, which are not relevant here, we restrict ourselves to very special S, K, and T.

CAP and CIP. A complex manifold X satisfies the *convex approximation property* (CAP) if, whenever K is a convex compact subset of $\mathbb{C}^m$ for some m, every holomorphic map $K \to X$ can be approximated, uniformly on K, by holomorphic maps $\mathbb{C}^m \to X$. A complex manifold X satisfies the *convex interpolation property* (CIP) if, whenever T is a contractible subvariety of $\mathbb{C}^m$ for some m, every holomorphic map $T \to X$ extends to a holomorphic map $\mathbb{C}^m \to X$.

It is rather easy to see that CIP implies CAP. (This is not to say that the Cartan extension theorem implies the Oka-Weil approximation theorem: the proof that CIP implies CAP uses the Oka-Weil theorem.) Forstnerič's work contains a difficult, roundabout proof of the converse; no simple proof is known.

We define a complex manifold to be *Oka* if it satisfies the equivalent properties CAP and CIP.

Oka Properties. There are more than a dozen other so-called *Oka properties* that are nontrivially equivalent to CAP and CIP. If S is a Stein manifold and X is an Oka manifold, then every continuous map $f : S \to X$ can be deformed to a holomorphic map. If f is already holomorphic on a subvariety T of S, then the restriction $f|T$ may be kept fixed during the deformation. If f is already holomorphic on a holomorphically convex compact subset K of S, then the restriction $f|K$ may be kept arbitrarily close to being fixed during the deformation. All this can be done parametrically. If we have a family of maps f, depending continuously on a parameter in a compact subset P of $\mathbb{R}^k$, then the maps can be deformed with continuous dependence on the parameter. If the maps parameterized by a compact subset of P are already holomorphic on S, then they may be kept fixed during the deformation.

It follows that the inclusion $\mathcal{O}(S,X) \hookrightarrow C(S,X)$ is a weak homotopy equivalence. Here, the spaces $\mathcal{O}(S,X)$ of holomorphic maps and $C(S,X)$ of continuous maps $S \to X$ are endowed with the compact-open topology.

Examples. The "classical" examples of Oka manifolds, by renowned work of H. Grauert from around 1960, are complex Lie groups and their homogeneous spaces. Among other examples are the complement in $\mathbb{C}^n$ of an algebraic or a tame analytic subvariety of codimension at least 2, the complement in complex projective space of a subvariety of codimension at least 2, Hopf manifolds, Hirzebruch surfaces, and the complement of a finite set in a complex torus of dimension at least 2. A Riemann surface is Oka if and only if it is not hyperbolic. Our understanding of the geography of Oka manifolds is poor. For example, it is an open problem to determine which compact complex surfaces are Oka.

Gromov's Oka Principle. The most important sufficient condition for the Oka property to hold is ellipticity, introduced by Gromov in [2]. It is yet another way to say that a complex manifold X is the target of many holomorphic maps from $\mathbb{C}$. More precisely, X is *elliptic* if there is a holomorphic map $s : E \to X$, called a *dominating spray,* defined on the total space of a holomorphic vector bundle E over X, such that $s(0_x) = x$ and $s|E_x \to X$ is a submersion at 0_x for all $x \in X$. The theorem that ellipticity implies the Oka property is one version of Gromov's Oka principle.

A Stein manifold is elliptic if and only if it is Oka. There are no known examples of Oka manifolds that are not elliptic. So why focus on the Oka property rather than ellipticity? One reason is that the Oka property has good functorial properties that we cannot at present prove or disprove for ellipticity.

Model categories. There is abstract homotopy theory lurking in the background. The author has shown that the category of complex manifolds can be embedded into a model category in the sense of D. Quillen (roughly speaking, a category in which one can do homotopy theory) in such a way that a

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Professor of Mathematics

The Department of Mathematics at ETH Zurich (www.math.ethz.ch) invites applications for a faculty position in mathematics. Applications in the fields of algebra and topology are particularly welcome. We are looking for candidates with an outstanding research record and a proven ability to direct research work of high quality. Willingness to teach at all university levels and to participate in collaborative work both within and outside of ETH Zurich is expected.

In association with other members of the Department, the future professor will be responsible for teaching mathematics courses for students of mathematics, natural sciences and engineering. He or she will be expected to teach undergraduate level courses (German or English) and graduate level courses (English).

Please submit your application together with a curriculum vitae, a list of publications, the names of at least three referees, and a short overview of the research interests to the **President of ETH Zurich, Prof. Dr. Ralph Eichler, Raemistrasse 101, ETH Zurich, 8092 Zurich, Switzerland, (or via e-mail to faculty-recruiting@sl.ethz.ch), no later than April 15, 2010.** With a view toward increasing the number of female professors, ETH Zurich specifically encourages qualified female candidates to apply.

manifold is cofibrant if and only if it is Stein, and fibrant if and only if it is Oka.

Applications. The fact that the complement in $\mathbb{C}^n$, $n \geq 2$, of an algebraic subvariety of codimension at least 2 is Oka is a crucial ingredient in the proof of *Forster's conjecture* by Y. Eliashberg and Gromov, and by J. Schürmann. For each $n \geq 2$, Forster's conjecture identifies the smallest $N(n) = n + [n/2] + 1$ such that every n-dimensional Stein manifold embeds into $\mathbb{C}^{N(n)}$.

B. Ivarsson and F. Kutzschebauch have used Gromov's Oka principle, as developed by Forstnerič, to solve the *holomorphic Vaserstein problem* posed by Gromov [3]. They show that the inclusion of the ring of holomorphic functions on a contractible Stein manifold into the ring of continuous functions does not induce an isomorphism of K_1-groups, whereas by Grauert's Oka principle it does induce an isomorphism of K_0-groups. Here, amusingly, Gromov's Oka principle reveals a limitation of a more general Oka principle.

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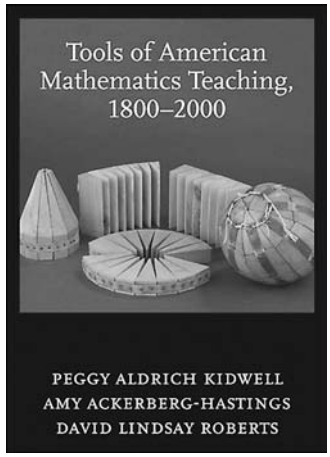
[1] F. Forstnerič, Oka manifolds, *C. R. Math. Acad. Sci. Paris* **347** (2009), 1017–20.
[2] M. Gromov, Oka's principle for holomorphic sections of elliptic bundles, *J. Amer. Math. Soc.* **2** (1989), 851–97.
[3] B. Ivarsson and F. Kutzschebauch, A solution of Gromov's Vaserstein problem, *C. R. Math. Acad. Sci. Paris* **346** (2008), 1239–43.

Tools of American Mathematics Teaching, 1800–2000



Reviewed by Andrew G. Bennett

Tools of American Mathematics Teaching, 1800–2000
Peggy Aldrich Kidwell, Amy Ackerberg-Hastings, and David Lindsay Roberts
Johns Hopkins University Press, July 2008
US$70.00, 440 pages
ISBN-13: 978-0801888144

With the advent of the calculator and computer, questions have been raised about whether we should continue to teach mathematics the way we always have, or if we would be better served by adjusting instruction to take advantage of the power of these new devices. *Tools of American Mathematics Teaching* makes clear that this is not a new question. Indeed, the whole notion of teaching the way we always have makes little sense. As this volume makes clear, tools and instruction have changed throughout history.

This volume is a museum exhibit in book form, based in part on a temporary exhibit on "Slates, Slide Rules, and Software: Teaching Math in America", at the National Museum of American History (part of the Smithsonian Institution). Sections of the book focus on tools with a common purpose (presentation, calculation, measurement, etc.) while individual chapters focus on specific types of tools (blackboards, slide rules, graph paper, calculators, etc.). The individual chapters provide historical context not just for the particular devices but also for the pedagogical ideas that underlie their use in the classroom, and sometimes short biographies of the key figures in their development and adoption. There are many illustrations and the coverage is quite broad. Museums and books are different beasts, however. The focus on things rather than ideas can be rather limiting. In most cases, the chapters look at a limited time period based on when the tools changed form, rather than following ideas through history. For example, the chapter on standardized testing finishes up in the mid-1920s. From a museum perspective this makes sense, since the basic form of the exams is now set and a patron won't see much of anything new looking at additional college entrance exams in glass exhibit cases. However, leaving off in the mid-1920s hides the major changes in standardized testing and how it was used during the twentieth century, which would easily have fit into the text. Other times the focus on tools leads to overemphasizing or underemphasizing ideas based on whether they created tangible objects rather than their importance to mathematics or education. B. F. Skinner and his theories are discussed since he created a visible tool, the Skinner box, but Piaget's ideas get only a brief mention since they don't come with an object to display. This is unfortunate since Piaget's ideas are more important for understanding the current controversies in how to teach mathematics, including the appropriate use of tools.

As you might expect, the chapters can profitably be browsed in any order, though occasionally references are made to ideas introduced in other chapters, not always in order (for instance, "Pestalozzian ideals" are mentioned in chapter 1 but not defined until chapter 6, with additional discussion in chapters 8, 9, and 10). However, reading the book through you do get a sense of the broad themes of educational development over the last two centuries, both in general pedagogy and in specific approaches to mathematics.

An interesting aspect of the book is that it points out that the tools we take for granted—the textbook, the blackboard, graph paper, etc.—all have a history, and we used to do without them. Improvements in production and printing made it

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feasible for all children in a school to have their own textbooks. Along with the introduction of the large blackboard in place of the hand slate, this made possible new approaches where students worked problems from the book on the board for all to see. Soon this led to larger (and cheaper) classes mixing lecture with recitation, where students recited from the book. Some mathematics teachers recognized the need for a series of textbooks that students could use to build mathematical ideas over a series of classes. While America has never had an official national curriculum, the common textbook series have provided the basic outlines of a standard curriculum used across the country. In the uniquely American way, this curriculum has been shaped as much by entrepreneurs looking to profit from book sales as by pedagogical concerns, and the reader will recognize the names of some of the early publishers whose companies are still sending textbook representatives to visit us today.

Cheaper paper and printing also made it feasible to supply school children with prepared graph paper. While engineers made use of ruled paper for surveying and design in the nineteenth century, this was a specialty product and wasn't typically used in schools until early in the twentieth century. Prepared graph paper made it more reasonable to cover graphical ideas in algebra texts. Given the large role graphing plays in algebra classes today, it is striking that the first American algebra text to include graphical treatments was published in 1902, when graph paper was available.

Not all tools led to lasting changes. The overhead projector was developed to help nineteenth-century public lecturers share their slides with a large audience eager to hear about expeditions to faraway lands. While there were hopes that the ability to use prepared illustrations in class would greatly improve classroom attention, the biggest advantage the overhead actually delivered was to let the teacher face the class. The book devotes a chapter to cube root blocks, a dissected cube that could be used to illustrate the algebraic identities underlying the standard algorithm for the arithmetic extraction of cube roots. Despite these demonstrations, the students still found the process difficult and confusing. Since in practice one would use logarithms and/or tables if a cube root was needed, and from a theoretical standpoint the Newton-Raphson algorithm had more to offer, the tool and eventually the entire topic would disappear from the elementary curriculum.

Manipulatives for students to use to build conceptual ideas of numbers are often associated with recent "reform" curricula, but actually have a long history. The ideas of Pestalozzi and later Montessori on early childhood education supported the development of tools to help students visualize numbers and experiment with different ways of combining smaller numbers to make the same sum. These lead in a straight line to the modern Cuisenaire rods, unifix cubes, and base 10 blocks. As children progress, it is natural to move from counting specific objects to a number frame or abacus. Oddly, the early number frames usually featured twelve beads to a wire instead of ten. And, just as today, there were opponents to "object teaching". An 1835 pamphlet[1] "On the Dangerous Tendency to Innovation and Extremes in Education" has much that would fit easily into the current math wars, with complaints about textbooks being "adapted to please rather than to profit" and worries that the students would have difficulty later when studying more abstract topics.

Another situation where history repeats itself is in the discussion of the metric system. I have always found it odd that measurement is usually considered part of the mathematics curriculum, since mathematicians are not experimentalists and usually don't have a talent for measurement. While I presumed measurement fit into the mathematics curriculum because of rounding, it appears it actually entered as an attempt to get students to understand the metric system. Since mathematics has always been taught much more broadly than science, it made much more sense to teach the metric system as a mathematics unit if the goal was to prepare the whole community to adopt a new system. The text shows various demonstration materials that were intended to aid students in getting a sense of what a meter or liter or kilogram meant. However, as we know, the big push for the metric system in the 1970s was mostly a failure. What I didn't know is that there was an earlier push in the 1870s, which was also mostly a failure. The authors quote a Philadelphia editor in 1882: "Easy as it might be to furnish us with rules and sticks graduated off in metres and their parts and with measuring glasses and weights accurately made … it would be by no means so easy to furnish us with the mental standards of reference which our English feet, inches, and yards have become, after years of intimate knowledge of them." The same editorial could have run a century later. The main effect of this early effort to teach the metric system was to solidify measurement as part of the mathematical curriculum, and to ensure that students now all head off to school with a ruler, though for feet instead of centimeters. Perhaps in 2070 America will finally be ready to convert to the metric system.

The final section on electronic devices is by far the weakest of the book. The authors note that it is difficult to write a history of electronic

[1] *Winslow Hubbard,* On the Dangerous Tendency to Innovations and Extremes in Education*, Tuttle & Weeks, Boston, MA, 1835. A copy of this work is in vol. 16 of the Benjamin Silliman Miscellaneous Pamphlets, Beinecke Library, Yale University, New Haven, CT.*

aids at this time because of the lack of historical perspective. With the focus on tools, there are too many examples covered too quickly to do justice to the big ideas. These tools also fit awkwardly in the framework the authors use. Since computers are used for both presentation and calculation, they don't fit neatly into either section. The authors have therefore decided to put electronic devices into their own section. This means early teaching machines and programmed instruction (such as the Skinner box) are discussed in chapter 5 while computer-aided instruction and other natural descendants aren't discussed until chapter 16. This section should be where the ideas introduced earlier come together to provide a context for understanding the current issues in how we should use tools (or not use tools) in teaching. Unfortunately, the focus on tools rather than ideas gets in the way of developing such a synthesis.

The writers have done a lot of research, with eighty-four pages of footnotes for 317 pages of text. Their research is historical and not mathematical, and the only equation in the text is one reference to $f(x, y) = 0$. There are a few places where I wish they had included a bit more technical detail. For example, in the section on the protractor there is a picture of a Ramsden dividing engine capable of marking a large protractor in divisions as small as five seconds. I was intrigued as to how the machine accomplished such a feat, but the text offered no discussion of this. However, there was enough historical detail given that it was easy to look up information online to find out how the engine worked. The indexing is well done, and when I did encounter references in one section that I vaguely recalled from another section, I didn't find it too hard to track them down.

The book is quite attractive with its many pictures, though they are all in black and white. It would be a nice addition to a department common room or undergraduate lounge, particularly given the format that provides a few pages of description for many different tools, making it a good book for browsing. For the serious student of the history of mathematics education or educational technology, or even the general history of mathematics, this volume provides much information unavailable elsewhere, and, because of that, I believe this is a book that belongs in your university library. However, I find myself unconvinced by the authors' claim that the history of mathematics education "is best understood by considering the stories of specific teaching tools." Such an approach is better suited to a museum than a book. This is an excellent book about the history of teaching tools, but just a good book on the history of mathematics education.

ASSISTANT PROFESSOR

Department of Mathematics

The Department of Mathematics invites applications for a tenure-track position at the Assistant Professor level in the general area of Modern Analysis, with the appointment to begin on August 16, 2010. We are particularly interested in multivariate operator theory and analysis on function spaces however, we are also interested in other major areas of modern analysis. Candidates must possess a doctoral degree in mathematics or a closely related field by August 16, 2010. Experience in teaching and research is expected.

Applicants should apply online at **https://facultyjobs.ua.edu**; attach a curriculum vita along with a letter of application and arrange for three letters of recommendation to be sent to: Chair of the Search Committee, Department of Mathematics, The University of Alabama, Tuscaloosa, AL 35487-0350. Applications will be reviewed on an ongoing basis and will continue to be accepted until the position is filled. For more information about the department and the university visit our website at **http://math.ua.edu**

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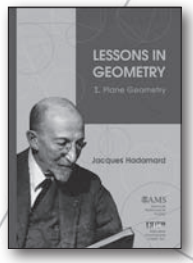

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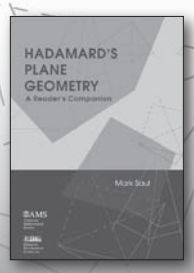

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Kalman Receives National Medal of Science

Rudolf Kalman receiving National Medal of Science from President Barack Obama.

Rudolf Kalman has received the 2008 National Medal of Science, the highest honor the United States gives for scientific achievement. President Barack Obama honored Kalman and eight other medalists in an awards ceremony at the White House on October 7, 2009.

The Work of Rudolf Kalman

The *Notices* asked Eduardo Sontag of Rutgers University, a Ph.D. student of Rudolf Kalman, to describe briefly Kalman's achievements. Sontag writes:

"Among Kalman's early work was the development of what is now called the Kalman filter for detection of signals in noise. This revolutionized the field of estimation, by providing a recursive approach to the filtering problem. Before the advent of the Kalman filter, most mathematical work was based on Norbert Wiener's ideas, but the 'Wiener filtering' had proved difficult to apply. Kalman's approach, based on the use of state space techniques and a recursive least-squares algorithm, opened up many new theoretical and practical possibilities. The impact of Kalman filtering on all areas of applied mathematics, engineering, and sciences has been tremendous. It is impossible to even begin to enumerate its practical applications. Just as examples of their diversity, one may mention the guidance of the Apollo spacecraft and of commercial airplanes, uses in seismic data processing, nuclear power plant instrumentation, and demographic models, as well as applications in econometrics.

"During the 1960s, Kalman was the leader in the development of a rigorous theory of control systems. He formulated and clarified a number of fundamental notions, such as controllability, observability, and minimality, that are nowadays central to the theory. During the 1970s, he played a major role in the introduction of sophisticated mathematical techniques in the study of linear as well as nonlinear systems, in the former area pioneering the study of moduli spaces of linear systems and in the latter introducing the view of internal states as spectra of observation algebras. His recent work has concentrated on a system-theoretic approach to the foundations of statistics and identification, as well as on classical problems of passive network synthesis."

Biographical Sketch

Rudolf Kalman was born on May 19, 1930, in Budapest. He obtained a bachelor's degree (1953) and a master's degree (1954) from the Massachusetts Institute of Technology, and a D. Sci. degree (1957) from Columbia University, all in electrical engineering.

Kalman worked as a research mathematician at RIAS (the Research Institute for Advanced Study, in Baltimore) from 1958 until 1964. He subsequently became a professor at Stanford University (1964–1971) and later a graduate research professor jointly in the departments of mathematics,

electrical engineering, and industrial and systems engineering at the University of Florida, where he also established the Center for Mathematical System Theory, directing it until his retirement in 1992. In 1973, he was elected to an *ad personam* chair in mathematical system theory at the Eidgenössisches Technische Hochschule in Zürich, a position he held until compulsory retirement in 1997.

Kalman is a member of the U.S. National Academy of Sciences, the U.S. National Academy of Engineering, and the American Academy of Arts and Sciences. He is also a foreign member of the Hungarian, French, and Russian Academies of Science and is the holder of many honorary doctorates. He was awarded the IEEE Medal of Honor in 1974, the IEEE Centennial Medal in 1984, the Inamori Foundation's Kyoto Prize in High Technology in 1985, the AMS Steele Prize in 1987, the Richard E. Bellman Control Heritage Award in 1997, and the NAE Charles Stark Draper Prize in 2008.

About the National Medal of Science

Awarded annually and administered for the White House by the National Science Foundation, the National Medal of Science celebrated its fiftieth anniversary since being created by statute in 1959. The Medal recognizes individuals who have made outstanding contributions to science and engineering, based on their advanced knowledge in, and contributions to, the biological, behavioral/social and physical sciences, as well as chemistry, engineering, computing and mathematics.

—Allyn Jackson

About the Cover

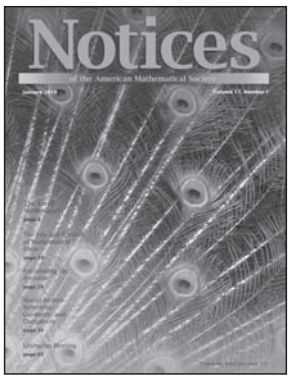
Creativity issue

This issue is dedicated to mathematics and its interaction with art. The peacock's tail is intended to represent this symbiosis.

The cover photo was taken by mathematician-photographer Geir Arne Hjelle at De Apenheul zoo just outside Apeldoorn, Netherlands.

The cover image was composed using GIMP (GNU Image Manipulation Program) freeware. See `http://www.gimp.org/`. The cover concept and design are by Geir Arne Hjelle and Marie Taris.

—Steven G. Krantz



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Mathematics People

Mahadevan Receives MacArthur Fellowship

L. MAHADEVAN of Harvard University is among twenty-four new MacArthur Fellows for 2009. Each fellow will receive a grant of US$500,000 in "no strings attached" support over the next five years.

L. Mahadevan uses mathematics to investigate simple-sounding but complex questions across the physical and biological sciences, such as how cloth folds when draped, how skin wrinkles, how flags flutter, and how Venus flytraps snap closed. Through his explorations of shape and motion in many different material types, sizes, and time frames, Mahadevan strives to identify commonalities of the fundamental nonlinear and nonequilibrium behavior driving them. One line of his research considers the relationship between the biochemistry and mechanics of structural molecules that form polymers, such as actin, within the cell. These investigations have parallels in his work on the hydrodynamics and elasticity of thin films and sheets (e.g., made of fabric). Mahadevan also considers properties of materials at larger scales, such as cell shape, adhesion, and migration in developmental biology, avalanche dynamics, or the role of water in determining the tensile characteristics of plants. Though he searches for and elucidates mathematical principles underpinning these complex behaviors, his focus remains on developing hypotheses that can be confirmed or rejected empirically in the lab. The unusually broad scope of his theoretical and experimental investigations defies facile categorization, but they are linked by an effort to discover the geometric and mechanical principles that determine the behavior of complex biological and physical systems.

L. Mahadevan received a B.Tech. degree (1986) from the Indian Institute of Technology in Madras, an M.S. (1987) from the University of Texas at Austin, and an M.S. (1992) and Ph.D. (1995) from Stanford University. Since 2003 he has been affiliated with Harvard University, where he is currently the De Valpine Professor of Applied Mathematics. He served previously as an assistant and associate professor (1996–2000) in the Department of Mechanical Engineering at Massachusetts Institute of Technology and as the Schlumberger Professor of Complex Physical Systems (2001–2003) in the Department of Applied Mathematics and Theoretical Physics and a fellow of Trinity College at the University of Cambridge. He holds visiting professorships at the University of Oxford's Mathematics Institute and the National Center for Biological Sciences in Bangalore, India.

The MacArthur Fellows Program awards unrestricted fellowships to talented individuals who have shown extraordinary originality and dedication in their creative pursuits and a marked capacity for self-direction. There are three criteria for selection of Fellows: exceptional creativity, promise for important future advances based on a track record of significant accomplishment, and potential for the fellowship to facilitate subsequent creative work.

—From a MacArthur Foundation announcement

Bringmann Awarded 2009 SASTRA Ramanujan Prize

KATHRIN BRINGMANN of the University of Cologne and the University of Minnesota has been awarded the 2009 SASTRA Ramanujan Prize. This annual prize is for outstanding contributions to areas of mathematics influenced by the Indian genius Srinivasa Ramanujan. The age limit for the prize has been set at thirty-two because Ramanujan achieved so much in his brief life of thirty-two years. The prize carries a cash award of US$10,000.

The 2009 SASTRA Ramanujan Prize Citation reads as follows: "Kathrin Bringmann is awarded the 2009 SASTRA Ramanujan Prize for her outstanding research on modular forms and mock theta functions, by herself and in collaboration with several mathematicians, in which important connections between mock theta functions and the theory of modular forms initially observed by Sander

Zwegers are analyzed and established explicitly, questions concerning asymptotics and congruences are addressed, and a comprehensive theory relating holomorphic cusp forms to Maass forms is developed. The prize recognizes her outstanding Ph.D. thesis of 2004 dealing with applications of Poincaré series on Jacobi groups, the results of which were published in *Mathematische Zeitschrift* (2006) and the *Journal of the London Mathematical Society* (2006); her path-breaking paper with Ken Ono in the *Annals of Mathematics* that builds on work of Sander Zwegers and Don Zagier and shows that Ramanujan's twenty-two mock theta functions are special cases of infinite families of weak Maass forms of weight ½; her seminal paper with Ono in *Inventiones Mathematicae* (2006) in which exact formulas for the coefficients of one of Ramanujan's third-order mock theta functions is obtained, the consequence of which is the resolution of the forty-year-old Andrews-Dragonnette conjecture; another landmark paper with Ono in the *Proceedings of the National Academy of Sciences USA* (2007) on lifts of homomorphic cusp forms of half integral weight to harmonic weak Maass forms, which leads to an understanding of all of Ramanujan's mock theta functions; and her fundamental paper in the *Journal of the American Mathematical Society* (2008), with Ono and Robert Rhoades, explaining the Eulerian identities associated with the mock theta conjectures of George Andrews and Frank Garvan. The prize also recognizes her significant collaborations with Frank Garvan and Karl Mahlburg on partition statistics and quasi-harmonic Maass forms, published in *International Mathematics Research Notices* (2008); her work with Amanda Folsom and Ono on q-series and weight 3/2 Maass forms, in *Compositio Mathematica* (2009); her recent work with Sander Zwegers on rank-crank type partial differential equations and nonholomorphic Jacobi forms, in *Mathematics Research Letters*; and her collaboration with Jeremy Lovejoy, which includes their joint paper in *International Mathematics Research Notices* (2007) on Dyson's rank, over partitions and weak Maass forms."

Kathrin Bringmann was born on May 8, 1977, in Muenster, Germany. She passed the State Examinations in Mathematics and Theology at the University of Würzburg, Germany, in 2002, and obtained a Diploma in Mathematics with top honors at Würzburg in 2003. She then joined the University of Heidelberg, where she received her Ph.D. in 2004 under the direction of Professor Winfried Kohnen. From 2004 to 2007 she was Van Vleck Assistant Professor at the University of Wisconsin, where she began her great collaboration with Ken Ono. After briefly serving as an assistant professor at the University of Minnesota, she recently joined the University of Cologne, Germany, as professor. Earlier this year she was awarded the prestigious Krupp Prize, a one-million-euro research grant for a five-year period awarded to young professors.

The 2009 SASTRA Ramanujan Prize Committee consisted of Krishnaswami Alladi (chair), Bruce Berndt, Jonathan Borwein, Dorian Goldfeld, Stephen Milne, Wolfgang Schmidt, and Jeffrey Vaaler. Previous recipients of the SASTRA Ramanujan Prize are Manjul Bhargava and Kannan Soundararajan (2005), Terence Tao (2006), Ben Green (2007), and Akshay Venkatesh (2008).

—From a SASTRA Ramanujan Prize announcement

Lytchak Awarded von Kaven Prize

ALEXANDER LYTCHAK of Mathematisches Institut, University of Bonn, has been awarded the 2009 von Kaven Prize in Mathematics of the von Kaven Foundation, which is administered by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation). The prize carries a cash award of 10,000 euros (approximately US$15,000).

Lytchak was honored for his outstanding work in the area of differential geometry, particularly singular Riemannian foliations, his major research area. The prize citation says that Lytchak is full of ideas and is versatile, with strong communication skills. He received his Ph.D. in 2001 from the University of Bonn and his *Habilitation* in 2008. He currently holds a Heisenberg Fellowship.

The von Kaven prize is funded from the proceeds of the von Kaven Foundation, which was established in December 2004 by mathematician Herbert von Kaven, who died in the summer of 2009 at the age of 101.

—From a DFG announcement

NSF Postdoctoral Fellowships Awarded

The Mathematical Sciences Postdoctoral Research Fellowship program of the Division of Mathematical Sciences (DMS) of the National Science Foundation (NSF) awards fellowships each year for postdoctoral research in pure mathematics, applied mathematics and operations research, and statistics. Below are the names of the fellowship recipients for 2009, together with their Ph.D. institutions (in parentheses) and the institutions at which they will use their fellowships.

DAVID ANDERSON (University of Michigan), University of Washington; JEFFREY ARISTOFF (Massachusetts Institute of Technology), Princeton University; ASHER AUEL (University of Pennsylvania), Emory University; DAVID AYALA (Stanford University), Harvard University; MICHAEL BATEMAN (Indiana University), University of California Los Angeles; MICHAEL BAYM (Massachusetts Institute of Technology), Harvard Medical School; JACOB BERNSTEIN (Massachusetts Institute of Technology), Stanford University; IAN BIRINGER (University of Chicago), Yale University; JONAH BLASIAK (University of California Berkeley), University of Chicago; MARK BLUNK (University of California Los Angeles), University of British Columbia; CHRISTINE BREINER (Johns Hopkins University), Massachusetts Institute of Technology; EMMA BRUNSKILL (Massachusetts Institute of Technology), University of California Berkeley; LYUBOV CHUMAKOVA (New York University), Massachusetts

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Two Assistant Professorships in Mathematics

The Department of Mathematics at ETH Zurich (www.math.ethz.ch) invites applications for qualified candidates from all areas of mathematics. Duties of these positions include, in addition to research, an active participation in teaching courses of mathematics for students of mathematics, natural sciences, and engineering.

Candidates should have a Ph.D. or equivalent and have demonstrated the ability to carry out independent research work. Willingness to teach at all university levels and to participate in collaborative work both within and outside of ETH Zurich is expected. The successful candidates will teach undergraduate level courses (German and English) and graduate level courses (English).

Assistant professorships have been established to promote the careers of younger scientists. The initial appointment is for four years with the possibility of renewal for an additional two-year period.

Please submit your application together with a curriculum vitae and a list of publications **to the President of ETH Zurich, Prof. Dr. Ralph Eichler, ETH Zurich, Raemistrasse 101, 8092 Zurich, Switzerland (or via e-mail to faculty-recruiting@sl.ethz.ch), no later than February 28, 2010.** With a view toward increasing the number of female professors, ETH Zurich specifically encourages female candidates to apply.

Institute of Technology; JULIANNE CHUNG (Emory University), University of Maryland; BRIAN CLARKE (University of Leipzig), Stanford University; KEVIN COSTELLO (Rutgers University), Georgia Institute of Technology; ANDREW COTTON-CLAY (University of California Berkeley), Massachusetts Institute of Technology; RICHARD CUDNEY (University of Chicago), Harvard University; MICHAEL DAMRON (New York University), Princeton University; MATTHEW DOBSON (University of Minnesota), École National des Ponts et Chaussees; XANDER FABER (Columbia University), McGill University; EMILY FOX (Massachusetts Institute of Technology), University of California Berkeley; JOHN FRANCIS (Massachusetts Institute of Technology), Northwestern University; JOSH GREENE (Princeton University), Columbia University; WEI HO (Princeton University), Harvard University; STACY HOEHN (University of Notre Dame), Vanderbilt University; PETER HORN (Rice University), Columbia University; VALERIE HOWER (University of Georgia), University of California Berkeley; MATHEW JOHNSON (University of Illinois, Urbana-Champaign), Indiana University; PAUL JOHNSON (University of Michigan), Princeton University; KENNETH KAMRIN (Massachusetts Institute of Technology), Harvard University; AARON MAGID (University of Michigan), University of Maryland; CHRISTOPHER MANON (University of Maryland), University of California Berkeley; ADAM MARCUS (Georgia Institute of Technology), Yale University; MAKSIM MAYDANSKIY (Massachusetts Institute of Technology), Stanford University; AARON NABER (Princeton University), Massachusetts Institute of Technology; MICHAEL NEILAN (University of Tennessee), Louisiana State University; ANDREW OBUS (University of Pennsylvania), Columbia University; LILLIAN PIERCE (Princeton University), Institute for Advanced Study; JOSEPH RABINOFF (Stanford University), Massachusetts Institute of Technology; ROBERT RHOADES (University of Wisconsin), Stanford University; GRIGOR SARGSYAN (University of California Berkeley), University of California Los Angeles; CHRISTOPHER SCHOMMER-PRIES (University of California Berkeley), Harvard University; RUSSELL SCHWAB (University of Texas at Austin), Carnegie Mellon University; MICHAEL SHULMAN (University of Chicago), University of Chicago; ANDREW SNOWDEN (Princeton University), Stanford University; NOAH SNYDER (University of California Berkeley), Columbia University; LINDSAY STOVALL (University of California Berkeley), University of California Los Angeles; PETER TINGLEY (University of California Berkeley), Massachusetts Institute of Technology; DAVID UMINSKY (Boston University), University of California Los Angeles; PAUL VALIANT (Massachusetts Institute of Technology), University of California Berkeley; MICHAEL VAN VALKENBURGH (University of California Los Angeles), University of California Berkeley; DAVID VELA-VICK (University of Pennsylvania), Columbia University; VINCENT VU (University of California Berkeley), Carnegie Mellon University; RACHEL WARD (Princeton University), Courant Institute, New York University; PHILIP WOOD (Rutgers University), University of California Los Angeles.

—NSF announcement

Mathematics Opportunities

Proposal Due 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 proposal due dates for the year 2010. Please refer to the program announcement or contact the program director for more information.

December 15, 2009 (full proposal): Computational Mathematics

January 13, 2010 (full proposal): Mathematical Biology

January 28, 2010 (full proposal): Scientific Computing Research Environments for the Mathematical Sciences (SCREMS)

February 11, 2010 (full proposal): Interdisciplinary Training for Undergraduates in Biological and Mathematical Sciences (UBM)

February 20, 2010 (full proposal): Interdisciplinary Grants in the Mathematical Sciences (IGMS)

June 2, 2010 (full proposal): University-Industry Cooperative Research Programs in the Mathematical Sciences

June 4, 2010 (full proposal): Research Experiences for Undergraduates (REU)

June 15, 2010 (full proposal): Workforce Program in the Mathematical Sciences

July 22, 2010 (full proposal): Faculty Early Career Development (CAREER) Program

August 20, 2010 (letter of intent): Focused Research Groups (FRG) in the Mathematical Sciences

August 26, 2010 (full proposal): Conferences, Workshops, and Special Meetings in the Mathematical Sciences

September 17, 2010 (full proposal): Focused Research Groups (FRG) in the Mathematical Sciences

October 5, 2010 (full proposal): Algebra, Number Theory and Combinatorics; Analysis; Foundations

For further information see the website `http://www.nsf.gov/funding/pgm_list.jsp?org=DMS&ord=date`. 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 the DMS website

NDSEG Fellowships

As a means of increasing the number of U.S. citizens trained in disciplines of military importance in science and engineering, the Department of Defense (DoD) awards National Defense Science and Engineering Graduate (NDSEG) Fellowships each year to individuals who have demonstrated ability and special aptitude for advanced training in science and engineering. The fellowships are awarded for a period of three years for study and research leading to doctoral degrees in mathematical, physical, biological, ocean, and engineering sciences. Approximately two hundred fellowships will be awarded in 2010.

The NDSEG Fellowship Program is open only to applicants who are citizens or nationals of the United States. NDSEG Fellowships are intended for students at or near the beginning of their graduate studies in science or engineering. Applicants must have received or be on track to receive their bachelor's degrees by fall of 2010. Fellows selected in spring 2010 must begin their fellowship tenure in fall 2010. Fellowships are tenable only at U.S. institutions of higher education offering doctoral degrees in the scientific and engineering disciplines specified. Fellows will receive full tuition and stipends for 12-month tenures: US$30,500 for the first year, US$31,000 for the second year, and US$31,500 for the third year. Applications are encouraged from women, persons with disabilities, and minorities, including members of ethnic minority groups such as African American, American Indian and Alaska Native, Asian, Native Hawaiian and other Pacific Islander, Hispanic, or Latino.

Complete applications must be submitted electronically by **January 4, 2010**. Application forms are available online

at http://ndseg.asee.org/apply_online. For further information, see http://ndseg.asee.org/.

—From an NDSEG announcement

National Academies Research Associateship Programs

The Policy and Global Affairs Division of the National Academies is sponsoring the 2010 Postdoctoral and Senior Research Associateship Programs. The programs are meant to provide opportunities for Ph.D., Sc.D., or M.D. scientists and engineers of unusual promise and ability to perform research at more than one hundred research laboratories throughout the United States and overseas.

Full-time associateships will be awarded for research in the fields of mathematics, chemistry, earth and atmospheric sciences, engineering, applied sciences, life sciences, space sciences, and physics. Most of the laboratories are open to both U.S. and non-U.S. nationals and to both recent doctoral recipients and senior investigators. Amounts of stipends depend on the sponsoring laboratory. Support is also provided for allowable relocation expenses and for limited professional travel during the period of the award.

Awards will be made four times during the year: in February, May, August, and November. The deadline for application materials to be postmarked or for electronic submissions for the February 2010 review is **February 1, 2010**. Materials for the May review are due **May 1, 2010**; for the August review, **August 1, 2010**; and for the November review, **November 1, 2010**.

For further information and application materials, see the National Academies website at http://sites.nationalacademies.org/PGA/RAP/PGA_050491 or contact Research Associateship Programs, National Research Council, Keck 568, 500 Fifth Street, NW, Washington, DC 20001; telephone 202-334-2760; fax 202-334-2759; email: rap@nas.edu.

—From an NRC announcement

AMS-AAAS Mass Media Summer Fellowship

The American Association for the Advancement of Science (AAAS) sponsors the Mass Media Science and Engineering Summer Fellows Program, through which graduate students work during the summer in major media outlets. The AMS provides support each year for a graduate student in the mathematical sciences to participate in the program. In past years the AMS-sponsored fellows have held positions at *Scientific American, Business Week*, Voice of America, Discovery Channel Online, National Geographic Television, *Popular Science, The Chicago Tribune*, and *Time* magazine.

Fellows receive a weekly stipend of US$450 plus travel expenses to work for ten weeks during the summer as reporters, researchers, and production assistants in media organizations. They observe and participate in the process by which events and ideas become news, improve their ability to communicate about complex technical subjects in a manner understandable to the public, and increase their understanding of editorial decision making and of how information is effectively disseminated. Each fellow attends an orientation and evaluation session in Washington DC and begins the internship in mid-June. Fellows submit interim and final reports to AAAS. A wrap-up session is held at the end of the summer.

Mathematical sciences faculty are urged to make their graduate students aware of this program. The deadline to apply for fellowships for the summer of 2010 is **January 15, 2010**. Further information about the fellowship program and application procedures is available online at http://www.aaas.org/programs/education/MassMedia/index.shtml, or applicants may contact Stacey Pasco, Manager, Mass Media Program, AAAS Mass Media Science and Engineering Fellows Program, 1200 New York Avenue, NW, Washington, DC 20005; telephone 202-326-6441; fax 202-371-9849; email: spasco@aaas.org. Further information is also available at http://www.ams.org/government/massmediaann.html and through the AMS Washington Office, 1527 Eighteenth Street, NW, Washington, DC 20036; telephone 202-588-1100; fax 202-588-1853; email: amsdc@ams.org.

—AMS Washington Office

AWM Essay Contest

To increase awareness of women's ongoing contributions to the mathematical sciences, the Association for Women in Mathematics (AWM) is holding an essay contest for biographies of contemporary women mathematicians and statisticians in academic, industrial, and government careers.

The essays will be based primarily on interviews with women who are currently working in mathematical sciences careers. The contest is open to students in the following categories: 6th–8th grades, 9th–12th grades, and college undergraduates. At least one winning submission will be chosen from each category. Winners will receive a prize, and their essays will be published online at the AWM website. A grand prize winner will have his or her submission published in the *AWM Newsletter* as well. The deadline for entries is **February 27, 2010**.

In addition to student entries, organizers are currently seeking women mathematicians to volunteer as the subjects of these essays. For more information, see http://www.awm-math.org/biographies/contest.html.

—From an AWM announcement

Departments Again Coordinate Job Offer Deadlines

A group of mathematical sciences departments has adopted an agreement to coordinate deadlines for acceptance of postdoctoral job offers for jobs that begin in the fall of 2010. 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 and not tenure-track positions, and only to applicants who are two years or less past the Ph.D. The departments have agreed not to require these applicants to decide about a job offer before Friday, February 5, 2010. The NSF has already agreed that it will complete its review of applications by January 26, 2010, at the latest. The list of participating departments, together with additional information, may be found on the Web at `http://www.ams.org/employment/postdoc-offers.html`.

—AMS Career Services announcement

News from the Fields Institute

The 2010 winter/spring thematic program at the Fields Institute will be Quantitative Finance: Foundations and Applications. Four workshops will be held:

Workshop on Foundations of Mathematical Finance, January 11–15, 2010

Workshop on Computational Methods in Finance, March 22–24, 2010

Workshop on Financial Econometrics, April 23–24, 2010

Workshop on Financial Derivatives and Risk Management, May 24–28, 2010

The Distinguished Lecture Series will be held April 21–23, 2010. Darrell Duffie (Stanford University) will deliver the lecture series.

The Coxeter Lectures will be delivered by Nicole El Karoui (École Polytechnique, Paris) at a date to be announced.

There will also be (at least) five Industrial-Academic Forums on dates to be announced: Financial Engineering and Insurance Mathematics, Emissions Trading and Other Market-Based Solutions to Environmental Problems, Structured Products, Systemic Stability and Liquidity, and Hedge Funds. See `http://www.fields.utoronto.ca/programs/scientific/09-10/finance` for up-to-date information on this thematic program.

Future thematic programs include Mathematics of Drug Resistance in Infectious Diseases (summer 2010); Asymptotic Geometric Analysis (fall 2010); Dynamics and Transport in Disordered Systems (winter/spring 2011); Discrete Geometry and Applications (fall 2011); and Galois Representations (winter/spring 2012).

Other future activities at the Institute include: Nathan and Beatrice Keyfitz Lectures in Mathematics and the Social Sciences, Robert C. Merton (Harvard Business School), April 16, 2010; the 14th International Congress on Insurance: Mathematics and Economics, University of Toronto, June 17–19, 2010; the Sixth World Congress of the Bachelier Society, Toronto Hilton Hotel, June 22–26, 2010; a Workshop on Fluid Motion Driven by Immersed Structures, August 9–13, 2010; and the Conference on Asymptotic Geometric Analysis and Convexity, September 13–17, 2010.

Please see `http://www.fields.utoronto.ca/programs/scientific/` for information on all activities at the Institute.

—Fields Institute announcement

PIMS IGTC Fellowship for 2010–2011

The PIMS International Graduate Training Centre in Mathematical Biology invites applicants for the IGTC fellowship for the 2010-2011 academic year. Fellowships are worth up to C$20,000 a year and are for students working in mathematical biology at the Pacific Institute for Mathematical Sciences (PIMS) universities (Alberta, British Columbia, Calgary, Regina, Saskatchewan, Simon Fraser and Victoria).

If you have excellent students, either potential students applying now or current students, please encourage them to apply. There are also opportunities for students to enroll in the programme. All students can benefit from IGTC graduate training elements including annual research summits, summer courses, new term-time courses, seminars, graduate student exchanges, and international visitors.

Full details of the IGTC Programme and application process can be found at: `http://www.pims.math.ca/scientific/igtc/mathematical-biology`. If you have further questions, please contact the IGTC coordinator, Maryna Yaskina (`igtcmathbio@math.ualberta.ca`) or Programme Director Mark Lewis (`mlewis@math.ualberta.ca`).

Application deadline is **February 5, 2010**.

—PIMS announcement

Inside the AMS

Trjitzinsky Memorial Awards Presented

The AMS has made awards to seven undergraduate students through the Waldemar J. Trjitzinsky Memorial Fund. The fund is made possible by a bequest from the estate of Waldemar J., Barbara G., and Juliette Trjitzinsky. The will of Barbara Trjitzinsky stipulates that the income from the bequest should be used to establish a fund in honor of the memory of her husband to assist needy students in mathematics.

For the 2009 awards, the AMS chose seven geographically distributed schools to receive one-time awards of US$3,000 each. The mathematics departments at those schools then chose students to receive the funds to assist them in pursuit of careers in mathematics. The schools were selected in a random drawing from the pool of AMS institutional members.

Waldemar J. Trjitzinsky was born in Russia in 1901 and received his doctorate from the University of California, Berkeley, in 1926. He taught at a number of institutions before taking a position at the University of Illinois, Urbana-Champaign, where he remained for the rest of his professional life. He showed particular concern for students of mathematics and in some cases made personal efforts to ensure that financial considerations would not hinder their studies. Trjitzinsky was the author of about sixty mathematics papers, primarily on quasi-analytic functions and partial differential equations. A member of the AMS for forty-six years, he died in 1973.

Following are the names of the selected schools for 2009, the names of the students receiving Trjitzinsky awards, and brief biographical sketches of the students.

California State University, Fresno: ANA-CRISTINA CERDA JIMENEZ. Jimenez is a first-generation college student who intends to continue on into graduate school. She began college as a chemistry major, then switched to mathematics in her second semester. Last summer she worked as part of a summer research project in knot theory. She is a member of the Golden Key International Honor Society. She enjoys teaching and has been tutoring in mathematics, English, Spanish, and the sciences since high school. She is involved in activities with her church, where she assisted as a peer leader with Local Life Teen. She is interested in creative writing, graphic design, and piano.

University of California Santa Barbara: DAVID HASSAN. Hassan is a member of Phi Beta Kappa and carries a double major in pure mathematics and physics. He is a returning student completing his studies after a tour of duty as an Arabic interpreter with the U.S. Marine Corps in Iraq.

Jackson State University: MANTATISI S. WALKER. Walker is a senior majoring in mathematics education. After graduating she plans to teach high school mathematics in the Mississippi Delta while attending graduate school. She is a SIMET (Students Investing in Mathematics, Engineering, and Technology) counselor, a member of the Mississippi Association of Educators and the National Education Association, a volunteer tutor for various high schools, and a participant and presenter at the National Council of Teachers of Mathematics conference. Walker's career goals include directing a mathematics program for high school students and becoming a professor at a local college.

Kenyon College: JONATHAN JORDAN EDWARDS. Edwards is deeply interested in both mathematics and theoretical physics and has conducted undergraduate research in both fields. He is a recipient of an Ernest F. Hollings Undergraduate Scholarship from the National Oceanic and Atmospheric Administration to cover a summer internship at a NOAA facility, where he hopes to be involved in modeling storm systems and working with satellites. He has lived in Pakistan and Indonesia as well as the United States, and he plans to enter a Ph.D. program upon graduation.

Smith College: ZEHUI CHEN. Chen completed high school in Guangdong, China, and is a mathematics major with a concentration in statistics. She spent the summer of 2007 at the London School of Economics and Political Science studying the economy of China. As a special studies project in statistical consulting, Chen used mathematical

skills to improve the quality of an industrial product. She says, "This experience showed me the value that mathematics contributes to industry. In the future, I look forward to increasing my mathematical skills and ultimately using my expertise to solve real-world problems."

Truman State University: KENDALL O. BROWN. Brown lives in St. Charles, Missouri, and is a sophomore studying for both a bachelor's degree in mathematics and a master's degree in mathematics education. She is president of her Kappa Mu Epsilon chapter and a student member of the Missouri State Teachers Association. Her goal is to be a master teacher of mathematics.

University of Vermont: ALISON L. ASHE. Ashe is a native of Buffalo, New York. She worked in technical theater until she returned to full-time study to pursue a bachelor's degree in applied mathematics, minoring in computer science and business administration. After graduation she plans to enter graduate study in industrial engineering.

—Elaine Kehoe

Erdős Memorial Lecture

The Erdős Memorial Lecture is an annual invited address named for the prolific mathematician Paul Erdős (1913–1996). The lectures are supported by a fund created by Andrew Beal, a Dallas banker and mathematics enthusiast. The Beal Prize Fund, now US$100,000, is being held by the AMS until it is awarded for a correct solution to the Beal Conjecture (see http://www.math.unt.edu/~mauldin/beal.html). At Beal's request, the interest from the fund is used to support the Erdős Memorial Lecture.

The Erdős Memorial Lecturer for 2009 was Jeffrey Lagarias of the University of Michigan, who delivered a lecture titled "From Apollonian circle packings to Fibonacci numbers" at the Spring Central Section Meeting at the University of Illinois at Urbana-Champaign in March 2009. The Erdős Memorial Lecturer for 2010 will be Doron Zeilberger of Rutgers University, who will deliver the lecture at the 2010 Spring Southeastern Section Meeting in Lexington, Kentucky, in March 2010.

—AMS announcement

From the AMS Public Awareness Office

• **2010 Calendar of Mathematical Imagery.** The 2010 calendar includes selected works from the *Mathematical Imagery* collection (http://www.ams.org/mathimagery)—computer-generated work, crochet, origami, sculpture, painting, and more. Download the pdf of the calendar at *This Mathematical Month*, http://www.ams.org/thismathmonth, or request the printed calendar by email to paoffice@ams.org, subject line "2010 calendar", with your mailing address. The supply is limited, so please limit your request to three copies so others may also have the opportunity to have a copy.

• **Mathematics at the National SACNAS conference.** The 2009 conference of the Society for the Advancement of Chicanos and Native Americans in Science (SACNAS), held in Dallas, Texas, in October, included math institutes, sessions, and presentations by graduate and undergraduate students in mathematics. The AMS hosted an exhibit and ran *Who Wants to Be a Mathematician*, a highlight of the conference. Read about mathematics on the program and see photographs at http://www.ams.org/ams/sacnas2009-mtg.html.

• **Arnold Ross Lecture.** Dana Randall of the Georgia Institute of Technology gave the 2009 Arnold Ross Lecture, "Domino Tilings of the Chessboard: An Introduction to Sampling and Counting", at the National Science Center/Fort Discovery in Augusta, Georgia, in October. The AMS ran *Who Wants to Be a Mathematician* after the lecture. Read about the events at http://www.ams.org/wwtbam/archive/arl2009.html.

—Annette Emerson and Mike Breen
AMS Public Awareness Officers
paoffice@ams.org

Deaths of AMS Members

CHARLES E. AULL, professor emeritus, College of Science at Virginia Tech, died on July 4, 2009. Born on September 1, 1927, he was a member of the Society for 51 years.

SILVIO AURORA, retired professor, Rutgers University, Newark, died on October 11, 2001. Born on February 25, 1925, he was a member of the Society for 56 years.

FRANK S. BECKMAN, retired, CUNY Graduate Center, died on October 16, 2009. Born on April 10, 1921, he was a member of the Society for 62 years.

WILLIAM A. BEYER, Los Alamos National Laboratory, died on August 16, 2008. Born on November 9, 1924, he was a member of the Society for 56 years.

STANLEY J. BEZUSZKA, S.J., retired professor, Boston College, died on December 27, 2008. Born on January 26, 1914, he was a member of the Society for 54 years.

GARY S. BLOOM, professor, City College, CUNY, died on September 6, 2009. Born on March 30, 1940, he was a member of the Society for 29 years.

JOHN W. BRACE, professor emeritus, University of Maryland, died on December 26, 2008. Born on January 19, 1926, he was a member of the Society for 57 years.

WRAY G. BRADY, retired professor, Slippery Rock University, died on November 17, 2008. Born on July 20, 1918, he was a member of the Society for 61 years.

JAMES L. BROOKS, retired professor, Villanova University, died on September 12, 2009. Born on July 7, 1930, he was a member of the Society for 53 years.

HUGH D. BRUNK, professor, Oregon State University, died on July 19, 2009. Born on August 22, 1919, he was a member of the Society for 67 years.

ALTON T. BUTSON, Lake Worth, FL, died in September 1997. Born on February 18, 1926, he was a member of the Society for 44 years.

JOEL CARROLL, Poway, CA, died on November 18, 2005. Born on April 8, 1924, he was a member of the Society for 50 years.

CHARLES M. CHAMBERS, past president, Lawrence Technological University, died on May 20, 2009. Born on June 22, 1941, he was a member of the Society for 42 years.

ROBERT L. DAVIS, from Chapel Hill, NC, died on October 12, 2009. Born on May 23, 1919, he was a member of the Society for 56 years.

ALBERT L. DEAL III, professor, Virginia Military Institute, died on August 1, 2009. Born on August 31, 1937, he was a member of the Society for 49 years.

RANJIT S. DHALIWAL, professor emeritus, University of Calgary, died on October 10, 2007. Born on June 21, 1930, he was a member of the Society for 40 years.

LEROY J. DERR, retired professor, University of New Orleans, died on November 7, 2004. Born on January 31, 1926, he was a member of the Society for 54 years.

H. P. EDMUNDSON, professor emeritus, University of Maryland, died on July 9, 2009. Born on December 13, 1921, he was a member of the Society for 56 years.

SHELDON E. ELLIOTT, chancellor, Phillips University, died on January 6, 2009. Born on July 9, 1925, he was a member of the Society for 52 years.

BENJAMIN EPSTEIN, professor emeritus, Technion-Israel Institute of Technology, died on December 22, 2004. Born on March 5, 1918, he was a member of the Society for 65 years.

KLAUS G. FISCHER, professor, George Mason University, died on July 2, 2009. Born on November 12, 1943, he was a member of the Society for 40 years.

ISRAEL M. GELFAND, professor, Rutgers University, died on October 5, 2009. Born on August 20, 1913, he was a member of the Society for 45 years.

LEONARD GILLMAN, emeritus professor, University of Texas at Austin, and former president of the MAA, died on April 7, 2009. Born on January 8, 1917, he was a member of the Society for 67 years.

GEORGE H. HANDELMAN, professor emeritus at Rensselaer Polytechnic Institute, died on September 13, 2008. Born on March 24, 1921, he was a member of the Society for 64 years.

MELVIN HENRIKSEN, professor of mathematics emeritus at Harvey Mudd College, died on October 14, 2009. Born on February 23, 1927, he was a member of the Society for 59 years.

ANNA S. HENRIQUES, chairman emeritus, College of Santa Fe, died on November 28, 2004. Born on August 20, 1905, she was a member of the Society for 74 years.

ABRAHAM A. HOCHMAN, Barcelona, Spain, died on June 30, 2008. Born on March 27, 1952, he was a member of the Society for 8 years.

CHUAN C. HSIUNG, retired professor, Lehigh University, died on May 6, 2009. Born on February 15, 1915, he was a member of the Society for 63 years.

WILLIAM J. JAFFE, professor emeritus, New Jersey Institute of Technology, died on September 25, 2000. Born on March 22, 1910, he was a member of the Society for 54 years.

HAROLD H. JOHNSON, retired professor from Trinity University, died on September 25, 2009. Born on September 20, 1929, he was a member of the Society for 52 years.

L. WAYNE JOHNSON, from Brownsburg, IN, died on July 22, 1989. Born on October 21, 1901, he was a member of the Society for 53 years.

JAMES T. JOICHI, retired professor, University of Minnesota, died on October 11, 2008. Born on May 22, 1927, he was a member of the Society for 52 years.

ERWIN O. KREYSZIG, retired professor, Carleton University, died on December 12, 2008. Born on January 6, 1922, he was a member of the Society for 51 years.

MARGARET M. LASALLE, assistant professor from Louisiana, died on August 12, 2009. Born on July 8, 1923, she was a member of the Society for 43 years.

HENRY S. LIEBERMAN, Waban, MA, died on May 14, 2009. Born on September 26, 1940, he was a member of the Society for 42 years.

ROBERT A. LIEBLER, professor, Colorado State University, died on July 19, 2009. Born on October 23, 1944, he was a member of the Society for 40 years.

JOHN J. MACDONNELL, S.J., associate professor emeritus, College of the Holy Cross, died on July 29, 2004. Born on March 28, 1927, he was a member of the Society for 43 years.

NATHANIEL MACON, retired professor, American University, died on November 26, 2001. Born on November 15, 1926, he was a member of the Society for 51 years.

MILTON ROSENBERG, from Delray Beach, FL, died on September 14, 1999. Born on May 2, 1934, he was a member of the Society for 37 years.

BENJAMIN L. SCHWARTZ, Vienna, VA, died on March 7, 1998. Born on January 11, 1926, he was a member of the Society for 51 years.

RICHARD SEE, from Seattle, WA, died on January 16, 2002. Born on December 3, 1923, he was a member of the Society for 42 years.

G. OLOF THORIN, from Sweden, died on February 14, 2004. Born on February 23, 1912, he was a member of the Society for 51 years.

HIROSHI UEHARA, professor, Oklahoma State University, died on November 29, 1997. Born on March 7, 1923, he was a member of the Society for 38 years.

CLARENCE J. WALLEN, S.J., professor emeritus, Loyola Marymount University, died on October 28, 2000. Born on October 16, 1916, he was a member of the Society for 44 years.

KENNETH G. WOLFSON, professor emeritus, Rutgers University, New Brunswick, died on October 7, 2000. Born on November 21, 1924, he was a member of the Society for 49 years.

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.wustl.edu in the case of the editor and notices@ams.org in the case of the managing editor. The fax numbers are 314-935-6839 for the editor and 401-331-3842 for the managing editor. Postal addresses may be found in the masthead.

Upcoming Deadlines

December 15, 2009: Applications for AMS Epsilon Fund grants. See http://www.ams.org/outreach/epsilon.html or contact the AMS Membership and Programs Department, telephone: 800-321-4267, ext. 4170; email: prof-serv@ams.org.

December 15, 2009: Nominations for the International Mathematical Union (IMU) Chern Medal Award. See http://www.mathunion.org/fileadmin/IMU/Prizes/Chern/.

January 4, 2010: Applications for NDSEG Fellowship Program. See "Mathematics Opportunities" in this issue.

January 10, 2010: Applications for AAUW Educational Foundation Fellowships and Grants. See http://www.aauw.org/fga/fellowships_grants/selected.cfm or contact the AAUW Educational Foundation, Selected Professions Fellowships, Dept. 60, 301 ACT Drive, Iowa City, IA 52243-4030; telephone: 800-326-2289; email: connect@aauw.org.

January 15, 2010: Applications for AMS-AAAS Mass Media Summer Fellowships. See http://www.aaas.org/programs/education/MassMedia/, or contact Stacey Pasco, Manager, Mass Media Program, AAAS Mass Media Science and Engineering Fellows Program, 1200 New York Avenue, NW, Washington, DC 20005; telephone 202-326-6441; fax 202-371-9849; email: spasco@aaas.org. Also see http://www.ams.org/government/massmediaann.html or contact 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, 2010: Applications for Jefferson Science Fellows Program. See http://www7.nationalacademies.org/jefferson/ or email: jsf@nas.edu or telephone 202-334-2643.

January 28, 2010: Proposals for National Science Foundation Scientific Computing Research Environments for the Mathematical Sciences (SCREMS). See http://www.nsf.gov/pubs/2007/nsf07502/nsf07502.htm.

February 1, 2010: Applications for February review for National Academies Postdoctoral and Senior Research Associateship Program.

Where to Find It

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

See "Mathematics Opportunities" in this issue.

February 1, 2010: Applications for AWM Travel Grants and Mentoring Travel Grants. See http://www.awm-math.org/travelgrants.html; telephone: 703-934-0163; email: awm@awm-math.org; or contact Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

February 5, 2010: Applications for Math for America Fellowship Program. See http://www.mathforamerica.org/.

February 5, 2010: Applications for PIMS IGTC Fellowship for 2010–2011. See "Mathematics Opportunities" in this issue.

February 15, 2010: Applications for Enhancing Diversity in Graduate Education (EDGE) Summer Program. See http://www.edgeforwomen.org/?page_id=5.

February 15, 2010: Applications for Institute for Pure and Applied Mathematics (IPAM) Research in Industrial Projects for Students (RIPS) undergraduate summer research program. See http://www.ipam.ucla.edu.

February 15, 2010: Applications for AMS-AAAS Congressional Fellowship. See http://www.ams.org/government/congressfellowann.html or contact the AMS Washington Office, telephone: 202-588-1100; email: amsdc@ams.org.

February 27, 2010: Entries for AWM Essay Contest. See "Mathematics Opportunities" in this issue.

April 15, 2010: Applications for fall 2010 semester of Math in Moscow. See http://www.mccme.ru/mathinmoscow or write to: Math in Moscow, P.O. Box 524, Wynnewood, PA 19096; fax: +7095-291-65-01; email: mim@mccme.ru. For information on AMS scholarships see http://www.ams.org/employment/mimoscow.html or write to: Math in Moscow Program, Membership and Programs Department, American Mathematical Society, 201 Charles Street, Providence RI 02904-2294; email: student-serv@ams.org.

May 1, 2010: Applications for May review for National Academies Postdoctoral and Senior Research Associateship Program. See "Mathematics Opportunities" in this issue.

May 1, 2010: Applications for the fall 2010 program of the Christine Mirzayan Science and Technology Policy Graduate Fellowship program of the National Academies. See http://sites.nationalacademies.org/PGA/policyfellows/index.htm or contact The National Academies Christine Mirzayan Science and Technology Policy Graduate Fellowship Program, 500 Fifth Street, NW, Room 508, Washington, DC 20001; telephone: 202-334-2455; fax: 202-334-1667; email: policyfellows@nas.edu.

May 1, 2010: Applications for AWM Travel Grants. See http://www.awm-math.org/travelgrants.html; telephone: 703-934-0163; or email: awm@awm-math.org. The postal address is: Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

June 1, 2010: Applications for NSF's Enhancing the Mathematical Sciences Workforce in the Twenty-First Century (EMSW21) program. See http://www.nsf.gov/pubs/2005/nsf05595/nsf05595.htm.

August 1, 2010: Applications for August review for National Academies Postdoctoral and Senior Research Associateship Program. See "Mathematics Opportunities" in this issue.

October 1, 2010: Applications for AWM Travel Grants. See http://www.awm-math.org/travelgrants.html; telephone: 703-934-0163; email: awm@awm-math.org; or contact Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

November 1, 2010: Applications for November review for National Academies Postdoctoral and Senior Research Associateship Program. See "Mathematics Opportunities" in this issue.

National Science Board

The National Science Board is the policymaking body of the National Science Foundation. Listed below are the current members of the NSB. For further information, visit the website http://www.nsf.gov/nsb/.

Mark R. Abbott
Dean and Professor
College of Oceanic and Atmospheric Sciences
Oregon State University

Dan E. Arvizu
Director and Chief Executive
National Renewable Energy Laboratory (NREL)

Barry C. Barish (Consultant)
Linde Professor of Physics Emeritus
Director, Laser Interferometer Gravitational-Wave Observatory (LIGO)
California Institute of Technology

Steven C. Beering (Chair)
President Emeritus
Purdue University

Camilla P. Benbow
Patricia and Rodes Hart Dean of Education and Human Development
Peabody College of Education and Human Development
Vanderbilt University

Ray M. Bowen
President Emeritus
Texas A&M University

John T. Bruer
President
James S. McDonnell Foundation
St. Louis, Missouri

G. Wayne Clough
Secretary
Smithsonian Institution

France A. Cordova
President
Purdue University

Kelvin K. Droegemeier
Associate Vice President for Research
Regents' Professor of Meteorology and Weathernews Chair
University of Oklahoma

Patricia D. Galloway (Vice Chair)
Chief Executive Officer
Nielsen-Wurster Group, Inc.
Seattle, Washington

José-Marie Griffiths
Dean
School of Information and Library Science
University of North Carolina, Chapel Hill

Esin Gulari
Dean of Engineering and Science
Clemson University

Elizabeth Hoffman (Consultant)
Executive Vice President and Provost
Iowa State University

Louis J. Lanzerotti
Distinguished Research Professor of Physics
Center for Solar Terrestrial Research
New Jersey Institute of Technology

Alan I. Leshner
Chief Executive Officer
American Association for the Advancement of Science

G. P. Peterson
President
Georgia Institute of Technology

Douglas D. Randall
Professor of Biochemistry and Thomas Jefferson Fellow
Director, Interdisciplinary Plant Group
University of Missouri

Arthur K. Reilly
Senior Director
Cisco Systems, Inc.

Diane L. Souvaine
Professor and Chair, Computer Science
Tufts University

Jon C. Strauss
Interim Dean of Engineering
Texas Tech University

Kathryn D. Sullivan
Director
Battelle Center for Mathematics and Science Education Policy
John Glenn School of Public Affairs
Ohio State University

Thomas N. Taylor
Roy A. Roberts Distinguished Professor
Department of Ecology and Evolutionary Biology
Curator of Paleobotany in the Natural History Museum and Biodiversity Research Center
University of Kansas

Richard F. Thompson
Keck Professor of Psychology and Biological Sciences
University of Southern California

Arden L. Bement Jr.
(member ex officio)
Director
National Science Foundation

Craig R. Robinson
Executive Officer and Acting Office Director
National Science Board

The contact information for the Board is: National Science Board, National Science Foundation, 4201 Wilson Boulevard, Room 1225N, Arlington, VA 22230; telephone 703-292-7000; 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 Archimedes Codex: How a Medieval Prayer Book Is Revealing the True Genius of Antiquity's Greatest Scientist, by Reviel Netz and William Noel. Da Capo Press, October 2007. ISBN 978-03068-1580-5. (Reviewed September 2008.)

The Best of All Possible Worlds: Mathematics and Destiny, by Ivar Ekeland. University of Chicago Press, October 2006. ISBN-13: 978-0-226-19994-8. (Reviewed March 2009.)

The Calculus of Friendship: What a Teacher and Student Learned About Life While Corresponding About Math, by Steven Strogatz. Princeton University Press, August 2009. ISBN-13: 978-06911-349-32.

The Calculus Wars: Newton, Leibniz, and the Greatest Mathematical Clash of All Time, by Jason Socrates Bardi. Thunder's Mouth Press, April 2007. ISBN-13: 978-15602-5992-3. (Reviewed May 2009.)

Chez les Weils (French), by Sylvie Weil. Buchet-Chastel, January 2009. ISBN-13: 978-22830-236-93.

Crossing the Equal Sign, by Marion D. Cohen. Plain View Press, January 2007. ISBN-13: 978-18913-866-95.

Crocheting Adventures with Hyperbolic Planes, by Daina Taimina. A K Peters, March 2009. ISBN-13: 978-15688-145-20.

Decoding the Heavens: A 2,000-Year-Old Computer—and the Century-Long Search to Discover Its Secrets, by Jo Marchant. Da Capo Press, February 2009. ISBN-13: 978-03068-174-27.

The Drunkard's Walk: How Randomness Rules Our Lives, by Leonard Mlodinow. Pantheon, May 2008. ISBN-13: 978-03754-240-45.

Embracing the Wide Sky: A Tour Across the Horizons of the Human Mind, by Daniel Tammet. Free Press, January 2009. ISBN-13: 978-14165-696-95.

Ernst Zermelo: An Approach to His Life and Work, by Heinz-Dieter Ebbinghaus. Springer, April 2007. ISBN-13 978-3-540-49551-2. (Reviewed August 2009.)

Gaming the Vote (Why Elections Aren't Fair and What We Can Do About It), by William Poundstone. Hill and Wang, February 2009. ISBN-13: 978-08090-489-22.

The Housekeeper and the Professor, by Yoko Ogawa. Picador, February 2009. ISBN-13: 978-03124-278-01.

How Math Explains the World: A Guide to the Power of Numbers, from Car Repair to Modern Physics, by

James D. Stein. Collins, April 2008. ISBN-13: 978-00612-417-65.

How to Think Like a Mathematician: A Companion to Undergraduate Mathematics, by Kevin Houston. Cambridge University Press, March 2009. ISBN-13: 978-05217-197-80.

Leonhard Euler and His Friends: Switzerland's Great Scientific Expatriate, by Luis-Gustave du Pasquier (translated by John S. D. Glaus). CreateSpace, July 2008. ISBN: 978-14348-332-73.

Lewis Carroll in Numberland: His Fantastical Mathematical Logical Life: An Agony in Eight Fits, by Robin Wilson. W. W. Norton & Company. ISBN-13: 978-03930-602-70.

**Mathematicans Fleeing from Nazi Germany: Individual Fates and Global Impact,* by Reinhard Siegmund-Schultze. Princeton University Press, July 2009. ISBN 978-0-691-14041-4.

**The Mathematical Mechanic: Using Physical Reason to Solve Problems*, by Mark Levi. Princeton University Press. ISBN: 978-0691140209.

Logic's Lost Genius: The Life of Gerhard Gentzen, by Eckart Menzler-Trott, Craig Smorynski (translator), Edward R. Griffor (translator). AMS-LMS, November 2007. ISBN-13: 978-0-8218-3550-0.

Mathematicians of the World, Unite!: The International Congress of Mathematicians: A Human Endeavor, by Guillermo P. Curbera. A K Peters, March 2009. ISBN-13: 978-15688-133-01.

Mathematics and Common Sense: A Case of Creative Tension, by Philip J. Davis. A K Peters, October 2006. ISBN 1-568-81270-1. (Reviewed June/July 2009.)

Mathematics Emerging: A Sourcebook 1540–1900, by Jacqueline Stedall. Oxford University Press, November 2008. ISBN-13: 978-01992-269-00.

Mathematics in Ancient Iraq: A Social History, by Eleanor Robson. Princeton University Press, August 2008. ISBN-13: 978-06910-918-22.

Mathematics in India, by Kim Plofker. Princeton University Press, January 2009. ISBN-13: 978-06911-206-76.

Mathematics in 10 Lessons: The Grand Tour, by Jerry P. King. Prometheus Books, May 2009. ISBN: 978-1-59102-686-0.

The Mathematics of Egypt, Mesopotamia, China, India, and Islam: A Sourcebook, by Victor J. Katz et al. Princeton University Press, July 2007. ISBN-13: 978-0-6911-2745-3.

The Millenium Prize Problems, edited by James Carlson, Arthur Jaffe, and Andrew Wiles. AMS, June 2006. ISBN-13: 978-08218-3679-8. (Reviewed December 2009.)

More Mathematical Astronomy Morsels, by Jean Meeus. Willmann-Bell, 2002. ISBN 0-943396743.

The Numbers Behind NUMB3RS: Solving Crime with Mathematics, by Keith Devlin and Gary Lorden. Plume, August 2007. ISBN-13: 978-04522-8857-7. (Reviewed March 2009.)

The Numbers Game: The Commonsense Guide to Understanding Numbers in the News, in Politics, and in Life, by Michael Blastland and Andrew Dilnot. Gotham, December 2008. ISBN-13: 978-15924-042-30.

The Numerati, by Stephen Baker. Houghton Mifflin, August 2008. ISBN-13: 978-06187-846-08. (Reviewed October 2009.)

Our Days Are Numbered: How Mathematics Orders Our Lives, by Jason Brown. McClelland and Stewart, April 2009. ISBN-13: 978-07710-169-67.

Out of the Labyrinth: Setting Mathematics Free, by Robert Kaplan and Ellen Kaplan. Oxford University Press, January 2007. ISBN-13: 978-0-19514-744-5. (Reviewed June/July 2009.)

A Passion for Discovery, by Peter Freund. World Scientific, August 2007. ISBN-13: 978-9-8127-7214-5.

Picturing the Uncertain World: How to Understand, Communicate, and Control Uncertainty Through Graphical Display, by Howard Wainer, Princeton University Press, April 2009. ISBN-13: 978-06911-375-99.

Plato's Ghost: The Modernist Transformation of Mathematics, by Jeremy Gray. Princeton University Press, September 2008. ISBN-13: 978-06911-361-03.

The Princeton Companion to Mathematics, edited by Timothy Gowers (June Barrow-Green and Imre Leader, associate editors). Princeton University Press, November 2008. ISBN-13: 978-06911-188-02. (Reviewed November 2009.)

Pythagoras' Revenge: A Mathematical Mystery, by Arturo Sangalli. Princeton University Press, May 2009. ISBN-13: 978-06910-495-57.

Recountings: Conversations with MIT Mathematicians, edited by Joel Segel. A K Peters, January 2009. ISBN-13: 978-15688-144-90.

Rock, Paper, Scissors: Game Theory in Everyday Life, by Len Fisher. Basic Books, November 2008. ISBN-13: 978-04650-093-81.

Sacred Mathematics: Japanese Temple Geometry, by Fukagawa Hidetoshi and Tony Rothman. Princeton University Press, July 2008. ISBN-13: 978-0-6911-2745-3.

**Sphere Packing, Lewis Carroll, and Reversi*, by Martin Gardner. Cambridge University Press, July 2009. ISBN: 978-0521756075.

Strange Attractors: Poems of Love and Mathematics, edited by Sarah Glaz and JoAnne Growney. A K Peters, November 2008. ISBN-13: 978-15688-134-17. (Reviewed September 2009.)

Super Crunchers: Why Thinking-by-Numbers Is the New Way to Be Smart, by Ian Ayres. Bantam, August 2007. ISBN-13: 978-05538-054-06. (Reviewed April 2009.)

Tools of American Math Teaching, 1800–2000, by Peggy Aldrich Kidwell, Amy Ackerberg-Hastings, and David Lindsay Roberts. Johns Hopkins University Press, July 2008. ISBN-13: 978-0801888144. (Reviewed in this issue.)

The Unfinished Game: Pascal, Fermat, and the Seventeenth-Century Letter That Made the World Modern, by Keith Devlin. Basic Books, September 2008. ISBN-13: 978-0-4650-0910-7.

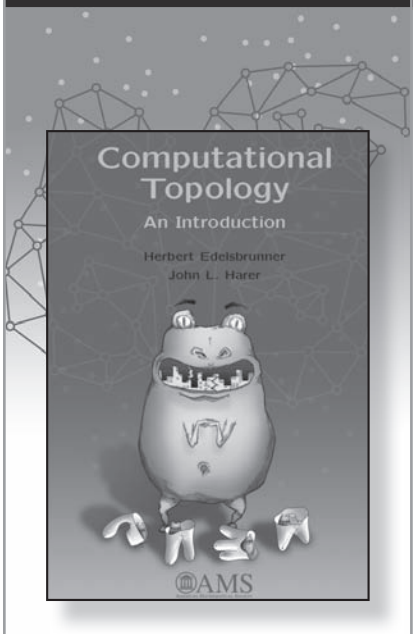
What Is a Number?: Mathematical Concepts and Their Origins, by Robert Tubbs. Johns Hopkins University Press, December 2008. ISBN-13: 978-08018-901-85.

What's Happening in the Mathematical Sciences, by Dana Mackenzie. AMS, 2009. ISBN-13: 978-08218-447-86.

Why Does E=mc²? (And Why Should We Care?), by Brian Cox and Jeff Forshaw. Da Capo Press, July 2009. ISBN-13: 978-03068-175-88.

Zeno's Paradox: Unraveling the Ancient Mystery Behind the Science of Space and Time, by Joseph Mazur. Plume, March 2008 (reprint edition). ISBN-13: 978-0-4522-8917-8.

AMERICAN MATHEMATICAL SOCIETY



TEXTBOOK

Computational Topology

An Introduction

Herbert Edelsbrunner, *Duke University, Durham, NC, and Geomagic, Research Triangle Park, NC*, and **John L. Harer**, *Duke University, Durham, NC*

This text offers a combination of topics in geometry, topology and algorithms, in a manner showing how the fields benefit from one another. It develops all the background of both the mathematical and algorithmic aspects of computational topology from first principles. It builds intuition by relating the material to situations in different walks of life.

2010; 241 pages; Hardcover; ISBN: 978-0-8218-4925-5; List US$59; AMS members US$47; Order code MBK/69

For many more publications of interest, visit the AMS Bookstore

www.ams.org/bookstore

Mathematics Advanced Study Semesters (MASS)

Department of Mathematics of the Penn State University runs a yearly semester-long intensive program for undergraduate students seriously interested in pursuing career in mathematics. MASS is held during the fall semester of each year. For most of its participants, the program is a spring board to graduate schools in mathematics. The participants are usually juniors and seniors.

The MASS program consists of three core courses (4 credits each), Seminar (3 credits) and Colloquium (1 credit), fully transferable to the participants' home schools. The core courses offered in 2010 are:

Differential equations from an algebraic perspective (N. Higson),
Dynamics, mechanics and geometry (M. Levi),
Function Field Arithmetic (M. Papikian).

Applications for fall semester of 2010 are accepted now.

Financial arrangements:

Successful applicants are awarded *Penn State MASS Fellowship* which reduces their tuition to the in-state level. Applicants who are US citizens or permanent residents receive *NSF MASS Fellowship* which covers room and board, travel to and from Penn State and provides additional stipend. Applicants with outstanding previous record are awarded additional *MASS Merit Fellowship*. Participants who significantly exceed expectations during the program will be awarded *MASS Performance Fellowships* at the end of the semester.

For complete information, see
http://www/math/psu.edu/mass
e-mail to mass@math.psu.edu
or call (814)865-8462

ETH

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Assistant Professor of Quantitative Finance

The Department of Mathematics at ETH Zurich (www.math.ethz.ch) invites applications for an assistant professorship in Quantitative Finance. Duties of this position include an active participation in teaching students of mathematics, natural sciences, and engineering. The candidate is expected to engage in excellent innovative mathematical research related to mathematical finance and insurance, for example computational and/or statistical and/or probabilistic aspects of quantitative finance, insurance and risk management.

Candidates should have a Ph.D. or equivalent and have demonstrated the ability to carry out independent research work. Willingness to teach at all university levels, to collaborate with colleagues as well as representatives from industry are expected. The new professor will be expected to teach undergraduate level courses (German or English) and graduate level courses (English).

Assistant professorships have been established to promote the careers of younger scientists. The initial appointment is for four years with the possibility of renewal for an additional two-year period.

Please submit your application together with a curriculum vitae and a list of publications **to the President of ETH Zurich, Prof. Dr. Ralph Eichler, ETH Zurich, Raemistrasse 101, 8092 Zurich, Switzerland (or via e-mail to faculty-recruiting@sl.ethz.ch), no later than February 28, 2010.** With a view toward increasing the number of female professors, ETH Zurich specifically encourages qualified female candidates to apply.

Mathematics Calendar

January 2010

* 25–February 5 **Periodic approximation in dynamics**, Centro di Ricerca Matematica Ennio De Giorgi, Pisa, Italy.
Description: The Dynamical Systems School on Periodic Approximations in Ergodic Theory will focus on the study of periodic approximations as a tool to understand the ergodic properties of deterministic dynamical systems, and as a method of construction of examples (and counter-examples) of ergodic behavior, especially in dynamics related to quasi-periodic motion, such as perturbations of completely integrable systems, KAM theory, Arnol'd diffusion theory, quasi-periodic cocycles, Schrodinger equation, 1-dimensional complex dynamics around elliptic xed points, etc. The topics included in the courses cover areas of dynamics that have been experiencing a growing activity recently, raising interests among many young researchers and doctoral students both in Europe and in the U.S. The school will be aimed at student and young researchers and its goal is to provide them with the state of the art ideas and techniques of the included topics.
Information: `http://tinyurl.com/ykxpemz`.

* 30–February 6 **Winter School in Abstract Analysis, section Topology**, Hejnice, Czech Republic.
Description: The meeting continues the long tradition started by Z. Frolik. The topology section is devoted to the fields of Set Theory and Set Theoretic Topology. There is an emphasis on the "school" part of the name. The meeting is very informal with plenty of time devoted to discussions. The talks are split into a tutorial track (this year J. Brendle, A. Dow, S. D. Friedman and M. Magidor will each give a tutorial) and a research track, where research and work in progress may be presented.
Information: More information, registration deadline, etc. is available on the website `http://winterschool.eu`.

February 2010

* 8–12 **YMIS 10 - Young Mathematicians in Segovia**, Segovia, Spain.
Description: This is the sixth edition of the school Young Mathematicians in Segovia. YMIS is mostly intended for Ph.D. students and young postdocs working on algebraic geometry, singularities or commutative algebra. YMIS 10 will consist of four courses: Course 1 by Norbert A'Campo (Universität Basel), Course 2: "Homological Algebra of Gorenstein Singularities" by Ragnar-Olaf Buchweitz (University of Toronto), Course 3: "Algebraic curves and their combinatorics" by Pierrette Cassou-Noguès (Université de Bordeaux I) and Course 4: "Zeta functions and exponential sums: homological and geometric methods" by Antonio Rojas León (Universidad de Sevilla). Traditionally, these courses will be supplemented by short talks by junior participants.
Accommodation/Deadline: Lodging, meals will take place at the Hotel Las Sirenas in Segovia. Lectures will take place at the Palacio de Mansilla, C/Trinidad, 3. Accommodation and food is fully funded. If you are interested in participating please contact `ann.lemahieu@wis.kuleuven.be`. The number of places is limited and deadline for registration is December 20th.

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 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. If there is any application deadline with respect to participation in the meeting, this fact should be noted. All communications on meetings and conferences in the mathematical sciences should be sent to the Editor of the *Notices* in care of the American Mathematical Society in Providence or electronically to `notices@ams.org` or `mathcal@ams.org`.
In order to allow participants to arrange their travel plans, organizers of meetings are urged to submit information for these listings early enough to allow them to appear in more than one issue of the *Notices* prior to the meeting in question. To achieve this, listings should be received in Providence **eight months** prior to the scheduled date of the meeting.
The complete listing of the Mathematics Calendar will be published only in the September issue of the *Notices*. The March, June/July, 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/`.

Information: http://www.singacom.uva.es/oldsite/segovia10/index.html.

* 9–13 **31st Linz Seminar on Fuzzy Set Theory – "Lattice-Valued Logic and its Applications"**, Linz, Austria.
Description: The 31st Linz Seminar on Fuzzy Set Theory is devoted to the theme "Lattice-Valued Logic and its Applications". The goal of the seminar is to present and discuss recent advances of mathematical fuzzy logic (understood in broader framework of lattice-valued logics) and concentrate on its applications in various areas of computer science, linguistics, and philosophy.
Information: http://www.flll.jku.at/div/research/linz2010/index.html.

* 16–19 **17 SIMMAC - International Symposium on Mathematical Methods Applied to the Sciences**, University of Costa Rica, San Jose, Costa Rica.
Description: The SIMMAC is the most important meeting on Applied Mathematics in Central America. It takes place every two years in San Jose, Costa Rica, since 1978.
Topics: Data Analysis, Statistics, Classification Optimization, Operations Research, Probabilty, Stochastic Processes, Numerical Analysis, Approximation, Modeling, Financial Mathematics, Biomathematics, Dynamical Systems, Optimal Control, Applications.
Deadline: For abstracts: November 20, 2009. Full articles: February 19, 2010. A refereed selection of full articles presented will be published at the Revista de Matematica: Teoria y Aplicaciones.
Information: http://www.cimpa.ucr.ac.cr/simmac/.

* 18–20 **International Conference on Partial Differential Equations**, University of Poitiers, France.
Description: The conference is dedicated to Professor Michel Chipot on the occasion of his 60th birthday.
Information: http://www-math.univ-poitiers.fr/icpde2010/.

* 22–26 **Magma 2010 Conference on *p*-adic *L*-functions**, Centre de recherches mathématiques, Université de Montréal, Pavillon André-Aisenstadt, 2920, Chemin de la tour, room 5357, Montréal (Québec) H3T 1J4, CANADA.
Description: This workshop is being run under the auspices of the MAGMA Computer Algebra Group (University of Sydney), and is devoted to computational aspects of the the theory of *p*-adic *L*-functions. This topic has a rich history both in itself and in relation to global *L*-functions. It is only recently that the ability to explore various conjectures has become practical. An explicit example is with *p*-adic variants of Stark's conjectures, which have been investigated at least in the abelian case. In some contexts, the computations have truly acted as an "experimental science", in that the final refinements of the conjectures were largely aided by the numerical data.
Information: http://www.crm.umontreal.ca/NT2010.

* 22–March 5 **Advanced Course on Arithmetic Geometry for Function Fields of Positive Characteristic**, Centre de Recerca Matemàtica Apartat 50 E-08193, Bellaterra, Spain.
Titles: Curves and Jacobians over function fields. On main conjectures in geometric Iwasawa theory and related conjectures. Arithmetic of gamma, zeta, multizeta values in function fields. A cohomology for function fields arithmetic, and applications.
Information: http://www.crm.cat/acarithff.

* 22–March 5 **Second International School on Geometry and Physics. Geometric Langlands and Gauge Theory**, Centre de Recerca Matemàtica, Apartat 50 E-08193, Bellaterra, Spain.
Description: The geometric Langlands correspondence lies at the core of one of the most significant current interactions between geometry and physics, integrating far-reaching discoveries and conjectures originating in physics, geometry, representation theory and arithmetic. This advanced school is designed to deliver training on this interdisciplinary topic. It is targetted at graduate students, postdocs and researchers working in geometry and physics at an international level.
Information: http://www.crm.cat/aclanglands.

March 2010

* 8–12 **Graphs and Arithmetic**, Centre de recherches mathématiques, Université de Montréal, Pavillon André-Aisenstadt, 2920, Chemin de la tour, room 5357, Montréal (Québec) H3T 1J4, Canada.
Description: There is a long history of interaction between number theory and combinatorics. In the past two decades, deep results in automorphic forms and number theory were used to construct (optimal) expanders, which are known to have wide applications in computer science and communication networks. These techniques were generalized to construct higher dimensional analogues. In the meanwhile, zeta functions for graphs and complexes are better understood. Recent exciting developments in arithmetic combinatorics provide new tools to construct families of good expanders, and these expanders in turn are used to obtain deep number theoretic results. At the same time, the concept of expansion is extended in group theory and computer science to a different context.
Information: http://www.crm.math.ca/Arithmetic10/index_e.php.

* 22–26 **Computer Methods for *L*-functions and Automorphic Forms**, Centre de recherches mathématiques, Université de Montréal, Pavillon André-Aisenstadt, 2920, Chemin de la tour, room 5357, Montréal (Québec) H3T 1J4, Canada.
Description: For years, computers have also played a key role in investigating the most central questions in the analytic theory of automorphic forms such as the existence of Maass wave forms. Recently, a team of researchers, including M. Rubinstein (Waterloo) and W. Stein (Seattle), has embarked on an ambitious collaborative effort to systematically gather vast amounts of data concerning, among other things, automorphic forms on higher rank groups. This effort is part of a three year (2008-2011) NSF funded Focused Research Group (FRG) grant dealing with *L*-functions and automorphic forms. The FRG effort is sure to generate challenges and new questions for people working both on the theoretical and the experimental side of the subject, as well as gathering valuable data that will be precious in suggesting conjectures or revealing new lines of enquiry.
Information: http://www.crm.math.ca/Computer10.

* 26–28 **CoNE Revisited: Celebrating the Inspirations of Michael O. Albertson**, Smith College, Northampton, Massachusetts.
Description: A mathematics research conference will be held in memory of Michael O. Albertson, March 26–28, 2010, at Smith College, Northampton, MA, USA. The conference is entitled "CoNE Revisited: Celebrating the Inspirations of Michael O. Albertson" and focuses on his areas of research interest, graph theory, combinatorics, and discrete geometry. With Professor Ruth Haas of Smith and Professor Karen Collins (Smith'81) of Wesleyan, Professor Albertson ran at Smith, from 1992 until 2001, a series of CoNE (Combinatorists of New England) conferences, whose open, collaborative, and diverse style we plan to emulate in this memorial conference. All are welcome to attend the talks and social events. Please send any questions to Prof. Joan P. Hutchinson at hutchinson@macalester.edu.
Information: Visit http://www.math.smith.edu/cone/MikeAlbertsonConference.html.

April 2010

* 5–9 **PDEs, relativity and nonlinear waves**, Granada, Spain.
Description: The mathematical work concerned with or inspired by General Relativity has increased substantially over the years and is still expanding, thanks to the wide variety of interesting and challenging problems that General Relativity can offer in several distinct areas of Mathematics, for example PDEs, Geometry and Numerical Analysis. Fundamental open questions in General Relativity, such as the stability of Kerr, the formation and structure of Black Holes and

the Cosmic Censorship Conjecture, require for their understanding a deep analysis of the global behavior of solutions to the Einsten equations. This conference brings together leading experts on General Relativity/non-linear wave equations and will cover topics of current and future research in these fields.
Information: http://www.ugr.es/~kinetic/rel.

* 6–10 **Workshop on Iwasawa Theory over Function Fields of Characteristic p**, Centre de Recerca Matemàtica Apartat 50 E-08193, BellaterraSpain.
Scientific Committee: Francesc Bars (Universitat Autònoma de Barcelona), Gebhard Böckle (Universität Duisburg-Essen), David Burns (King's College of London), David Goss (Ohio State University), Ignazio Longhi (Università di Milano), Douglas Ulmer (Georgia Institute of Technology), Fabien Trihan (University of Nottingham), Xavier Xarles (Universitat Autònoma de Barcelona).
Tentative List of Speakers: Anglès, Bruno, Laboratoire de Mathématiques Nicolas Oresme; Bandini, Andrea, Università di Pisa; Burns, David, King's College London; Pablos Romo, Fernando, Universidad de Salamanca; Pál, Ambrus, Imperial College London; Popescu, Cristian D., University of California at San Diego; Tan, Ki-Seng, National Taiwan University; Thakur, Dinesh S., University of Arizona; Ulmer, Douglas, Georgia Institute of Technology; Yasuda, Seidai, University of Kyoto.
Information: http://www.crm.cat/wkiwasawa.

* 6–June 25 **Trimester in Combinatorics and Control: Workshop, School, Advanced Course, Research in Teams, and International Conference**, Madrid and Zaragoza, Spain.
Focus: The role of combinatorial Hopf algebras at the interface of geometric control theory, algebraic combinatorics, and geometric numerical integration. April 6–9, 2010, Madrid: Workshop. April 12–16, 2010, Zaragoza, School: Targeted at graduate and postdoctoral students in control, computation and combinatorics. April 19–June 18, 2010, Madrid, Research in Teams: 2-4 researchers each work collaboratively on projects for periods of 2-4 weeks. May, 2010, Madrid: Advanced Course "Modern Algebraic Combinatorics and its Applications to Control Theory": Targeted at Ph.D. students. June 21–25, 2010, Madrid, International Conference: Summarizing current research results and redefining future research objectives. Grant support for travel and subsistence is pending. Researchers in the early stages of their careers, including advanced graduate students, especially from traditionally underrepresented groups, are encouraged to apply for support.
Information: http://dftuz.unizar.es/coco2010.

* 12–16 **Advanced Course and Workshop on Drinfeld Modules and *L*-functions**, Centre de Recerca Matemàtica Apartat 50 E-08193, Bellaterra, Spain.
Scientific Committee: Francesc Bars (Universitat Autònoma de Barcelona), Gebhard Böckle (Universität Duisburg-Essen), David Burns (King's College of London), David Goss (Ohio State University), Ignazio Longhi (Università di Milano), Douglas Ulmer (Georgia Institute of Technology), Fabien Trihan (University of Nottingham), Xavier Xarles (Universitat Autònoma de Barcelona).
Advanced Course's Tentative List of Speakers: Goss, David, Ohio State University at Columbus.
Workshop's Tentative List of Speakers: Böckle, Gebhard, Universität Duisburg-Essen; Chang, Chieh-Yu, National Center for Theoretical Sciences (NCTS); Consani, Caterina, Johns Hopkins University; Gekeler, Ernst-Ulrich, Universität des Saarlandes; Papanikolas, Matthew, Texas A&M University; Papikian, Mihran, The Pennsylvania State University; Pellarin, Federico, Université Jean Monnet; Taelman, Lenny, Universiteit Leiden; Thakur, Dinesh S., University of Arizona.
Information: http://www.crm.cat/wkacdrinfeld.

* 19–23 **Counting Points: Theory, Algorithms and Practice**, Centre de recherches mathématiques, Université de Montréal, Pavillon André-Aisenstadt, 2920, Chemin de la tour, room 5357, Montréal (Québec), H3T 1J4 Canada.
Description: The development of efficient (polynomial time) algorithms for counting the number of points on varieties over finite fields represents a highly attractive area of application, in part because it relies on sophisticated mathematical theories like the étale and p-adic cohomology theories whose development was a cornerstone of number theory in the second half of the 20th century. The workshop will be devoted to recent advances in this area and its applications.
Information: http://www.crm.math.ca/Points10/index_e.php.

* 21–23 **Bone Tissue: Hierarchical Simulations for Clinical Applications**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.
Organizing Committee: Maria-Grazia Ascenzi (UCLA Orthopedic Hospital), John S. Adams (UCLA Orthopedic Hospital), Elena Cherkaev (University of Utah), Paul Dechow (Texas A&M Baylor College of Dentistry), Eve Donnelly (Hospital for Special Surgery), Gwendolen Reilly (University of Sheffield).
Aim: To bring together orthopedic surgeons, clinicians, system biologists, mechanical and software engineers, and applied mathematicians to share the latest findings and formulate a plan to develop the next generation of three-dimensional multi-scale virtual rendering of bone tissue able to address specific clinical issues.
Application/Registration: Registration form is available at: http://www.ipam.ucla.edu/programs/bone2010. Early registration closes Jan. 15, 2010. Residents and junior investigators, and women, underrepresented minorities, and individuals with disabilities are encouraged to apply. Scholarships will be awarded to the first author of the nine most meritorious abstracts.
Information: http://www.ipam.ucla.edu/programs/bone2010/.

May 2010

* 3–7 **Second International Workshop on Zeta Functions in Algebra and Geometry**, Universitat de les Illes Balears, Palma de Mallorca, Spain.
Description: The conference will focus on zeta functions in algebra and geometry. Among the main topics to be covered are: 1) Arithmetic and geometric aspects of local, topological and motivic zeta functions, 2) Poincaré series of valuations, 3) Zeta functions of groups, rings and representations, 4) Prehomogeneous vector spaces and their zeta functions, 5) Height zeta functions, 6) Computation of zeta functions and applications.
Scientific Committee: A. Campillo (Spain), J. Denef (Belgium), F. Grunewald (Germany), S. M. Gusein-Zade (Russia), M. Larsen (USA), I. Luengo (Spain), Y. Tshinkel (USA), A. Yukie (Japan).
Organizing Committee: A. Melle-Hernández (Spain), W. Veys (Belgium), W. A. Zúñiga-Galindo (México).
Local Organizing Committee: L l. Huguet (Chair), A. Campillo, G. Cardona, M. González-Hidalgo, A. Mir (Spain).
Information: http://www.singacom.uva.es/oldsite/seminarios/cartel.jpg.

June 2010

* 3–5 **12th Chico Topology Conference**, Chico, California.
Description: Researchers at all levels are invited to present 20-minute contributed talks in any area of topology. To apply, please send a title and abstract to Thomas Mattman (email: TMattman@CSUChico.edu) by May 1, 2010.
Invited speakers: Alejandro Illanes (UNAM, Mexico); Marcus March (CSU, Sacramento); Chris Mouron (Rhodes College, Memphis); and Ramin Naimi (Occidental College, LA).
Information: http://www.csuchico.edu/~tmattman/CTC.html.

* 8–9 **2010 Clay Research Conference**, Institut Henri Poincaré, Paris, France.
Information: http://www.claymath.org.

* 22–July 2 **RMMC 2010: Conservation Laws and Applications**, University of Wyoming, Laramie, Wyoming.
Description: Conservation Laws (or balance laws) are systems of partial differential equations which arise naturally as models for a variety of physical phenomena (e.g., fluid dynamics, magneto-hydrodynamics, combustion, oil recovery, and nonlinear elasticity). The primary focus of this summer program will be on recent developments in our understanding of such equations. Beginning with a rapid tutorial phase, the aim of the program will be to expose participants to current areas of active research and to help prepare them to pursue open problems in the field. The program will touch on both theoretical and computational aspects of conservation laws, and application areas (old and new) in which conservation laws play a central role will be highlighted.
Speakers: H. Kristian Jenssen (Penn State University), James Rossmanith (University of Wisconsin-Madison), Benjamin Texier (Universite Paris-Diderot (Paris 7)).
Sponsors: Rocky Mountain Mathematics Consortium. NSF and IMA Funding possible.
Deadline: For applications/abstracts of talks: April 1, 2010.
Information: http://math.uwyo.edu/rmmc/2010; Gregory Lyng, glyng@uwyo.edu, A. Duane Porter, adporter@uwyo.edu, Department of Mathematics, University of Wyoming, Laramie, WY 82071. For information about Laramie, http://www.laramie.org/.

* 24–27 **ACA 2010: Applications of Computer Algebra**, Vlora, Albania.
Description: The ACA series of conferences is devoted to promoting the applications and development of Computer Algebra and Symbolic Computation. Topics include computer algebra and symbolic computation in engineering, the sciences, medicine, pure and applied mathematics, education, communication and computer science. Call for Sessions: We are still accepting proposals to organize sessions at the conference. Session chairs are expected to organize four or more speakers on a theme consistent with that of the conference.
Information: See http://aca2010.info/index.php/aca2010/aca2010.

July 2010

* 5–9 **Modular Conference: Arithmetic of Modular Forms and Modularity Results**, Centre de Recerca Matemàtica Apartat 50 E-08193, Bellaterra, Spain.
Scientific Committee: Henri Darmon (McGill University, Montreal), Fred Diamond (King's College of London), Luis Dieulefait (Universitat de Barcelona), Bas Edixhoven (Leiden University), Victor Rotger (Universitat Politècnica de Catalunya).
Tentative List of Speakers: Barnet-Lamb, Thomas, Brandeis University; Berger, Laurent, École Normale Superieure de Lyon; Böckle, Gebhard, Universität Duisburg-Essen; Colmez, Pierre, CNRS; Dettweiler, Michael, Universität Heidelberg; Diamond, Fred, King's College London; Dieulefait, Luis, Universitat de Barcelona; Dimitrov, Mladen, Université Denis-Diderot Paris 7; Harris, Michael, Jussieu, Paris; Katz, Nicholas, Princeton University; Paskunas, Vytautas, Universität Bielefeld; Ramakrishnan, Dinakar, Caltech University; Serre, Jean-Pierre, Collège de France; Tilouine, Jacques, Université de Paris XIII; Wiese, Gabor, Institut für Experimentelle Mathematik.
Information: http://www.crm.cat/cmodular.

* 11–14 **24th European Conference on Operational Research (EURO XXIV)**, FCUL - University of Lisbon, Lisbon, Portugal.
Description: This large conference is organized by EURO (The Association of European O.R. Societies) and APDIO (The Portuguese O.R. Society). All researchers, academicians, practitioners, as well as students interested in any branch of operational research, mathematical modelling or economic analysis are invited to participate in the conference and to present their papers. Abstract submission and registration are done online, via the Conference web page.
Deadline: For abstract submission: February 28, 2010.
Information: http://www.euro2010lisbon.org.

* 13–17 **5th International Conference on Origami in Science, Mathematics and Education (5OSME)**, Singapore Management University, Singapore, Singapore.
Description: Provides a platform for researchers, educators and artists to share and explore new ideas at the crossroads of origami, science, technology, mathematics, education and art. Conference: (Tuesday July 13; Thursday July 15). The conference starts with an evening reception on Tuesday, followed by two days of concurrent sessions covering origami in mathematics, science, engineering, education, art and design. Professor Erik Demaine and Dr. Robert J. Lang will present keynote lectures during the conference. Convention: (Friday July 16; Saturday July 17). Following the conference is a two-day origami convention, which includes folding classes, free folding sessions, an exhibition and more!
Information: http://www.origami-usa.org/5osme.

* 15–30 **XIII Summer Diffiety School**, Santo Stefano del Sole (Avellino), Italy.
Description: The aim of this permanent school is to introduce undergraduate and Ph.D. students in Mathematics and Physics as well as post-doctoral researchers in a recently emerged area of Mathematics and Theoretical Physics: Secondary Calculus. A "diffiety" is a new geometrical object that properly formalizes the concept of the solution space of a given system of (nonlinear) PDEs, much as an algebraic variety does with respect to solutions of a given system of algebraic equations. Secondary Calculus is a natural diffiety analogue of the standard Calculus on smooth manifolds, and as such leads to a very rich general theory of nonlinear PDEs. It appears that it is this the only natural language of quantum physics, just as the standard Calculus is for classical physics.
Information: http://school.diffiety.org/page3/page0/page112/page112.html

* 27–31 **LinStat'2010 - International Conference on Trends and Perspectives in Linear Statistical Inference**, Polytechnic Institute of Tomar, Portugal.
Description: The aim of the conference is to bring together researchers sharing an interest in a variety of aspects of statistics and its applications and offer them a possibility to discuss current developments in these subjects. The format of this meeting will involve plenary talks and sessions with contributed talks. The conference will mainly focus on a number of topics: estimation, prediction and testing in linear models, robustness of relevant statistical methods, estimation of variance components appearing in linear models, generalizations to nonlinear models, design and analysis of experiments, including optimality and comparison of linear experiments. The work of young scientists has a special position in the LINSTAT 2010 to encourage and promote them. The best poster as well as the best talk will be chosen. Prizes will be awarded to graduate students or scientists with a recently completed Ph.D. Prize-winning works will be widely publicized and promoted by the conference.
Information: http://www.linstat2010@ipt.pt.

August 2010

* 15–19 **Geometric, Asymptotic, Combinatorial Group Theory with Applications (GAGTA)**, Centre de recherches mathématiques, Université de Montréal, Pavillon André-Aisenstadt, 2920, Chemin de la tour, room 5357, Montréal (Québec), H3T 1J4 Canada.
Description: This workshop will be devoted to the study of a variety of topics in geometric and asymptotic group theory, with special emphasis on statistical methods and their applications (in theoretical cryptography). We have contributed to the organization of three similar conferences: in Manresa (Spain) in 2006, in Dortmund (Germany) in 2007, in New York in March 2008. We plan to gather leading specialists in various aspects of geometric, asymptotic, and algorithmic group theory. More specifically, the workshop topics will include quasi-isometries, isoperimetric functions, function growth, asymptotic invariants, random walks, algorithmic problems, etc.

Information: http://www.crm.umontreal.ca/GT2010/index.php/.

* 23–27 **Topics in Algorithmic and Geometric Group and Semigroup Theory**, Centre de recherches mathèmatiques, Université de Montréal, Pavillon André-Aisenstadt, 2920, Chemin de la tour, room 5357, Montréal (Québec) H3T 1J4 Canada.
Description: During the past 20 years, geometric group theory has developed many different facets, including relations with geometry, topology, analysis, and logic. The new, more geometric, perspectives have enabled rapid progress on many of these fronts. A tremendous solidification of previously disparate results has also occurred. In algorithmic group theory, in recent years, more and more interconnections between computer science and classical group and semigroup theory have been discovered. Automata theory has motivated the definition of new classes of groups, for instance, automaton groups and automatic groups. Techniques from rewriting theory, data compression, and automata theory are used in order to solve more efficiently word problems as well as other computational problems in (semi)group theory. The program of the workshop will capitalize on this recent surge of activity in both areas.
Information: http://www.crm.umontreal.ca/GT2010/index.php.

* 30–September 3 **Complexity and Group-based Cryptography**, Centre de recherches mathématiques, Université de Montréal, Pavillon André-Aisenstadt, 2920, Chemin de la tour, room 5357, Montréal (Québec) H3T 1J4 Canada.
Description: Building a solid mathematical foundation for the use of infinite groups in cryptography inevitably involves operating with various asymptotic and statistical aspects of infinite groups, and this is where modern group theory finds its important applications. We plan to invite specialists in group and number theory, computer science, and cryptography.
Information: http://www.crm.umontreal.ca/GT2010/index.php.

September 2010

* 2–4 **Moduli spaces**, Institut de Recherche Mathématique Avancée, University of Strasbourg, France.
Description: The focus is on moduli spaces. The conference is part of the series "Encounters between mathematicians and theoretical physicists". There will be survey lectures and specialized talks.
Speakers: Louis Funar (Grenoble), Lisa Jeffrey (Toronto), Dieter Kotschick (Muenchen), Kirill Krasnov (Nottingham), Andrei Losev (ITEP, Moscow), Feng Luo (Rutgers U.) Nikita Nekrasov (IHES), Sergei Oblezin (ITEP, Moscow), Jean-Marc Schlenker (Toulouse), Sergei Tabachnikov (Penn. State), Richard Wentworth (Maryland).
Organizers: Vladimir Fock (email: fock@math.u-strasbg.fr) and Athanase Papadopoulos (email: papadop@math.u-strasbg.fr).
Information: http://www-irma.u-strasbg.fr/spip.php?article915.

October 2010

* 4–9 **Group Actions and Dynamics**, Centre de recherches mathématiques, Université de Montréal, Pavillon André-Aisenstadt, 2920, Chemin de la tour, room 5357, Montréal (Québec) H3T 1J4 Canada.
Description: In his seminal book "Trees", Serre laid down the fundamentals of the theory of groups acting freely on simplicial trees. In the following decade Serre's novel approach unified several geometric, algebraic, and combinatorial methods of group theory into a unique powerful tool, known today as Bass-Serre Theory. Topologists became interested in R-trees with the work of Morgan and Shalen (1985) which generalized parts of Thurston's Geometrization Theorem. A joint effort of several researchers culminated in a description of finitely generated groups acting freely on R-trees, which is now known as Rips' theorem. The key ingredient of the theory is the so-called "Rips machine". The idea of the Rips machine comes from Makanin's algorithm (or elimination process) for solving equations in free groups.
Information: http://www.crm.umontreal.ca/GT2010/index.php.

* 10–15 **International Conference in Systems Biology (ICSB)**, Edinburgh International Conference Centre, The Exchange, Edinburgh, EH3 8EE, Scotland.
Description: The leading international conference in Systems Biology, covering all aspects of the field. This conference is held annually attracting up to 1000 participants from across the globe and provides a ideal platform for catalysing international collaboration and showcasing the latest developments in the field.
Information: http://www.icsb2010.org.uk/.

* 11–15 **Equations and First-order Properties in Groups**, Centre de recherches mathématiques, Université de Montrèal, Pavillon André-Aisenstadt, 2920, Chemin de la tour, room 5357 Montréal (Québec) H3T 1J41 Canada
Description: Solving equations is one of the main topics in mathematics. A more general and more difficult problem is to describe which formulas of the first-order logic hold in a given group. Recent works on the Tarski's problems (Kharlampovich, Miasnikov, Sela) opened a new direction of research called now "Algebraic geometry over groups". We are going to discuss some methods and techniques used for the solution of these problems, and developments in the algebraic geometry for groups, Lie Algebras, and other algebraic systems.
Information: http://www.crm.umontreal.ca/GT2010/index.php.

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.

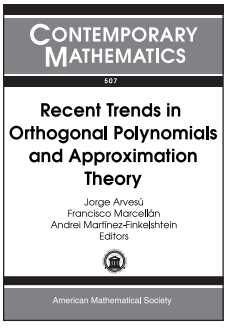
March 2011

* 14–June 17 **Navigating Chemical Compound Space for Materials and BioDesign**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.
Overview: This long program will bring together senior as well as junior researchers of diverse scientific communities, which are involved in addressing the question of how to best navigate chemical compound space, such that they can discuss current bottlenecks with each other and, in particular, with the applied mathematics community. It is expected to lead to fruitful collaborations where all participants benefit largely from mathematical insights on their specific optimization and design problems.
Organizing Committee: Anatole von Lilienfeld, Jean-Loup Faulon, William Hart, Kendall Houk, Peter Jones, Steven Lustig, Tamar Seideman, Mark Tuckerman.
Application: An application form is available at: http://www.ipam.ucla.edu/programs/ccs2011. Applications for individual workshops will be posted on individual workshop home pages. Encouraging the careers of women and minority mathematicians and scientists is an important component of IPAM's mission and we welcome their applications.
Information: http://www.ipam.ucla.edu/programs/ccs2011/.

New Publications Offered by the AMS

To subscribe to email notification of new AMS publications, please go to http://www.ams.org/bookstore-email.

Algebra and Algebraic Geometry



Recent Trends in Orthogonal Polynomials and Approximation Theory

Jorge Arvesú and **Francisco Marcellán**, *Universidad Carlos III de Madrid, Leganés, Spain*, and **Andrei Martínez-Finkelshtein**, *Universidad de Almería, Spain*, Editors

This volume contains invited lectures and selected contributions from the International Workshop on Orthogonal Polynomials and Approximation Theory, held at Universidad Carlos III de Madrid on September 8–12, 2008, and which honored Guillermo López Lagomasino on his 60th birthday.

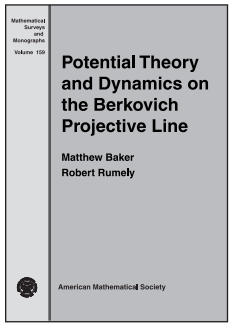
This book presents the state of the art in the theory of orthogonal polynomials and rational approximation with a special emphasis on their applications in random matrices, integrable systems, and numerical quadrature. New results and methods are presented in the papers as well as a careful choice of open problems, which can foster interest in research in these mathematical areas. This volume also includes a brief account of the scientific contributions by Guillermo López Lagomasino.

This item will also be of interest to those working in analysis.

Contents: F. Marcellán and **A. Martínez-Finkelshtein**, Guillermo López Lagomasino: Mathematical life; **B. de la Calle Ysern**, A walk through approximation theory; **L. Baratchart** and **M. Yattselev**, Asymptotic uniqueness of best rational approximants to complex Cauchy transforms in L^2 of the circle; **L. Garza** and **F. Marcellán**, Quadrature rules on the unit circle. A survey.; **A. Ibort**, **P. Linares**, and **J. G. Llavona**, On the multilinear trigonometric problem of moments; **A. B. J. Kuijlaars**, Multiple orthogonal polynomial ensembles; **E. Levin** and **D. S. Lubinsky**, Some equivalent formulations of universality limits in the bulk; **A. López García**, Greedy energy points with external fields; **A. Martínez-Finkelshtein** and **E. A. Rakhmanov**, On asymptotic behavior of Heine-Stieltjes and Van Vleck polynomials; **E. B. Saff**, Remarks on relative asymptotics for general orthogonal polynomials; **B. Simon**, Fine structure of the zeros of orthogonal polynomials: A progress report; **H. Stahl**, A potential-theoretic problem connected with complex orthogonality; **W. Van Assche**, Orthogonal polynomials and approximation theory: Some open problems.

Contemporary Mathematics, Volume 507

March 2010, 298 pages, Softcover, ISBN: 978-0-8218-4803-6, LC 2009040384, 2000 *Mathematics Subject Classification:* 15A52, 26C10, 30E10, 31A15, 31C15, 33C47, 41A20, 42C05, 44A60, 65D32, **AMS members US$71**, List US$89, Order code CONM/507



Potential Theory and Dynamics on the Berkovich Projective Line

Matthew Baker, *Georgia Institute of Technology, Atlanta, GA*, and **Robert Rumely**, *University of Georgia, Athens, GA*

The purpose of this book is to develop the foundations of potential theory and rational dynamics on the Berkovich projective line over an arbitrary complete, algebraically closed non-Archimedean field. In addition to providing a concrete and "elementary" introduction to Berkovich analytic spaces and to potential theory and rational iteration on the Berkovich line, the book contains applications to arithmetic geometry and arithmetic dynamics. A number of results in the book are new, and most have not previously appeared in book form. Three appendices—on analysis, $\mathbb{R}$-trees, and Berkovich's general theory of analytic spaces—are included to make the book as self-contained as possible.

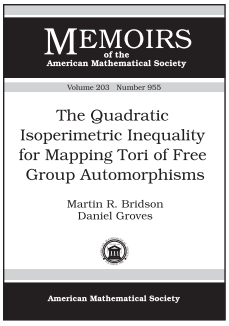
The authors first give a detailed description of the topological structure of the Berkovich projective line and then introduce the Hsia kernel, the fundamental kernel for potential theory. Using the theory of metrized graphs, they define a Laplacian operator on the Berkovich line and construct theories of capacities, harmonic and subharmonic functions, and Green's functions, all of which are strikingly similar to their classical complex counterparts. After developing a theory of multiplicities for rational functions, they

give applications to non-Archimedean dynamics, including local and global equidistribution theorems, fixed point theorems, and Berkovich space analogues of many fundamental results from the classical Fatou-Julia theory of rational iteration. They illustrate the theory with concrete examples and exposit Rivera-Letelier's results concerning rational dynamics over the field of p-adic complex numbers. They also establish Berkovich space versions of arithmetic results such as the Fekete-Szegö theorem and Bilu's equidistribution theorem.

Contents: The Berkovich unit disc; The Berkovich projective line; Metrized graphs; The Hsia kernel; The Laplacian on the Berkovich projective line; Capacity theory; Harmonic functions; Subharmonic functions; Multiplicities; Applications to the dynamics of rational maps; Some results from analysis and topology; $\mathbb{R}$-trees and Gromov hyperbolicity; Brief overview of Berkovich's theory; Bibliography; Index.

Mathematical Surveys and Monographs, Volume 159

March 2010, approximately 454 pages, Hardcover, ISBN: 978-0-8218-4924-8, LC 2009036372, 2000 *Mathematics Subject Classification:* 14G20; 14G22, 14G40, 37F10, 37F99, 31C05, 31C15, 31C45, **AMS members US$88**, List US$110, Order code SURV/159



The Quadratic Isoperimetric Inequality for Mapping Tori of Free Group Automorphisms

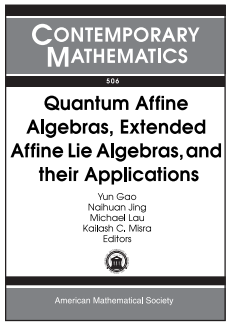
Martin R. Bridson, *Mathematical Institute, Oxford, England*, and **Daniel Groves**, *University of Illinois at Chicago, IL*

This item will also be of interest to those working in geometry and topology.

Contents: Positive automorphisms; Train tracks and the beaded decomposition; The general case; Bibliography; Index.

Memoirs of the American Mathematical Society, Volume 203, Number 955

January 2010, 152 pages, Softcover, ISBN: 978-0-8218-4631-5, LC 2009042849, 2000 *Mathematics Subject Classification:* 20F65; 20F06, 20E36, 57M07, **Individual member US$44**, List US$74, Institutional member US$59, Order code MEMO/203/955



Quantum Affine Algebras, Extended Affine Lie Algebras, and their Applications

Yun Gao, *York University, Toronto, ON, Canada*, **Naihuan Jing**, *North Carolina State University, Raleigh, NC*, **Michael Lau**, *University of Windsor, ON, Canada*, and **Kailash C. Misra**, *North Carolina State University, Raleigh, NC*, Editors

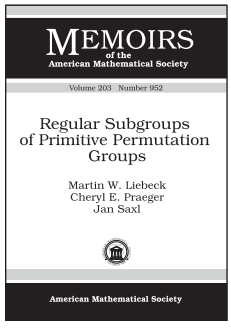
This volume contains the proceedings of the conference on Quantum Affine Algebras, Extended Affine Lie Algebras, and Applications, which was held at the Banff International Research Station, Banff, Canada, from March 2–7, 2008.

Many of the papers include new results on different aspects of quantum affine algebras, extended affine Lie algebras, and their applications in other areas of mathematics and physics. Any reader interested in learning about the recent developments in quantum affine algebras and extended affine Lie algebras will benefit from this book.

Contents: B. Allison and **G. Benkart**, Unitary Lie algebras and Lie tori of type $BC_r, r \geq 3$; **V. Chari** and **D. Hernandez**, Beyond Kirillov–Reshetikhin modules; **X. Chen** and **K.-B. Nam**, Root vectors and an integral PBW basis of composition algebra of the valued graph $A_2^{(2)}$; **B. Cox**, **V. Futorny**, and **K. C. Misra**, Imaginary Verma modules and Kashiwara algebras for $U_q(\widehat{\mathfrak{sl}(2)})$; **G. Fourier**, **M. Okado**, and **A. Schilling**, Perfectness of Kirillov–Reshetikhin crystals for nonexceptional types; **Y. Pei**, **N. Hu**, and **M. Rosso**, Multiparameter quantum groups and quantum shuffles, (I); **J. Morita**, Tilings, Lie theory and combinatorics; **E. Mukhin**, **V. Tarasov**, and **A. Varchenko**, The $\mathfrak{gl}_2$ Bethe algebra associated with a nilpotent element; **M. Igarashi** and **T. Nakashima**, Affine geometric crystal of type $D_4^{(3)}$; **K.-H. Neeb**, Unitary highest weight modules of locally affine Lie algebras; **P. Senesi**, Finite-dimensional representation theory of loop algebras: A survey; **Y. Yoshii**, Locally extended affine root systems.

Contemporary Mathematics, Volume 506

February 2010, approximately 303 pages, Softcover, ISBN: 978-0-8218-4507-3, LC 2009037983, 2000 *Mathematics Subject Classification:* 17B10, 17B37, 17B65, 17B67, **AMS members US$71**, List US$89, Order code CONM/506



Regular Subgroups of Primitive Permutation Groups

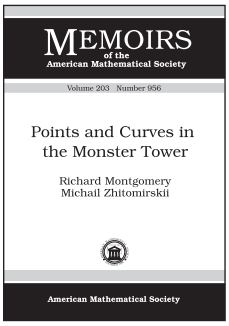
Martin W. Liebeck, *Imperial College, London, England*, **Cheryl E. Praeger**, *University of Western Australia, Crawley, Australia*, and **Jan Saxl**, *University of Cambridge, England*

Contents: Introduction; Preliminaries; Transitive and antiflag transitive linear groups; Subgroups of classical groups transitive on

subspaces; Proof of Theorem 1.1: Linear groups; Proof of Theorem 1.1: Unitary groups; Proof of Theorem 1.1: Orthogonal groups in odd dimension; Proof of Theorem 1.1: Orthogonal groups of minus type; Proof of Theorem 1.1: Some special actions of symplectic and orthogonal groups; Proof of Theorem 1.1: Remaining symplectic cases; Proof of Theorem 1.1: Orthogonal groups of plus type; Proof of Theorem 1.1: Exceptional groups of Lie type; Proof of Theorem 1.1: Alternating groups; Proof of Theorem 1.1: Sporadic groups; Proof of Theorem 1.4 and Corollary 1.3; The tables in Theorem 1.1; References.

Memoirs of the American Mathematical Society, Volume 203, Number 952

January 2010, 74 pages, Softcover, ISBN: 978-0-8218-4654-4, LC 2009041395, 2000 *Mathematics Subject Classification:* 20B15, 05C25, **Individual member US$38**, List US$64, Institutional member US$51, Order code MEMO/203/952



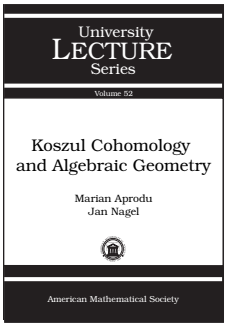
Points and Curves in the Monster Tower

Richard Montgomery, *University of California, Santa Cruz, CA*, and **Michail Zhitomirskii**, *Technion–Israel Institute of Technology, Haifa, Israel*

Contents: Introduction; Prolongations of integral curves. Regular, vertical, and critical curves and points; RVT classes. RVT codes of plane curves. RVT and Puiseux; Monsterization and Legendrization. Reduction theorems; Reduction algorithm. Examples of classification results; Determination of simple points; Local coordinate systems on the Monster; Prolongations and directional blow-up. Proof of Theorems A and B; Open questions; Appendix A. Classification of integral Engel curves; Appendix B. Contact classification of Legendrian curves; Appendix C. Critical, singular and rigid curves; Bibliography; Index.

Memoirs of the American Mathematical Society, Volume 203, Number 956

January 2010, 137 pages, Softcover, ISBN: 978-0-8218-4818-0, LC 2009041682, 2000 *Mathematics Subject Classification:* 58A30; 58A17, 53A55, 58K55, **Individual member US$43**, List US$72, Institutional member US$58, Order code MEMO/203/956



Koszul Cohomology and Algebraic Geometry

Marian Aprodu, *Institute of Mathematics 'Simion Stoilow' of the Romanian Academy, Bucharest, Romania*, and **Jan Nagel**, *Université de Bourgogne, Dijon, France*

The systematic use of Koszul cohomology computations in algebraic geometry can be traced back to the foundational work of Mark Green in the 1980s. Green connected classical results concerning the ideal of a projective variety with vanishing theorems for Koszul cohomology. Green and Lazarsfeld also stated two conjectures that relate the Koszul cohomology of algebraic curves with the existence of special divisors on the curve. These conjectures became an important guideline for future research. In the intervening years, there has been a growing interaction between Koszul cohomology and algebraic geometry. Green and Voisin applied Koszul cohomology to a number of Hodge-theoretic problems, with remarkable success. More recently, Voisin achieved a breakthrough by proving Green's conjecture for general curves; soon afterwards, the Green-Lazarsfeld conjecture for general curves was proved as well.

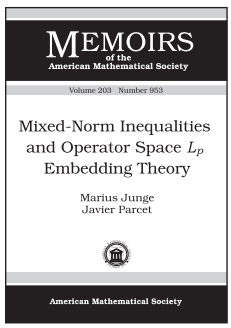
This book is primarily concerned with applications of Koszul cohomology to algebraic geometry, with an emphasis on syzygies of complex projective curves. The authors' main goal is to present Voisin's proof of the generic Green conjecture, and subsequent refinements. They discuss the geometric aspects of the theory and a number of concrete applications of Koszul cohomology to problems in algebraic geometry, including applications to Hodge theory and to the geometry of the moduli space of curves.

Contents: Basic definitions; Basic results; Syzygy schemes; The conjectures of Green and Green-Lazarsfeld; Koszul cohomology and the Hilbert scheme; Koszul cohomology of a $K3$ surface; Specific versions of the syzygy conjectures; Applications; Bibliography; Index.

University Lecture Series, Volume 52

January 2010, 125 pages, Softcover, ISBN: 978-0-8218-4964-4, LC 2009042378, 2000 *Mathematics Subject Classification:* 14H51, 14C20, 14H60, 14J28, 13D02, 16E05, **AMS members US$31**, List US$39, Order code ULECT/52

Analysis



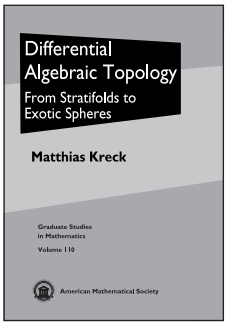
Mixed-Norm Inequalities and Operator Space L_p Embedding Theory

Marius Junge, *University of Illinois at Urbana-Champaign, IL*, and **Javier Parcet**, *Instituto de Ciencias Matemáticas CSIC-UAM-UC3M-UCM, Madrid, Spain*

Contents: Introduction; Noncommutative integration; Amalgamated L_p spaces; An interpolation theorem; Conditional L_p spaces; Intersections of L_p spaces; Factorization of $\mathcal{J}^n_{p,q}(\mathcal{M}, \mathsf{E})$; Mixed-norm inequalities; Operator space L_p embeddings; Bibliography.

Memoirs of the American Mathematical Society, Volume 203, Number 953

January 2010, 155 pages, Softcover, ISBN: 978-0-8218-4655-1, LC 2009041393, 2000 *Mathematics Subject Classification:* 46L07, 46L09, 46L51, 46L52, 46L53, **Individual member US$44**, List US$74, Institutional member US$59, Order code MEMO/203/953



Differential Algebraic Topology

From Stratifolds to Exotic Spheres

Matthias Kreck, *Hausdorff Research Institute for Mathematics, Bonn, Germany*

This book presents a geometric introduction to the homology of topological spaces and the cohomology of smooth manifolds. The author introduces a new class of stratified spaces, so-called stratifolds. He derives basic concepts from differential topology such as Sard's theorem, partitions of unity and transversality. Based on this, homology groups are constructed in the framework of stratifolds and the homology axioms are proved. This implies that for nice spaces these homology groups agree with ordinary singular homology. Besides the standard computations of homology groups using the axioms, straightforward constructions of important homology classes are given. The author also defines stratifold cohomology groups following an idea of Quillen. Again, certain important cohomology classes occur very naturally in this description, for example, the characteristic classes which are constructed in the book and applied later on. One of the most fundamental results, Poincaré duality, is almost a triviality in this approach.

Some fundamental invariants, such as the Euler characteristic and the signature, are derived from (co)homology groups. These invariants play a significant role in some of the most spectacular results in differential topology. In particular, the author proves a special case of Hirzebruch's signature theorem and presents as a highlight Milnor's exotic 7-spheres.

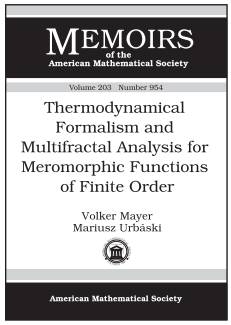
This book is based on courses the author taught in Mainz and Heidelberg. Readers should be familiar with the basic notions of point-set topology and differential topology. The book can be used for a combined introduction to differential and algebraic topology, as well as for a quick presentation of (co)homology in a course about differential geometry.

This item will also be of interest to those working in geometry and topology.

Contents: A quick introduction to stratifolds; Smooth manifolds revisited; Stratifolds; Stratifolds with boundary: c-stratifolds; $\mathbb{Z}/2$-homology; The Mayer-Vietoris sequence and homology groups of spheres; Brouwer's fixed point theorem, separation, invariance of dimension; Homology of some important spaces and the Euler characteristic; Integral homology and the mapping degree; A comparison theorem for homology theories and CW-complexes; Künneth's theorem; Some lens spaces and quaternionic generalizations; Cohomology and Poincaré duality; Induced maps and the cohomology axioms; Products in cohomology and the Kronecker pairing; The signature; The Euler class; Chern classes and Stiefel-Whitney classes; Pontrjagin classes and applications to bordism; Exotic 7-spheres; Relation to ordinary singular (co)homology; Appendix A: Constructions of stratifolds; Appendix B: The detailed proof of the Mayer-Vietoris sequence; Appendix C: The tensor product; Bibliography; Index.

Graduate Studies in Mathematics, Volume 110

March 2010, approximately 215 pages, Hardcover, ISBN: 978-0-8218-4898-2, 2000 *Mathematics Subject Classification:* 55-01, 55R40, 57-01, 57R20, 57R55, **AMS members US$44**, List US$55, Order code GSM/110



Thermodynamical Formalism and Multifractal Analysis for Meromorphic Functions of Finite Order

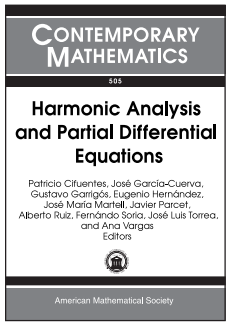
Volker Mayer, *Université de Lille I, Villeneuve d'Ascq, France*, and **Mariusz Urbański**, *University of North Texas, Denton, TX*

Contents: Introduction; Balanced functions; Transfer operator and Nevanlinna theory; Preliminaries, Hyperbolicity and distortion properties; Perron-Frobenius operators and generalized conformal measures; Finer properties of Gibbs states; Regularity of Perron-Frobenius operators and topological pressure; Multifractal analysis; Multifractal analysis of analytic families of dynamically regular functions; Bibliography; Index.

Memoirs of the American Mathematical Society, Volume 203, Number 954

January 2010, 107 pages, Softcover, ISBN: 978-0-8218-4659-9, LC 2009041681, 2000 *Mathematics Subject Classification:* 30D05, 37F10, **Individual member US$41**, List US$68, Institutional member US$54, Order code MEMO/203/954

Differential Equations



Harmonic Analysis and Partial Differential Equations

Patricio Cifuentes, José García-Cuerva, Gustavo Garrigós, Eugenio Hernández, José María Martell, Javier Parcet, Alberto Ruiz, Fernando Soria, José Luis Torrea, and **Ana Vargas**, *Universidad Autónoma de Madrid, Spain*, editors

This volume contains the proceedings of the 8th International Conference on Harmonic Analysis and Partial Differential Equations, held in El Escorial, Madrid, Spain, on June 16–20, 2008.

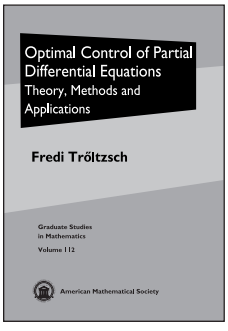
Featured in this book are papers by Steve Hoffmann and Carlos Kenig, which are based on two mini-courses given at the conference. These papers present topics of current interest, which assume minimal background from the reader, and represent state-of-the-art research in a useful way for young researchers. Other papers in this

volume cover a range of fields in Harmonic Analysis and Partial Differential Equations and, in particular, illustrate well the fruitful interplay between these two fields.

Contents: A. Cohen, **W. Dahmen**, and **R. DeVore**, Instance optimal decoding by thresholding in compressed sensing; **S. Hofmann**, Local $T(b)$ theorems and applications in PDE; **C. E. Kenig**, The global behavier of solutions to critical nonlinear dispersive and wave equations; **P. Auscher** and **J. M. Martell**, Weighted norm inequalities, off-diagonal estimates and elliptic operators; **J. Bennett**, Heat-flow monotonicity related to some inequalities in euclidean analysis; **A. Carbery**, A uniform sublevel set estimate; **P. Auscher**, **A. Axelsson**, and **A. McIntosh**, On a quadratic estimate related to the Kato conjecture and boundary value problems; **C. Muscalu**, Flag paraproducts; **J. Ortega-Cerdà** and **B. Pridhnani**, The Pólya-Tchebotarëv problem; **M. T. Lacey**, **S. Petermichl**, **J. C. Pipher**, and **B. D. Wick**, Iterated Riesz commutators: A simple proof of boundedness; **G. Garrigós** and **A. Seeger**, A mixed norm variant of Wolff's inequality for paraboloids; **S. Thangavelu**, On the unreasonable effectiveness of Gutzmer's formula; **L. Vega**, Bilinear virial identities and oscillatory integrals; **E. Hernández**, **H. Šikić**, **G. Weiss**, and **E. Wilson**, On the properties of the integer translates of a square integrable function.

Contemporary Mathematics, Volume 505

February 2010, 249 pages, Softcover, ISBN: 978-0-8218-4770-1, LC 2009036374, 2000 *Mathematics Subject Classification:* 35-XX, 42-XX, 47-XX, 52-XX, 53-XX, 58-XX, 65-XX, 94-XX, 30-XX, 26-XX, **AMS members US$63**, List US$79, Order code CONM/505



Optimal Control of Partial Differential Equations

Theory, Methods and Applications

Fredi Tröltzsch, *Technische Universität Berlin, Germany*
Translated by Jürgen Sprekels

Optimal control theory is concerned with finding control functions that minimize cost functions for systems described by differential equations. The methods have found widespread applications in aeronautics, mechanical engineering, the life sciences, and many other disciplines.

This book focuses on optimal control problems where the state equation is an elliptic or parabolic partial differential equation. Included are topics such as the existence of optimal solutions, necessary optimality conditions and adjoint equations, second-order sufficient conditions, and main principles of selected numerical techniques. It also contains a survey on the Karush-Kuhn-Tucker theory of nonlinear programming in Banach spaces.

The exposition begins with control problems with linear equation, quadratic cost function and control constraints. To make the book self-contained, basic facts on weak solutions of elliptic and parabolic equations are introduced. Principles of functional analysis are introduced and explained as they are needed. Many simple examples illustrate the theory and its hidden difficulties. This start to the book makes it fairly self-contained and suitable for advanced undergraduates or beginning graduate students.

Advanced control problems for nonlinear partial differential equations are also discussed. As prerequisites, results on boundedness and continuity of solutions to semilinear elliptic and parabolic equations are addressed. These topics are not yet readily available in books on PDEs, making the exposition also interesting for researchers.

Alongside the main theme of the analysis of problems of optimal control, Tröltzsch also discusses numerical techniques. The exposition is confined to brief introductions into the basic ideas in order to give the reader an impression of how the theory can be realized numerically. After reading this book, the reader will be familiar with the main principles of the numerical analysis of PDE-constrained optimization.

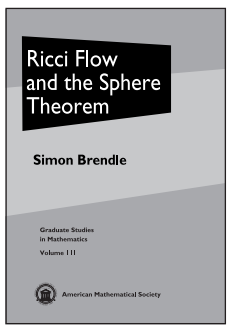
This item will also be of interest to those working in applications.

Contents: Introduction and examples; Linear-quadratic elliptic control problems; Linear-quadratic parabolic control problems; Optimal control of semilinear elliptic equations; Optimal control of semilienar parabolic equations; Optimization problems in Banach spaces; Supplementary results on partial differential equations; Bibliography; Index.

Graduate Studies in Mathematics, Volume 112

February 2010, approximately 408 pages, Hardcover, ISBN: 978-0-8218-4904-0, LC 2009037756, 2000 *Mathematics Subject Classification:* 49-01, 49K20, 35J65, 35K60, 90C48, 35B37, **AMS members US$55**, List US$69, Order code GSM/112

Geometry and Topology



Ricci Flow and the Sphere Theorem

Simon Brendle, *Stanford University, CA*

In 1982, R. Hamilton introduced a nonlinear evolution equation for Riemannian metrics with the aim of finding canonical metrics on manifolds. This evolution equation is known as the Ricci flow, and it has since been used widely and with great success, most notably in Perelman's solution of the Poincaré conjecture. Furthermore, various convergence theorems have been established.

This book provides a concise introduction to the subject as well as a comprehensive account of the convergence theory for the Ricci flow. The proofs rely mostly on maximum principle arguments. Special emphasis is placed on preserved curvature conditions, such as positive isotropic curvature. One of the major consequences of this theory is the Differentiable Sphere Theorem: a compact Riemannian manifold whose sectional curvatures all lie in the interval (1,4] is diffeomorphic to a spherical space form. This question has a long history, dating back to a seminal paper by H. E. Rauch in 1951, and it was resolved in 2007 by the author and Richard Schoen.

This text originated from graduate courses given at ETH Zürich and Stanford University, and is directed at graduate students and researchers. The reader is assumed to be familiar with basic Riemannian geometry, but no previous knowledge of Ricci flow is required.

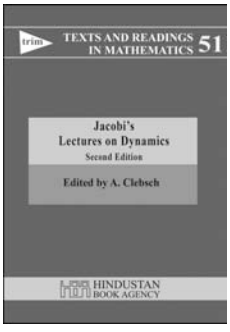
Contents: A survey of sphere theorems in geometry; Hamilton's Ricci flow; Interior estimates; Ricci flow on S^2; Pointwise curvature estimates; Curvature pinching in dimension 3; Preserved curvature conditions in higher dimensions; Convergence results in higher dimensions; Rigidity results; Convergence of evolving metrics; Results from complex linear algebra; Problems; Bibliography; Index.

Graduate Studies in Mathematics, Volume 111

February 2010, 176 pages, Hardcover, ISBN: 978-0-8218-4938-5, LC 2009037261, 2000 *Mathematics Subject Classification:* 53C20, 53C21, 53C44, **AMS members US$38**, List US$47, Order code GSM/111

New AMS-Distributed Publications

Differential Equations



Jacobi's Lectures on Dynamics

Second Edition

A. Clebsch, Editor

The name of C. G. J. Jacobi is familiar to every student of mathematics, thanks to the Jacobion determinant, the Hamilton-Jacobi equations in dynamics, and the Jacobi identity for vector fields. Best known for his contributions to the theory of elliptic and abelian functions, Jacobi is also known for his innovative teaching methods and for running the first research seminar in pure mathematics.

A record of his lectures on Dynamics given in 1842–43 at Königsberg, edited by A. Clebsch, has been available in the original German. This is an English translation. It is not just a historical document; the modern reader can learn much about the subject directly from one of its great masters.

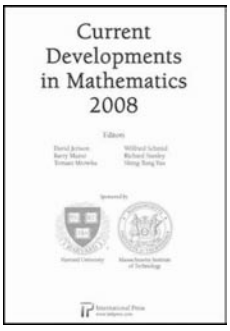
A publication of Hindustan Book Agency. Distributed on an exclusive basis by the AMS in North America. Online bookstore rights worldwide.

Contents: Introduction; The differential equations of motion; Conservation of motion of centre of gravity; The principle of conservation of 'vis viva'; Conservation of surface area; The principle of least action; Further considerations on the principle of least action—The Lagrange multipliers; Hamilton's integral and Lagrange's second form of dynamical equations; Hamilton's form of the equation of motion; The principle of the last multiplier; Survey of those properties of determinants that are used in the theory of the last multiplier; The multiplier for systems of differential equations with an arbitrary number of variables; Functional determinants. Their application in setting up the partial differential equation for the multiplier; The second form of the equation defining the multiplier. The multipliers of step wise reduced differential equations. The multiplier by the use of particular integrals; The multiplier for systems of differential equations with higher differential coefficients. Applications to a system of mass points without constraints; Examples of the search for multipliers. Attraction of a point by a fixed centre in a resisting medium and in empty space; The multiplier of the equations of motion of a system under constraint in the first Langrange form; The multiplier for the equations of motion of a constrained system in Hamiltonian form; Hamilton's partial differential equation and its extension to the isoperimetric problem; Proof that the integral equations derived from a complete solution of Hamilton's partial differential equation actually satisfy the system of ordinary differential equations. Hamilton's equation for free motion; Investigation of the case in which t does not occur explicitly; Lagrange's method of integration of first order partial differential equations in two independent variables. Application to problems of mechanics which depend only on two defining parameters. The free motion of a point on a plane and the shortest line on a surface; The reduction of the partial differential equation for those problems in which the principle of conservation of centre of gravity holds; Motion of a planet around the sun—Solution in polar coordinates; Solution of the same problem by introducing the distances of the planet from two fixed points; Elliptic coordinates; Geometric significance of elliptic coordinates on the plane and in space. Quadrature of the surface of an ellipsoid. Rectification of its lines of curvature; The shortest line on the tri-axial ellipsoid. The problem of map projection; Attraction of a point by two fixed centres; Abel's theorem; General investigations of the partial differential equations of the first order. Different forms of the integrability conditions; Direct proof of the most general form of the integrability condition. Introduction of the function H, which set equal to an arbitrary constant determines the p as functions of the q; On the simultaneous solutions of two linear partial differential equations; Application of the preceding investigation to the integration of partial differential equations of the first order, and in particular, to the case of mechanics. The theorem on the third integral derived from two given integrals of differential equations of dynamics; The two classes of integrals which one obtains according to Hamilton's method for problems of mechanics. Determination of the value of (φ, ψ) for them; Perturbation theory. Supplement.

Hindustan Book Agency

August 2009, 350 pages, Hardcover, ISBN: 978-81-85931-91-3, 2000 *Mathematics Subject Classification:* 01-01, 70H20, **AMS members US$38**, List US$48, Order code HIN/44

General and Interdisciplinary



Current Developments in Mathematics, 2008

Barry Mazur, **Wilfried Schmid**, and **Shing-Tung Yau**, *Harvard University, Cambridge, MA*, and **David Jerison**, **Tomasz Mrowka**, and **Richard P. Stanley**, *Massachusetts Institute of Technology, Cambridge, MA*, Editors

The Current Developments in Mathematics (CDM) conference is an annual seminar, jointly hosted by Harvard University and the Massachusetts Institute of Technology, devoted to surveying the most recent developments in mathematics. In choosing speakers, the hosts take a broad look at the field of geometry and select geometers who transcend classical perceptions within their field. All speakers are prominent specialists in the fields of algebraic geometry, mathematical physics, and other areas.

A publication of International Press. Distributed worldwide by the American Mathematical Society.

Contents: M. Dafermos, The evolution problem in general relativity; **L. Lovász**, Very large graphs; **J. Lurie**, On the classification of topological field theories; **W. H. Meeks III** and **J. Pérez**, Properly embedded minimal planar domains with infinite topology are Riemann minimal examples; **K. Ono**, Unearthing the visions of a master: Harmonic Maass forms and number theory.

International Press

October 2009, 454 pages, Softcover, ISBN: 978-1-57146-139-1, 2000 *Mathematics Subject Classification:* 53C44, **AMS members US$47**, List US$59, Order code INPR/84

Hans Freudenthal: Selecta

Tonny A. Springer and **Dirk van Dalen**, *Utrecht University, The Netherlands*, Editors

Hans Freudenthal (1905–1990) was a Dutch mathematician, born in Luckenwalde, Germany. His scientific activities were of a rich variety. Enrolling at the University of Berlin as a student in the 1920s, he followed in the footsteps of his teachers and became a topologist, but with a lively interest in group theory. After a long journey through the realm of mathematics, working on almost all subjects that drew his interest, he turned toward the practical and methodological issues of the didactics of mathematics.

The present Selecta are devoted to Freudenthal's mathematical oeuvre. They contain a selection of his major contributions, including his fundamental contributions to topology such as the foundation of the theory of ends (in the thesis of 1931) as well as the introduction (in 1937) of the suspension and its use in stability results for homotopy groups of spheres. In group theory there is work on topological groups (of the 1930s) and on various aspects of the theory of Lie groups, such as a paper on automorphisms of 1941. From the later work of the 1950s and 1960s, papers on geometric aspects of Lie theory (geometries associated to exceptional groups, space problems) have been included.

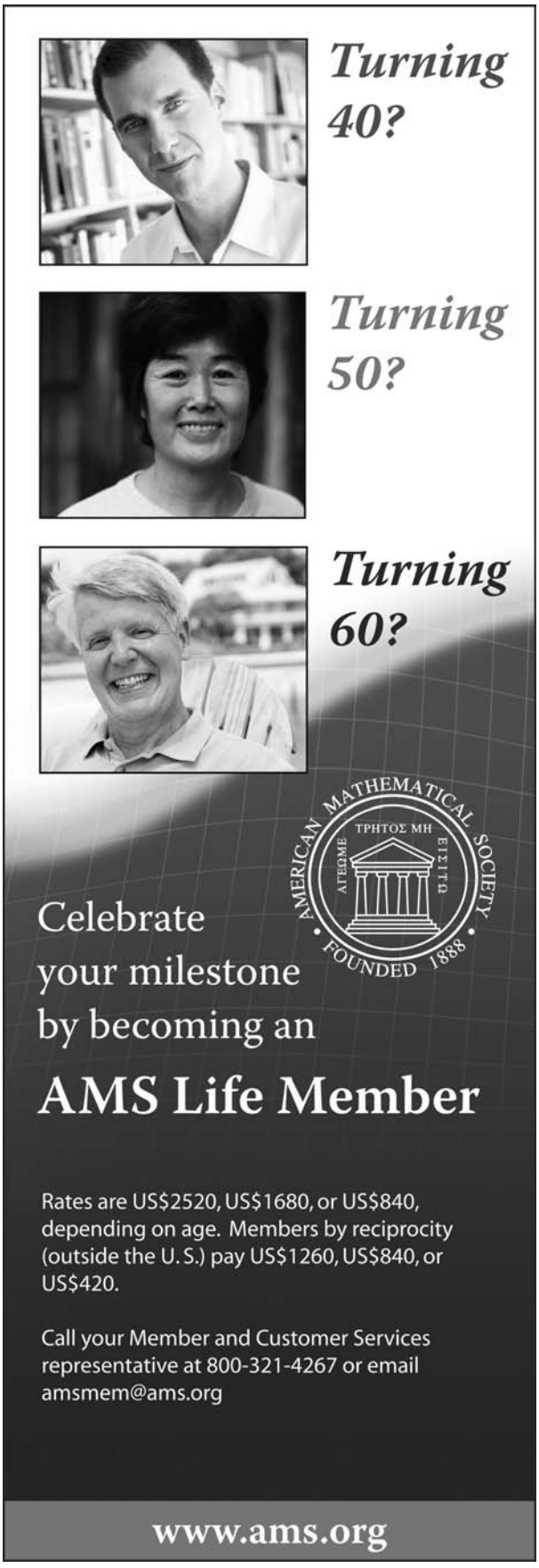
Freudenthal's versatility is further demonstrated by selections from his foundational and historical work: papers on intuitionistic logic and topology, a paper on axiomatic geometry reappraising Hilbert's Grundlagen, and a paper summarizing his development of Lincos, a universal ("cosmic") language.

A publication of the European Mathematical Society (EMS). Distributed within the Americas by the American Mathematical Society.

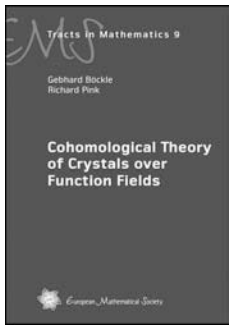
Contents: Biographical note; Ph.D. students of Hans Freudenthal; Über die Enden topologischer Räume und Gruppen; Einige Sätze über topologische Gruppen; Topologische Gruppen mit genügend vielen fastperiodischen Funktionen; Teilweise geordnete Moduln; Über die Friedrichssche Fortsetzung halbbeschränkter Hermitescher Operatoren; Zum intuitionistischen Raumbegriff; Zur intuitionistischen Deutung logischer Formelnm; Entwicklungen von Räumen und Gruppen; Alexanderscher und Gordonscher Ring und ihre Isomorphie; Zum Hopfschen Umkehrhomomorphismus; Über die Klassen der Sphärenabbildungen. I. Große Dimensionen; Die Topologie der Lieschen Gruppen als algebraisches Phänomen; Simplizialzerlegungen von beschränkter Flachheit; Über die Enden diskreter Räume und Gruppen; Oktaven, Ausnahmegruppen und Oktavengeometrie; Sur le groupe exceptionnel E_7; Sur des invariants caractéristiques des groupes semi-simples; Sur le groupe exceptionnel E_8; Zur ebenen Oktavengeometrie; Beziehungen der E_7 und E_8 zur Oktavenebene I; Beziehungen der $\mathfrak{E}_7$ und $\mathfrak{E}_8$ zur Oktavenebene II–XI; Zur Berechnung der Charaktere der halbeinfachen Lieschen Gruppen I–III; Neuere Fassungen des Riemann–Helmholtz–Lieschen Raumproblems; Grundzüge eines Entwurfes einer kosmischen Verkehrssprache; Zur Geschichte der Grundlagen der Geometrie; Zur Klassifikation der einfachen Lie–Gruppen; Symplektische und metasymplektische Geometrien; Bericht über die Theorie der Rosenfeldschen elliptischen Ebenen; Das Helmholtz-Liesche Raumproblem bei indefiniter Metrik; Lie groups in the foundation of geometry; Comments; Acknowledgements; Bibliography.

Heritage of European Mathematics, Volume 3

October 2009, 661 pages, Hardcover, ISBN: 978-3-03719-058-6, 2000 *Mathematics Subject Classification:* 00B60, 01A75, **AMS members US$150**, List US$188, Order code EMSHEM/3



Number Theory



Cohomological Theory of Crystals over Function Fields

Gebhard Böckle, *University of Duisburg-Essen, Germany*, and **Richard Pink**, *ETH-Zürich, Switzerland*

This book develops a new cohomological theory for schemes in positive characteristic p and it applies this theory to give a purely algebraic proof of a conjecture of Goss on the rationality of certain L-functions arising in the arithmetic of function fields. These L-functions are power series over a certain ring A, associated to any family of Drinfeld A-modules or, more generally, of A-motives on a variety of finite type over the finite field $\mathbb{F}_p$. By analogy to the Weil conjecture, Goss conjectured that these L-functions are in fact rational functions. In 1996 Taguchi and Wan gave a first proof of Goss's conjecture by analytic methods à la Dwork.

The present text introduces A-crystals, which can be viewed as generalizations of families of A-motives, and studies their cohomology. While A-crystals are defined in terms of coherent sheaves together with a Frobenius map, in many ways they actually behave like constructible ètale sheaves. A central result is a Lefschetz trace formula for L-functions of A-crystals, from which the rationality of these L-functions is immediate. Beyond its application to Goss's L-functions, the theory of A-crystals is closely related to the work of Emerton and Kisin on unit root F-crystals, and it is essential in an Eichler – Shimura type isomorphism for Drinfeld modular forms as constructed by the first author.

The book is intended for researchers and advanced graduate students interested in the arithmetic of function fields and/or cohomology theories for varieties in positive characteristic. It assumes a good working knowledge in algebraic geometry as well as familiarity with homological algebra and derived categories, as provided by standard textbooks. Beyond that the presentation is largely self contained.

A publication of the European Mathematical Society (EMS). Distributed within the Americas by the American Mathematical Society.

Contents: Introduction; Categorical preparations; Fundamental concepts; Functors; Derived categories; Derived functors; Flatness; Naive L-functions; Crystalline L-functions; Étale cohomology; Bibliography; List of notation; Index.

EMS Tracts in Mathematics, Volume 9

October 2009, 195 pages, Hardcover, ISBN: 978-3-03719-074-6, 2000 *Mathematics Subject Classification:* 11-02, 14-02, **AMS members US$51**, List US$64, Order code EMSTM/9

Classified Advertisements

Positions available, items for sale, services available, and more

GEORGIA

GEORGIA INSTITUTE OF TECHNOLOGY
School of Mathematics

The School of Mathematics at Georgia Tech is continuing an ambitious faculty recruitment program begun several years ago. Building on past successes, this recruiting effort is intended to make rapid advances in the scope and quality of our research and graduate education programs. Candidates will be considered at all ranks, with priority given to those candidates who: (1) show the potential to carry out research of exceptional quality at Georgia Tech; (2) complement existing strengths in the School of Mathematics; (3) reinforce bridges to programs in engineering and the physical, computing, and life sciences; (4) have strong potential for external funding; and (5) have a demonstrated commitment to high quality teaching at both the undergraduate and graduate levels. Consistent with these priorities, candidates will be considered in all areas of pure and applied mathematics and statistics. Applications should consist of a curriculum vitae, including a list of publications, summary of future research plans, and at least three letters of reference. Applications should also include evidence of teaching interest and abilities. Candidates for associate and full professor positions should submit a statement outlining their vision for service as a senior faculty member at Georgia Tech. Applications should be submitted directly to `http://www.mathjobs.org`. If a candidate cannot submit an application electronically, then it may be sent to the Hiring Committee, School of Mathematics, Georgia Institute of Technology, Atlanta, GA, 30332-0160, USA. Review of applications will begin in October 2009, and the roster of candidates being considered will be updated on a continual basis. Georgia Tech, an institution of the University System of Georgia, is an Equal Opportunity/Affirmative Action Employer.

000074

KANSAS

KANSAS STATE UNIVERSITY
Department of Mathematics

Applications are invited for a tenure-track assistant professor position to commence August 8, 2010, with salary commensurate with qualifications. A Ph.D. in mathematics is required and preference will be given to candidates with some postdoctoral experience. The department seeks candidates whose research interests are in analysis and/or applied mathematics. The successful candidate should have strong research credentials as well as strong accomplishment or promise in teaching, should demonstrate a strong commitment to mentoring students, and should value working with colleagues and students from diverse backgrounds. Applicants must submit the following: a letter of application, curriculum vita, outline of teaching philosophy, a statement of research objectives, and four letters of reference, at least one of which addresses the applicant's teaching ability and potential. All application materials must be submitted electronically via `http://www.mathjobs.org`. Screening begins November 1, 2009, and continues until the position is closed. Kansas State University is an Equal Opportunity Employer and actively seeks diversity among its employees and encourages applications from women and minorities. A background check is required.

000001

KENTUCKY

WESTERN KENTUCKY UNIVERSITY
Mathematics and Computer Science

The Department of Mathematics and Computer Science at Western Kentucky University invites applications for a tenure-track position in mathematics education starting August 2010 at the assistant professor level.

Qualifications: The applicant should have an earned doctorate in mathematics education and a minimum of 18 hours of graduate-level mathematics courses prior to the date of employment. Applicants should provide evidence of effective teaching, scholarly potential, and the ability to work collaboratively with colleagues in the Department of Mathematics, College of Education and K-12 schools. Experience in web-based learning is desirable.

Salary is commensurate with qualifications and experience.

Duties: The successful candidate will be expected to teach undergraduate and graduate courses in mathematics for preservice and inservice teachers; will be active in mathematics education research and grant writing; and will cooperate with other faculty members to review and revise mathematics courses for teachers at all levels, to recruit prospective mathematics teachers, and to support SKyTeach, WKU's replication of the UTeach program at the University of Texas-Austin.

Salary is commensurate with qualifications and experience. Review of docu-

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 2009 rate is $110 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 ads.

Upcoming deadlines for classified advertising are as follows: February 2010 issue–November 25, 2009; March 2010 issue–December 28, 2009; April 2010 issue–January 28, 2010; May 2010 issue–February 26, 2010; June/July 2010 issue–April 28, 2010; August 2010 issue–May 28, 2010.

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 20904. Advertisers will be billed upon publication.

ments will begin January 15, 2010, and will continue until the position is filled. A letter of application, vita, statement of philosophy of teaching, unofficial transcript and three letters of reference should be addressed to:

Dr. Wanda Weidemann
Department of Mathematics and Computer Science
Western Kentucky University
1906 College Heights Blvd. #11078
Bowling Green, KY 42101-1078

Western Kentucky University is an EO/AA Employer. For this type of employment, state law requires a state and national criminal history background check as a condition of employment. Immediately upon employment, the successful candidate must provide proof of legal eligibility to work in the United States. Western Kentucky University is committed to the promotion of stewardship and student engagement. For further information, please see our website at: http://www.wku.edu/math/ or contact the chair of the search committee at: wanda.weidemann@wku.edu.

000007

MASSACHUSETTS

NORTHEASTERN UNIVERSITY
Department of Mathematics
Tenure-Track Assistant Professorship

We invite applications for a tenure-track position at the assistant professor level to begin in September 2010. This position involves carrying out a productive research program, effective teaching, and service to the department, the university, and the profession. Appointments are based on exceptional research contributions in mathematics. Candidates with research in any area of mathematics and with an interest and ability to collaborate across disciplines and units in the university are urged to apply. Instructions: Applicants are requested to complete the following two steps by November 1, 2009, (late applications may be considered until the position is filled): 1.) Complete the Northeastern University application found at: http://www.northeastern.edu/cas/ (click on Faculty Positions on the lower left hand side of the page) 2.) Submit an application and at least three letters of recommendation at: http://www.mathjobs.org. These letters should address the applicant's research accomplishments and supply evidence that the applicant has the ability to communicate and teach effectively.

Northeastern University
Department of Mathematics, 567 Lake Hall, Boston MA 02115
http://www.math.neu.edu

Northeastern University is an Equal Opportunity, Affirmative Action Educational Institution and Employer, Title IX University. Northeastern University particularly welcomes applications from minorities, women and persons with disabilities. Northeastern University is an E-Verify Employer.

000004

MICHIGAN

MICHIGAN TECHNOLOGICAL UNIVERSITY
Department of Mathematical Sciences
Tenure-track Position in Mathematics Education

Applications are invited for a tenure-track assistant professorship in mathematics education, with a specialization in secondary mathematics education. A Ph.D. in mathematics education is required, with teaching experience at the secondary level and/or a master's degree in mathematics preferred. The ability to work with faculty in the department and across campus is desirable.

The Department of Mathematical Sciences offers BS, MS, and Ph.D. programs, including a very successful undergraduate concentration in secondary education. Current faculty have expertise in applied and computational mathematics; combinatorics, algebra, and number theory; and statistics and probability. Faculty are expected to have an active research program, seek external funding, and provide excellent teaching. Teaching loads are very competitive.

The position starts 16 August 2010, and candidates must complete all requirements for the Ph.D. in mathematics education by that date. Review of applications will begin December 1, 2009; candidates applying by that date are assured full consideration. Interested candidates should send a vita, three letters of recommendation (at least one of which addresses teaching), a description of proposed research program, and a statement of teaching interests to:

Search Committee
Mathematics Education Position
Department of Mathematical Sciences
Michigan Technological University
1400 Townsend Drive
Houghton, MI 49931-1295 or to:
http://mathdept@mtu.edu (electronic submissions in PDF format are encouraged)

In addition to the present search, strategic faculty hiring initiatives with up to ten new positions in "Next Generation Energy Systems" and "Health: Basic Sciences, Technologies, and Medical Informatics" are under way and qualified candidates are encouraged to send a separate application, following the "How to Apply" guidelines at: http://www.mtu.edu/sfhi.

Michigan Tech is an ADVANCE institution, one of a limited number of universities in receipt of NSF funds in support of our commitment to increase diversity and the participation and advancement of women in STEM.

Michigan Technological University is an Equal Opportunity Educational Institution/Equal Opportunity Employer/Affirmative Action Employer.

000003

NORTH CAROLINA

EAST CAROLINA UNIVERSITY
Mathematics Department

Mathematics: Chair. East Carolina University. (Vacancy #937801 at http://www.jobs.ecu.edu). Appointment at the level of professor with expectation of tenure, beginning on or before August 16, 2010. Requires earned Ph.D. in the mathematical sciences and a distinguished record of research, teaching, and service. Administrative experience is desirable. Visit: http://www.ecu.edu/math/ for departmental information. Screening begins December 1, 2009, (until filled). Applicants must submit a candidate profile, a letter of application, curriculum vitae, and a statement of administrative philosophy and experience online at http://www.jobs.ecu.edu. Three current, original, signed letters of recommendation should be sent directly to: Dr. Steve Culver, c/o Department of Mathematics, East Carolina University, Greenville, NC 27858-4353. At least one letter should address administrative/leadership/people skills. (Phone: 252-328-6461; culvers@ecu.edu.) For complete job description and requirements, see http://ecu.peopleadmin.com/applicantsCentral?quickind=60620. Official transcripts required upon employment. Equal Opportunity/Affirmative Action Employer.

000012

WAKE FOREST UNIVERSITY
Department of Mathematics

Applications are invited for one tenure-track position in mathematics at the assistant professor level beginning August 2010. We seek highly qualified candidates who have a commitment to excellence in both teaching and research. A Ph.D. in mathematics or a related area is required. Candidates with research interests in algebra will receive first consideration. The department has 20 members and offers both a B.A. and a B.S. in mathematics, with an optional concentration in statistics; a B.S. in interdisciplinary mathematics; and a B.S. in each of mathematical business and mathematical economics. The department has a graduate program offering an M.A. in mathematics. A complete application will include a letter of application, curriculum vitae, teaching statement, research statement, graduate transcripts, and three letters of recommendation. The application deadline is January 1, 2010. Applicants are encouraged to post materials electronically at: http://www.

mathjobs.org. Hard copy can be sent to Stephen Robinson, Wake Forest University, Department of Mathematics, P.O. Box 7388, Winston-Salem, NC 27109. (email: sbr@wfu.edu, http://www.math.wfu.edu). AA/EO Employer.

000006

OHIO

THE OHIO STATE UNIVERSITY
Faculty Position in Mathematical Biology

Ohio State University invites applications for faculty position in mathematical biology that will be jointly appointed in mathematics or statistics and an appropriate biological sciences department in the College of Arts and Sciences. Assistant professor level applicants will be given preference.

Submit vita, research and teaching statements, and three references to: http://www.mathjobs.org. Questions can be directed to http://search@mbi.osu.edu. Review of applications begins November 16, 2009.

To build a diverse workforce Ohio State encourages applications from minorities, veterans, women, and individuals with disabilities. Flexible work options are available. EEO/AA employer. Ohio State is an NSF Advance Institution.

000002

UNIVERSITY OF CINCINNATI
Department of Mathematical Sciences

Applications are invited for one or more tenure-track assistant professorships. Applicants with expertise in numerical analysis, financial mathematics, statistics and mathematical education are particularly encouraged to apply. However, strong candidates whose research interests mesh well with the research interests of department faculty will also be considered. For further details, please see the position announcement at: http://mathjobs.org or at: http://math.uc.edu/facstaff/jobs.html. The University of Cincinnati is an Equal Opportunity/Affirmative Action Employer. Women, people of color, the disabled, and veterans are encouraged to apply.

000009

TEXAS

TEXAS LUTHERAN UNIVERSITY
Department of Mathematics

Department of Mathematics invites applications for a tenure-track position beginning August 2010. Requirements include Ph.D. in mathematics by appointment date, ability to teach a wide range of introductory and advanced undergraduate courses, and a commitment to mentor students in an undergraduate research program. Submit letter of application, curriculum vitae, statement of teaching philosophy, and five professional references (names, addresses including email, telephone) electronically to: Dr. Reza Abbasian (facultysearch@tlu.edu), Chair of the Dept. of Mathematics and Computer Science, Texas Lutheran University, Seguin, TX. Review of applications will continue until the position is filled. Full position description is available at: http://www.tlu.edu. Texas Lutheran University is an Equal Opportunity Employer

000013

TEXAS TECH UNIVERSITY
Mathematics and Statistics

The Dept. of Mathematics and Statistics invites applications for at least one tenure-track position at the rank of assistant professor or higher beginning in the fall 2010 semester. Exceptional candidates will be considered for higher-level position.

Strong applicants in all areas will be considered. Candidates whose research interests complement existing departmental areas or have excellent potential for interdisciplinary collaboration are especially encouraged to apply. Areas of particular interest include computational mathematics, dynamical systems, geometry and topology.

Strong promise or accomplishment in scholarly activity and teaching and a Ph.D. or equivalent degree at time of appointment are required. The successful candidate should also contribute through professional and departmental service.

Texas Tech is an Affirmative Action/Equal Opportunity Employer committed to excellence through diversity. Texas Tech welcomes applications from minorities, women, veterans, and persons with disabilities.

Applications should be submitted at: http://jobs.texastech.edu using requisition number 80105 and should include completed AMS standard cover sheet and resume.

Three letters of reference and any material in addition to that submitted online should be sent to:

Professor Wayne Lewis
Chair, Faculty Search Committee
Dept. of Mathematics and Statistics
Texas Tech University
Lubbock, TX 79409-1042
math.hiring@ttu.edu

000005

TRINITY UNIVERSITY
Department of Mathematics
Chair of the Department of Mathematics

Trinity University invites applications for the rank of associate or full professor. The successful candidate will have a Ph.D. in the mathematical sciences, a record of excellence in undergraduate education, a productive research program in an area of applied mathematics or statistics, a strong history of service, and demonstrated leadership skills. Preference will be given to candidates with experience in undergraduate research.

Applications should be submitted to: Chair, Department of Mathematics, Trinity University, San Antonio, TX 78212, no later than January 18th, 2010. Applications should include a cover letter, curriculum vita, three letters of recommendation specific to the position, and a letter addressing teaching philosophy, research interests, and leadership style. In the cover letter, please indicate whether or not you plan to attend the San Francisco AMS-MAA Joint Mathematics Meetings in January.

Located in the culturally rich city of San Antonio, Trinity University is a highly selective independent coeducational institution providing broad and intensive educational opportunities primarily to undergraduates in liberal arts and sciences and in selected professional and pre-professional fields. Small class sizes, a ten-to-one student to faculty ratio, and exceptional facilities are some of the qualities that distinguish Trinity as one of the nation's best schools. For more information, please visit our website at: http://www.trinity.edu.

Trinity University is an Affirmative Action, Equal Opportunity Employer. Women and minorities are encouraged to apply. Trinity University does not discriminate in educational or employment opportunities or decisions for qualified persons on the basis of race, color, religion, sex, national origin, age, disability, sexual orientation, or veteran status.

Assistant Professor:

Trinity University invites applications for a tenure-track assistant professor in the Department of Mathematics. Requirements include a Ph.D. in the mathematical sciences, a commitment to excellence in undergraduate education, and the potential for a productive research program in an area of statistics or applied mathematics. The successful candidate will teach statistics courses in addition to sharing in the teaching of a broad range of undergraduate mathematics courses. Preference will be given to candidates whose research can include undergraduates.

Applications should be submitted to: Chair, Department of Mathematics, Trinity University, San Antonio, TX 78212, no later than January 18, 2010. Applications should include a cover letter, curriculum vita, official transcripts, three letters of recommendation specific to the position, and a letter addressing teaching philosophy and research interests. In the cover letter, please indicate whether or not you plan to attend the San Francisco AMS-MAA Joint Mathematics Meetings in January.

Located in the culturally rich city of San Antonio, Trinity University is a highly selective independent coeducational in-

stitution providing broad and intensive educational opportunities primarily to undergraduates in liberal arts and sciences and in selected professional and pre-professional fields. Small class sizes, a ten-to-one student to faculty ratio, and exceptional facilities are some of the qualities that distinguish Trinity as one of the nation's best schools. For more information, please visit our web site at: http://www.trinity.edu.

Trinity University is an Affirmative Action, Equal Opportunity Employer. Women and minorities are encouraged to apply. Trinity University does not discriminate in educational or employment opportunities or decisions for qualified persons on the basis of race, color, religion, sex, national origin, age, disability, sexual orientation, or veteran status.

000011

UNIVERSITY OF TEXAS, EL PASO
Department of Mathematics
Assistant/Associate Professor (Mathematics Education) and Lecturer Position(s)

The Department of Mathematical Sciences at the University of Texas at El Paso seeks to hire a tenure-track assistant or associate professor in mathematics education and one or more lecturer(s) beginning fall 2010.

For the tenure-track assistant or associate professor in mathematics education the successful candidates are expected to have an active research program in mathematics education. Responsibilities include directing undergraduate/graduate students' mathematics education research, developing/teaching mathematics education courses at various levels, and helping enhance recently-formed programs for in-service teachers. A doctorate in mathematics education or mathematics with extensive experience in mathematics education is required. Experience with doctoral programs, grant writing, and K-12 teaching are preferred. Interested applicants or nominations should provide a letter of interest, vita, graduate transcript (unofficial OK), research statement, statement of teaching philosophy, writing sample (e.g., article or grant), and 3-4 letters (including one on teaching experience) of recommendation to: Mathematics Education Hiring Committee, Mathematical Sciences Dept., UTEP, El Paso, TX 79968-0514 or to: search@math.utep.edu.

The lecturer positions carry a load of fifteen hours per semester and the primary responsibility is the teaching of freshman and sophomore level mathematics courses. Good communication skills and excellence in teaching are essential. The minimum qualifications for the positions consist of a Master's degree in any field and at least 18 graduate semesters hours in mathematics; a Master's or Ph.D. degree in the mathematical sciences is preferred. Interested applicants or nominations should provide Curriculum Vitae, transcripts and arrange for three letters of reference to be sent to: Lecturer Search Committee, Mathematical Sciences Dept., UTEP, El Paso, TX 79968-0514 or to: lecturersearch@math.utep.edu.

ABOUT THE UNIVERSITY: The University of Texas http://www.utep.edu at El Paso, a growing research-intensive doctoral university of 21,000+ students, is located in mountainous desert country at the U.S.-México border, offering opportunities to make a difference for many underrepresented learners in our rich cultural and natural environments. The Department of Mathematical Sciences (http://www.math.utep.edu/) offers an undergraduate minor in mathematics teaching, a Master of Arts in Teaching Mathematics degree, and also supports a Master Mathematics Teacher Certificate. Women and minorities are strongly encouraged to apply. The University of Texas at El Paso is an Equal Opportunity Employer (http://admin.utep.edu/eoaa) committed to excellence through diversity. The university does not discriminate on the basis of race, color, national origin, sex, religion, age, disability, veteran's status, or sexual orientation in employment or the provision of services.

000010

ENGLAND

UNIVERSITY OF SOUTHAMPTON
School of Mathematics
Two Professorships in Pure Mathematics

We are seeking to appoint two outstanding mathematicians with excellent track records of research and research leadership in areas which will enhance and extend the current interests of the Pure Mathematics Group. For at least one of the positions preference may be given to experts with an international reputation for excellent research in algebra, though exceptional candidates in any area will be seriously considered.

Duties, as determined by the Head of School, will include: conducting research of international status in pure mathematics, applying for externally funded research grants and enhancing the international profile of the research group, teaching undergraduate and postgraduate mathematics and supervision of research students. As part of the role you will also be expected to support effective management and administration of the school.

Both positions are available from 1 October 2010, or as soon as possible thereafter.

It is intended that applicants shortlisted for interview will be invited to give a lecture in the school. The provisional date for interviews is Tuesday, 16 March 2010.

Informal enquiries can be made at any time to Professor G. A. Niblo, email: G.A.Niblo@soton.ac.uk; tel: +44 (0)23 8059 3674; fax: +44 (0)23 8059 5147.

To apply online visit: http://www.jobs.soton.ac.uk. Alternatively telephone +44 (0)23 8059 2750. As part of your completed application you will be required to include addresses of three referees and your full CV.

Please quote the reference number 3957-09-E in all correspondence. The closing date for applications is 13 January 2010 at 12 noon.

At the University of Southampton we promote equality and value diversity.

000008

TAIWAN

ACADEMIA SINICA
Institute of Mathematics
Taiwan, R.O.C.

The Institute of Mathematics, Academia Sinica, is entrusted to promote mathematical research. The institute strives to become a national center of mathematical sciences in Taiwan, as well as an international mathematical institute. Mathematical researchers are welcome to apply for regular positions as well as 2010-2011 postdoctoral positions.

There is also the Institute of Mathematics Research Scholar position for young Ph.D. with exceptional research potential. This newly established position has the duration of 4-5 years.

Application for regular (resp. postdoctoral and Research Scholar) positions completed by Jan. 15, 2010 (resp. May 31, 2010), will be given full consideration.

Interested applicants should have the following materials

1. curriculum vitae
2. doctoral degree certificate
3. description of research
4. copies of representative publications
5. three letters of reference

either sent to :

The Chairman
The Hiring Committee
Institute of Mathematics
Academia Sinica
Nankang 11529,
Taipei, Taiwan

or input to the site: http://www.math.sinica.edu.tw/applicant. For any questions on applications, please contact: personnel@math.sinica.edu.tw.

For general information about the Inst., please see http://www.math.sinica.edu.tw/

000014

Co-Sponsored Conferences

State-of-the-Art Mathematical Modeling: The 2010 AAAS Meeting in San Diego

The 2010 Annual Meeting of the American Association for the Advancement of Science will be February 18–22, in San Diego, CA. The theme of this year's meeting is "Bridging Science and Society", and the mathematics program at the Annual Meeting strongly embraces this theme. Most of the symposia sponsored by Section A (Mathematics) feature mathematics applied to critical issues in society.

The Annual Meeting is organized into symposia which have three or more speakers, and often a discussant who reflects on the talks that are given. Section A is sponsoring seven symposia this year, featuring outstanding expository talks by prominent mathematicians. The seven symposia sponsored by Section A this year are:

- Sea Ice in a Changing climate: Modeling a Multiscale Nonlinear System (organized by Ken Golden, University of Utah)
- First-person Solvers? Learning Mathematics in a Videogame (organized by Keith Devlin, Stanford University)
- Moving Across Scales: Mathematics for Investigating Biological Hierarchies (organized by Louis Gross, National Institute for Mathematical and Biological Synthesis)
- Real Numbers: Mathematical Technologies for Counterterrorism and Border Security (organized by Jonathan David Farley, Johannes Kepler University Linz, and Tony Harkin, Rochester Institute of Technology)
- Traffic, Crowds and Society (organized by Nicoloa Bellomo, Politecnico di Torino)
- Mathematics and the Analysis of Fairness in Political Processes (organized by Michael Jones, American Mathematical Society)
- Can Singapore Mathematics Enhance Student Learning in the United States? (organized by Patsy Wang-Iverson, The Gabriella and Paul Rosenbaum Foundation)

Other symposia that will be of interest to the mathematical community include:

- Watching the Watchmen and Cheering the Heroes: The Science of Superheroes
- The Future of the National Science Foundation on Its 60th Anniversary
- Role of Community Colleges in Increasing Minority Students in the STEM Pipeline
- How Computational Science is Tackling the Grand Challenges Facing Science and Society
- Using GIS and Spatial Analysis to Better Understand Patterns and Causes of Violence
- Eyes on the Screen: Communicating Science in the New Information Age

The above symposia are only a few of the nearly 200 AAAS program offerings in the physical, life, social, and biological sciences. For further information, including the schedule of talks, go to `www.aaas.org/meetings`.

AAAS annual meetings are the showcases of American science, and they encourage participation by mathematicians and mathematics educators. Section A acknowledges the generous contribution of the American Mathematical Society for travel support. The AAAS Program Committee is genuinely interested in offering symposia on pure and applied mathematical topics of current interest, and in previous years there have been symposia on subjects such as origami, mathematics and the brain, quantum information theory, the changing nature of mathematical proof, and the mathematical analysis of the performance of baseball players.

The 2011 meeting will be held February 17–21 in Washington, DC. The Steering Committee for Section A seeks organizers and speakers who can present substantial new material in an accessible manner to a large scientific audience. All are invited to attend the Section A Committee business meeting in San Diego on Friday, February 19, 2010, at 7:45 p.m., where we will brainstorm ideas for symposia. In addition, I invite you to send me, and encourage your colleagues to send me, proposals for future AAAS annual meetings.

The following are the members of the Steering Committee for Section A from February 2009 to February 2010:
Chair: Keith Devlin (Stanford University)
Chair-Elect: Kenneth Millett (University of California, Santa Barbara)
Retiring Chair: William Jaco (Oklahoma State University)
Secretary: Edward Aboufadel (Grand Valley State University)
Members at Large:
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Claudia Neuhauser (University of Minnesota)
Warren Page (City University of New York)
Tony Chan (Hong Kong University of Science and Technology)

—Edward Aboufadel, Secretary of Section A of the AAAS
aboufade@gvsu.edu

Call for Organizers 2011 MRC Conferences

The American Mathematical Society invites individuals and groups of individuals to serve as organizers of summer conferences of the Mathematics Research Communities program to be held in Snowbird, Utah, in the summer of 2011. The 2011 MRC program is contingent on the receipt of funding from the National Science Foundation.

About the Mathematics Research Communities Program

Mathematics Research Communities (MRC), a newly-established program of the American Mathematical Society (AMS), nurtures early-career mathematicians—those who are close to finishing their doctorates or have recently finished—and provides them with opportunities to build social and collaborative networks through which they can inspire and sustain each other in their work. The structured program is designed to engage and guide all participants as they start their careers. The program includes one-week summer conferences for each topic; Special Sessions at the national meeting; discussion networks by research topic; ongoing mentoring; and a longitudinal study of early career mathematicians. Those accepted into this program will be fully supported for the summer conference, and will be partially supported for their participation in the following Joint Mathematics Meetings. The summer conferences of the MRC are held in the breathtaking mountain setting of the Snowbird Resort, Utah, where participants can enjoy the natural beauty and a collegial atmosphere. The MRC program is open to individuals who are U.S. citizens as well as to those who are affiliated with U.S. institutions. Women and underrepresented minorities are especially encouraged to participate.

The Division of Meetings and Professional Services of the AMS coordinates the Mathematics Research Communities program, and supports organizers throughout the entire program. Questions about the overall MRC program should be addressed to Ellen J. Maycock, Associate Executive Director, at ejm@ams.org or 401-455-4101.

Summer Conferences

The American Mathematical Society's Meetings and Conferences staff members arrange all the logistics of the summer conferences for the Mathematics Research Communities program. This administrative support allows organizers to focus almost exclusively on providing a high-quality scientific program and enables both organizers and participants to concentrate on the conference and take advantage of the services, venue, and surrounding attractions. The AMS Meetings and Conferences Department provides general information and details online at http://www.ams.org/amsmtgs/mrc.html.

The program pays for air transportation for all organizers and participants, as well as room and board for the stay at Snowbird and transportation by van from the Salt Lake City airport to the resort and back. Each organizer receives a stipend of US$3,000. Additionally, each organizing committee has the option of hiring a graduate student to assist with work before and during the conference, for a stipend of US$3,000. Young mathematicians apply to be participants in the MRC program by March 1, 2011. The organizers of each summer conference choose among these applicants during the month of March 2011, paying special attention to creating a diverse group of participants. Although the main emphasis of the summer conferences is the scientific program, it is important for the organizers to spend time with participants discussing professional development topics, such as the job search, writing grant proposals, giving talks, and other activities.

How To Apply

Members of the MRC Advisory Board and AMS staff members are pleased to provide guidance on the preparation of proposals.

Proposals:

The MRC Advisory Board encourages individuals to submit inquiries to ensure sufficient time for feedback. Proposals need to include the following information:

(1) Organizing Committee members, with names and addresses (4–5 for a 40-participant conference, 2–3 for a 20-participant conference);

(2) Scientific narrative addressing the focus, importance and timeliness of the topic, no more than 5 pages long;

(3) Organization of the week of the summer conference.

Preparation and submission guidelines are available at http://www.ams.org/amsmtgs/mrc-proposals.html. The current MRC Advisory Board members are listed at http://www.ams.org/amsmtgs/mrc-contact.html.

Send inquiries and proposals to:

Mathematics Research Communities
American Mathematical Society
by email: mrc2011@ams.org
by mail: 201 Charles Street, Providence, RI 02904
by fax: 401-455-4004

Deadlines for 2011 MRCs

Intent to submit proposal: **March 2, 2010**
Proposals: **April 1, 2010**

All individuals who submit proposals will be notified of the decisions before August 3, 2010.

About Snowbird Resort

Situated in a beautiful, breathtaking mountain setting, Snowbird Resort provides an extraordinary environment for the MRC program. The atmosphere is comparable to the collegial gatherings at Oberwolfach and other conferences that combine peaceful natural ambience with stimulating meetings. MRC participants have access to a range of activities such as a tram ride to the top of the mountain, walking and hiking trails in the surrounding mountains, and swimming in heated outdoor pools. Participants also enjoy the simpler pleasures of convening on the patios at the resort to read, work, and socialize. At the conclusion of the day's program colleagues may enjoy informal gatherings to network and continue discussion of the day's sessions over refreshments. Within a half hour of the University of Utah, Snowbird is easily accessible from the Salt Lake City International Airport. For more information about Snowbird Resort, see http://www.snowbird.com.

For myself and many others in mathematics, mentoring strong, eager students in small groups is one of the most rewarding things we do. Imagine the opportunity to choose a group of advanced graduate students and beginning postdocs in your field, from around the country, and spend an intense week getting to know them and helping them learn some new and valuable elements of your field.

—David Eisenbud, Chair, MRC Advisory Board

—Ellen J. Maycock
Associate Executive Director
Meetings and Professional Services

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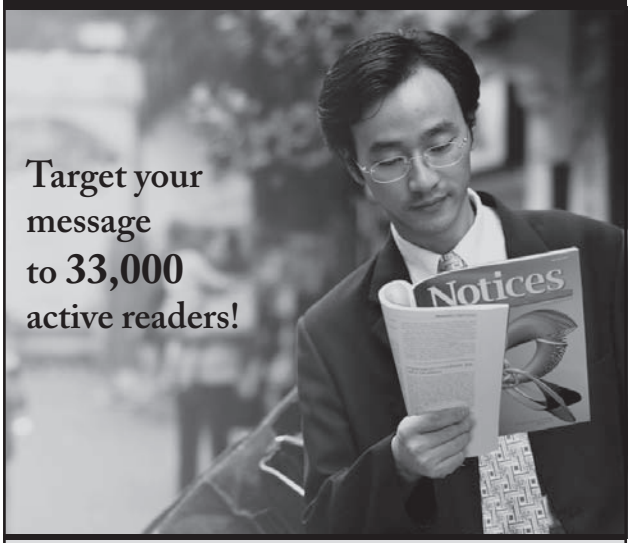

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General Information Regarding Meetings & Conferences of the AMS

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.

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 page 199 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 on page 199. 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 to the extent possible. The title and author of each paper accepted and the time of presentation will be listed in the program of the meeting. 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 *may* speak by invitation in more than one Special Session at the same meeting.

Other Sessions: In accordance with policy established by the AMS Committee on Meetings and Conferences, mathematicians interested in organizing a session (for either an annual or a 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.

Submission Procedures: Visit the Meetings and Conferences homepage on the Web at `http://www.ams.org/meetings` and select "Submit an abstract".

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 and a laptop projector for contributed paper sessions and Special Sessions, an auditorium with twin overhead projectors and a laptop projector 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/`. Final programs for Sectional Meetings will be archived on the AMS website accessible from the stated URL and in an electronic issue of the *Notices* as noted below for each meeting.

Seoul, South Korea

Ewha Womans University

December 16–20, 2009

Wednesday – Sunday

Meeting #1055

First Joint International Meeting of the AMS and the Korean Mathematical Society.
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: June 2009
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: Expired

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/internmtgs.html`.

Invited Addresses

Young Ju Choi, Pohang University of Science and Technology, *Title to be announced.*

Bumsig Kim, Korea Institute for Advanced Study, *Title to be announced.*

Minhyong Kim, University College London, *Title to be announced.*

Ki-ahm Lee, Seoul National University, *Title to be announced.*

James T. McKernan, Massachusetts Institute of Technology, *Title to be announced.*

Frank Morgan, Williams College, *Title to be announced.*

Hee Oh, Brown University, *Title to be announced.*

Terence Tao, University of California Los Angeles, *Title to be announced.*

Van Vu, Rutgers University, *Title to be announced.*

Special Sessions

Algebraic Combinatorics, **Dongsu Kim**, Korea Advanced Institute of Science & Technology, **Soojin Cho**, Ajou University, and **Bruce Sagan**, Michigan State University.

Algebraic Geometry, **Yongnam Lee**, Sogang University, **Ian Morrison**, Fordham University, and **James McKernan**, Massachusetts Institute of Technology.

Arithmetic of Quadratic Forms, **Myung-Hwan Kim**, Seoul National University, and **Wai Kiu Chan**, Wesleyan University.

Combinatorial Matrix Theory, **Suk-Geun Hwang**, Kyungpook National University, and **Bryan Shader**, University of Wyoming.

Computational Science and Engineering, **Jeehyun Lee**, Yonsei University, and **Max Gunzburger**, Florida State University.

Creativity, Giftedness, and Talent Development in Mathematics, **Kyeong-Hwa Lee**, Seoul National University, and **Bharath Sriraman**, University of Montana.

Cryptography, **Hyang-Sook Lee**, Ewha Womans University, and **Alice Silverberg**, University of California Irvine.

Differential and Integral Geometry, **Young Jin Suh**, Kyungpook National University, **Byung Hak Kim**, Kyung Hee University, **Yongdo Lim**, Kyungpook National University, **Gaoyong Zhang**, Polytechnic University of NYU, and **Jiazu Zhou**, Southwest University.

Ergodic Theory and Dynamical Systems, **Keonhee Lee**, Chungnam National University, **Jeong-Yup Lee**, Korea Institute for Advanced Study, and **Jane Hawkins**, University of North Carolina.

Financial Mathematics, **Hyejin Ku**, York University, **Hyunggeon Koo**, Ajou University, and **Kiseop Lee**, University of Louisville.

Geometric Structures and Geometric Group Theory, **In Kang Kim**, Korea Advanced Institute of Science & Technology, and **Seonhee Lim**, Cornell University.

Geometry of Varieties, Syzygies and Computations, **Sijong Kwak**, Korea Advanced Institute of Science & Technology, **Hyungju Park**, Pohang University of Science and Technology, and **Jerzy Weyman**, Northeastern University.

Harmonic Analysis and Its Applications, **Sunggeum Hong**, Chosun University, and **Andreas Seeger**, University of Wisconsin.

Inverse Problems and Imaging, **Hyeonbae Kang**, Inha University, and **Gunther Uhlmann**, University of Washington.

Knot Theory and Related Topics, **Jae Choon Cha**, Pohang University of Science and Technology, and **Kent Orr**, Indiana University.

Lie Symmetries and Solitons, **Woo-Pyo Hong**, Catholic University of Daegu, **Anjan Biswas**, Delaware State University, and **Chaudry M. Khalique**, North-West University.

Mathematical Analysis in Fluid, Gas Dynamics, and Related Equations, **Minkyu Kwak**, Chonnam National University, **Hyeong-Ohk Bae**, Ajou University, **Seung-Yeal Ha**, Seoul National University, and **Simon Seok Hwang**, LaGrange College.

Mathematical Biology, **Eunok Jung**, Konkuk University, and **Jae-Hun Jung**, SUNY at Buffalo.

Mathematical Logic and Foundation, **Byunghan Kim**, Yonsei University, and **Ivo Herzog**, Ohio State University.

Modular Forms and Related Topics, **Youn-Seo Choi**, Korea Institute for Advanced Study, **YoungJu Choie**, Pohang University of Science and Technology, and **Wen-ching Winnie Li**, Pennsylvania State University.

Noncommutative Ring Theory, **Yang Lee**, Pusan National University, **Nam Kyun Kim**, Hanbat National University, and **Pace P. Nielsen**, Brigham Young University.

Nonlinear Elliptic Partial Differential Equations, **Jaeyoung Byeon**, Pohang University of Science and Technology, and **Zhi-Qiang Wang**, Utah State University.

Nonlinear Partial Differential Equations and Viscosity Solutions, **Ki-ahm Lee**, Seoul National University, and **Inwon Kim**, University of California Los Angeles.

Operator Theory and Operator Algebras, **Il Bong Jung**, Kyungpook National University, **Ja A. Jeong**, Seoul National University, **George Exner**, Bucknell University, and **Ken Dykema**, Texas A&M University.

Operator Theory in Analytic Function Spaces, **Hyung Woon Koo** and **Boo Rim Choe**, Korea University, and **Kehe Zhu**, SUNY at Albany.

Representation Theory, **Jae-Hoon Kwon**, University of Seoul, and **Kyu-Hwan Lee**, University of Connecticut.

Spectral Geometry and Global Analysis, **Jinsung Park**, Korea Institute for Advanced Study, and **Maxim Braverman**, Northeastern University.

Symplectic Geometry and Mirror Symmetry, **Jae-Suk Park**, Yonsei University, **Cheol-Hyun Cho**, Seoul National University, and **Yong-Geun Oh**, University of Wisconsin.

San Francisco, California

Moscone Center West and the San Francisco Marriott

January 13–16, 2010

Wednesday – Saturday

Meeting #1056

Joint Mathematics Meetings, including the 116th Annual Meeting of the AMS, 93rd 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), with sessions contributed by the Society of Industrial and Applied Mathematics (SIAM).

Associate secretary: Matthew Miller
Announcement issue of *Notices*: October 2009
Program first available on AMS website: November 1, 2009
Program issue of electronic *Notices*: January 2010
Issue of *Abstracts*: Volume 31, Issue 1

Deadlines

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

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/national.html`.

Program Updates

The **AMS Committee on Science Policy–MAA Science Policy Committee Government Speaker** presentation on Friday afternoon has been cancelled.

MAA Program Updates

The **SIGMAA on Environmental Mathematics** will have a Guest Lecture on Thursday, 5:30 p.m. to 6:30 p.m., followed by a Business Meeting, 6:30 p.m. to 7:00 p.m.

The Art of Bruce Beasley, Friday, 8:00 p.m. to 9:00 p.m. Come meet this internationally known artist as he

discusses his sculptures that feature multiple intersecting forms developed using a computer program. Images of Bruce Beasley's sculptures can be seen at www.brucebeasley.com/home.htm. An article on his works appears in the December 2006 issue of *Hyperseeing*, www.isama.org/hyperseeing/. Sponsored by the SIGMAA on Mathematics and the Arts.

Social Events Updates

Ohio State University Alumni and Friends Reception, Friday, 6:00 p.m. to 8:00 p.m.

Lexington, Kentucky

University of Kentucky

March 27–28, 2010

Saturday – Sunday

Meeting #1057

Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: January 2010
Program first available on AMS website: February 11, 2010
Program issue of electronic *Notices*: March 2010
Issue of *Abstracts*: Volume 31, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: January 26, 2010 (NEW DATE!)

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Percy A. Deift, Courant Institute–New York University, *Open problems in integrable systems and random matrix theory.*

Irina Mitrea, Worcester Polytechnic Institute, *Recent progress in the area of elliptic boundary value problems on rough domains.*

Bruce Reznick, University of Illinois at Urbana Champaign, *The secret lives of polynomial identities.*

Bernd Ulrich, Purdue University, *Title to be announced.*

Doron Zeilberger, Rutgers University, *3x+1* (Erdős Memorial Lecture).

Special Sessions

Advances in Algebraic Coding Theory (Code: SS 6A), **Heide Gluesing-Luerssen**, University of Kentucky, and **Jon-Lark Kim**, University of Louisville.

Advances in Algebraic Statistics (Code: SS 2A), **Sonja Petrović**, University of Illinois, Chicago, and **Ruriko Yoshida**, University of Kentucky.

Advances in Algebraic and Geometric Combinatorics (Code: SS 14A), **Richard Ehrenborg** and **Margaret A. Readdy**, University of Kentucky.

Analysis and Control of Dispersive Partial Differential Equations (Code: SS 25A), **Michael J. Goldberg** and **Bingyu Zhang**, University of Cincinnati.

Combinatorial Algebra (Code: SS 7A), **Juan C. Migliore**, University of Notre Dame, and **Uwe Nagel**, University of Kentucky.

Commutative Algebra (Code: SS 1A), **Alberto Corso**, University of Kentucky, **Claudia Polini**, University of Notre Dame, and **Bernd Ulrich**, Purdue University.

Complex Analysis and Potential Theory (Code: SS 4A), **James E. Brennan** and **Vladimir Eiderman**, University of Kentucky.

Financial Mathematics and Statistics (Code: SS 22A), **Kiseop Lee**, University of Louisville, and **Jose Figueroa-Lopez**, Department of Statistics, Purdue University.

Function Theory, Harmonic Analysis, and Partial Differential Equations (Code: SS 5A), **Joel Kilty**, Centre College, **Irina Mitrea**, Worcester Polytechnic Institute, and **Katharine Ott**, University of Kentucky.

Geometric Function Theory and Analysis on Metric Spaces (Code: SS 3A), **John L. Lewis**, University of Kentucky, and **Nageswari Shanmugalingam**, University of Cincinnati.

Homotopy Theory and Geometric Aspects of Algebraic Topology (Code: SS 16A), **Serge Ochanine**, University of Kentucky, and **Marian F. Anton**, Centre College.

Interactions between Logic, Topology, and Complex Analysis (Code: SS 23A), **Matt Insall**, Missouri University of Science and Technology, and **Malgorzata Marciniak**, University of Toledo.

Inverse Problems, Riemann-Hilbert Problems, and Nonlinear Dispersive Equations (Code: SS 10A), **Peter A. Perry**, University of Kentucky, and **Peter Topalov**, Northeastern University.

Large Scale Matrix Computation (Code: SS 19A), **Qiang Ye**, University of Kentucky, and **Lothar Reichel**, Kent State University.

Mathematical Economics (Code: SS 21A), **Adib Bagh** and **Robert E. Molzon**, University of Kentucky.

Mathematical Problems in Mechanics and Materials Science (Code: SS 20A), **Michel E. Jabbour** and **Chi-Sing Man**, University of Kentucky, and **Kazumi Tanuma**, Gunma University.

Mathematical String Theory (Code: SS 18A), **Al Shapere**, Department of Physics and Astronomy, University of Kentucky, **Eric Sharpe**, Physics Department, Virginia Polytechnic Institute and State University, and **Mark A. Stern**, Duke University.

Mathematics Outreach (Code: SS 26A), **Carl W. Lee** and **David C. Royster**, University of Kentucky.

Matroid Theory (Code: SS 9A), **Jakayla Robbins**, University of Kentucky, and **Xiangqian Zhou**, Wright State University.

Multivariate and Banach Space Polynomials (Code: SS 15A), **Richard A. Aron**, Kent State University, and **Lawrence A. Harris**, University of Kentucky.

Noncommutative Algebraic Geometry (Code: SS 24A), **Dennis S. Keeler** and **Kimberly Retert**, Miami University.

Partial Differential Equations in Geometry and Variational Problems (Code: SS 8A), **Luca Capogna**, University of Arkansas, and **Changyou Wang**, University of Kentucky.

Recent Progress in Numerical Methods for Partial Differential Equations (Code: SS 12A), **Alan Demlow**, University of Kentucky, and **Xiaobing H. Feng**, University of Tennessee at Knoxville.

Relative Homological Algebra (Code: SS 11A), **Edgar E. Enochs**, University of Kentucky, and **Alina C. Iacob**, Georgia Southern University.

Sharp Spectral Estimates in Analysis, Geometry, and Probability (Code: SS 17A), **Richard S. Laugesen** and **Bartlomiej Siudeja**, University of Illinois.

Spectral and Transport Properties of Schrödinger Operators (Code: SS 13A), **Peter D. Hislop**, University of Kentucky, and **Jeffrey H. Schenker**, Michigan State University.

Accommodations

Participants should make their own arrangements directly with the hotel of their choice as early as possible and state that they will be part of the **Kentucky Math Conference** group. Special rates have been negotiated with the hotels you will find in this announcement. Rates quoted do not include sales tax. The AMS is not responsible for rate changes or for the quality of the accommodations. Cancellation and early checkout policies vary; be sure to check when you make your reservation.

University Inn, 1229 S. Limestone, Lexington, KY 40503. 859-278-6625 for front desk; 859-278-4530 for fax. See http://www.uinn.biz/index2.htm. Prices per room are US$79/king and US$85/two beds; includes oversized rooms, free wireless, and refrigerator; located 1.3 miles from the meeting site. **Deadline to book and obtain this reduced rate is February 26, 2010**. Be sure to check cancellation and early checkout policies.

Holiday Inn Express Hotel & Suites, 1000 Export Street, Lexington, KY 40504. 859-389-6800 for front desk; (859-389-6801) for fax. See http://www.hiexpress.com/h/d/ex/1/en/hotel/LEXKY/welcome?start=1. Price per room is US$84 and includes free continental breakfast; health and fitness center; indoor pool; complimentary wireless; business services including copying, computer, and printer; located 1.2 miles from the meeting site. **Deadline to book and obtain this reduced rate is February 26, 2010**. Be sure to check cancellation and early checkout policies.

Lexington Downtown Hotel & Conference Center, 369 West Vine Street, Lexington, KY 40507; 877-539-1648 or 859-231-9000. See http://www.lexingtondowntownhotel.com/. Price per room is US$109, and includes coffee/tea makers, spacious executive work desk, fitness center; refrigerators and microwaves available on request; complimentary airport shuttle. Wireless is free in the public areas on the first two floors; in-room service is available for $9.95/day. The hotel is 1.5 miles from the meeting site. **Deadline to book and obtain this reduced rate is February 26, 2010**. Be sure to check cancellation and early checkout policies.

Gratz Park Inn, 120 W. Second Street, Lexington, KY 40507; 859-231-1777. See http://www.gratzparkinn.com/. The hotel is 1.7 miles from the meeting site. Price per room is US$99/king or double queen. This historic inn is beautifully appointed with individually decorated rooms with fine 19th century antique reproductions and complimentary high-speed wireless Internet access. On-site dining is available at Jonathan at Gratz Park. **Deadline to book and obtain this reduced rate is February 26, 2010**. Be sure to check cancellation and early checkout policies.

Extended Stay America Hotel Tates Creek Road, 3575 Tates Creek Road, Lexington, KY 40517; 859-271-6160. See http://www.extendedstayamerica.com/hotels/lexington-tates-creek.html. The hotel is 5.5 miles from the meeting site. Price per room is US$39.99 and includes a kitchen with refrigerator, microwave, and stovetop with cooking utensils; workspace with computer dataport, free local phone calls, swimming pool, and pet-friendly rooms. Wireless Internet is available for a one-time fee of $4.99 per stay, NOTE: Participants who have difficulty climbing stairs should book a room on level 2 of the hotel, which is the main access floor for the hotel. **Deadline to book and obtain this reduced rate is February 26, 2010**. Be sure to check cancellation and early checkout policies.

Marriott at Griffin Gate, 1800 Newtown Pike, Lexington, KY 40511. 800-228-9290 for front desk; 859-255-9944 for fax. See http://www.marriott.com/hotels/travel/lexky-griffin-gate-marriott-resort-and-spa/. The hotel is 5 miles from the meeting site. Price per room is US$84 standard rate (typically king bed) includes in-room coffee maker; wired Internet, including all local and long distance calls, is available for US$12.95/day. Hotel features a luxurious full-service spa. There is complimentary on-site parking; valet parking is US$20 daily. This is a smoke-free property. **Deadline to book and obtain this reduced rate is February 26, 2010**. Be sure to check cancellation and early checkout policies.

Food Service

There is no dining on campus during the weekend. Within a short walking distance from the Patterson Office Tower there are a variety of choices for dining. Additional information and recommendations will be provided on-site.

Local Information

The University's website is http://www.uky.edu; the website of the Department of Mathematics is at http://www.math.uky.edu. The campus of the University of Kentucky offers wireless Internet connections to everyone. Visitors will have wireless guest access without the need of a password.

Other Activities

Book Sales: Stop by the on-site AMS Bookstore and review the newest titles from the AMS, enter the free book drawing, enjoy up to 25% off all AMS publications, or take home an AMS t-shirt! 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

A campus map is found at http://www.uky.edu/CampusGuide/. It can be used to identify a number of free parking facilities in the proximity of the White Hall Classroom Building (CB) and the Patterson Office Tower (POT). In addition, many hotels are in reasonable walking distance from campus.

Registration and Meeting Information

Invited Addresses, all sessions, registration, and the AMS book exhibit will be held in the White Hall Classroom Building (CB) on the campus of the University of Kentucky, Lexington, Kentucky. The registration desk will be open Saturday, March 27th, 7:30 a.m.–4:00 p.m., and Sunday, March 28th, 8:00 a.m.–noon. Fees are US$40 for AMS members, US$60 for nonmembers; and US$5 for students, unemployed mathematicians, and emeritus members. Fees are payable onsite via cash, check, or credit card. Please note that discounted registration fees will be available on site to those participants who choose to register for both the AMS and MAA meetings (see Satellite Mathematics Events below).

Social Event

The Department of Mathematics will host a reception for all participants. The reception will be held from 6:15 p.m. to 7:45 p.m. at the King Alumni House. Light snacks, hors d'oeuvres and beverages will be served. The AMS thanks the department for its hospitality.

The social event will then be followed at 8:00 p.m. by the Annual Erdős Memorial Lecture delivered by **Doron Zeilberger** Rutgers University.

Satellite Mathematics Events

Annual KY-MAA Meeting: The Annual Meeting of the Kentucky Section of the Mathematical Association of America will be held on Friday afternoon and Saturday morning, (March 26–27, 2010) and will partially overlap with the AMS meeting. In fact, Professor Bruce Reznik will be a joint speaker at both meetings. The other invited addresses of the MAA meeting will be given by the teaching award co-winners **David Shannon**, Transylvania University, **Christine Shannon**, Centre College, and **Martha Siegel**, Towson University, a former secretary of the MAA. The MAA meeting will also offer a number of short talks delivered by undergraduate students, graduate students, and faculty from institutions across the Commonwealth of Kentucky.

Hayden-Howard Lecture: To further raise the research quality of the events hosted during the weekend at the University of Kentucky, the Department of Mathematics will host its Annual Hayden-Howard Lecture on Thursday, March 25, 2010, at 4:00 p.m. The lecture will be delivered by **David Eisenbud**, University of California at Berkeley, a former president of the AMS.

Travel, Campus Map, and Directions

A campus map is found at http://www.uky.edu/CampusGuide/. Lexington is served by the Bluegrass Airport (LEX), 4000 Terminal Dr., Lexington, KY 40510.

Driving Directions to Campus

For more precise information, please use your favorite Internet mapping service (e.g., http://maps.yahoo.com, http://www/mapquest.com, http://www.randmcnally.com/). Here are some general directions.

South on I-64 or I-75

NOTE (I-64 and I-75 merge just south of Georgetown, Ky.) Follow I-64 or I-75 South to Exit 113 (marked Paris/Lexington). Turn right off the exit ramp onto North Broadway (U.S. 68). Follow through downtown for 3 miles. One block past the Hyatt Regency Hotel, turn left at the light onto Maxwell Street. At the 5th light, turn right onto Rose Street. At the next light, turn right. Just past Papa John's is Memorial Coliseum and two parking lots within walking distance of the White Hall Classroom Building.

North on I-75

Follow I-75 North to Exit 104 (marked Athens/Lexington). Turn left off of the ramp onto Athens- Boonesboro Road. Follow for 8.2 miles to downtown. Turn left onto Rose Street.

At the 4th light, turn right onto Avenue of Champions. Just past Papa John's is Memorial Coliseum and two parking lots within walking distance of the White Hall Classroom Building.

South and Southwest on Bluegrass Parkway

Follow the Bluegrass Parkway to Lexington. Turn right off the ramp onto Route 60 (Versailles Road). Follow until it becomes a one-way street, West Maxwell. At the 6th light, turn right onto Rose Street. At the next light, turn right. Just past Papa John's is Memorial Coliseum and two parking lots within walking distance of the White Hall Classroom Building.

Car Rental

Avis Rent A Car is the official car rental company for the meeting. Depending on variables such as location, length of rental, and size of vehicle, Avis will offer participants the best available rate which can range from 5%–25% discount off regular rates. Participants must use the assigned Meeting

(J098887) and meet Avis rate requirements to receive the discount. (Rate discounts are available at all corporate and participating licensee locations.) Reservations can be made by calling 800-331-1600 or online at http://www.avis.com.

All car rentals include unlimited free mileage and are available to renters 25 years and older. Renters must also meet Avis's driver and credit requirements. Return to the same rental location or additional surcharges may apply. Rates do not include any state or local surcharges, tax, optional coverages, or gas refueling charges.

Weather

March temperatures in Lexington range from a minimum of 35 to a maximum of 55, with an average temperature of 45. The adage is "if you don't like the weather, wait 5 minutes" as it changes often.

Information for International Participants

Visa regulations are continually changing for travel to the United States. Visa applications may take from three to four months to process and require a personal interview, as well as specific personal information. International participants should view the important information about traveling to the U.S. found at http://www7.nationalacademies.org/visas/Traveling_to_US.html and http://travel.state.gov/visa/index.html. If you need a preliminary conference invitation in order to secure a visa, please send your request to dls@ams.org.

If you discover you do need a visa, the National Academies website (see above) provides these tips for successful visa applications:

* Visa applicants are expected to provide evidence that they are intending to return to their country of residence. Therefore, applicants should provide proof of "binding" or sufficient ties to their home country or permanent residence abroad. This may include documentation of the following:

– family ties in home country or country of legal permanent residence

– property ownership

– bank accounts

– employment contract or statement from employer stating that the position will continue when the employee returns;

* Visa applications are more likely to be successful if done in a visitor's home country than in a third country;

* Applicants should present their entire trip itinerary, including travel to any countries other than the United States, at the time of their visa application;

* Include a letter of invitation from the meeting organizer or the U.S. host, specifying the subject, location and dates of the activity, and how travel and local expenses will be covered;

* If travel plans will depend on early approval of the visa application, specify this at the time of the application;

* Provide proof of professional scientific and/or educational status (students should provide a university transcript).

This list is not to be considered complete. Please visit the websites above for the most up-to-date information.

St. Paul, Minnesota

Macalester College

April 10–11, 2010

Saturday – Sunday

Meeting #1058

Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: February 2010
Program first available on AMS website: February 25, 2010
Program issue of electronic *Notices*: April 2010
Issue of *Abstracts*: Volume 31, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: December 22, 2009
For abstracts: February 16, 2010

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Charles Doering, University of Michigan, *Title to be announced.*

Matthew James Emerton, Northwestern University, *Title to be announced.*

Vladimir Touraev, Indiana University, *Title to be announced.*

Peter Webb, University of Minnesota, *Title to be announced.*

Special Sessions

Applications of a Geometric Approach to Chaotic Dynamics (Code: SS 16A), **Evelyn Sander**, George Mason University, **Judy Kennedy**, Lamar University, and **James Yorke**, University of Maryland.

Cohomology and Representation Theory of Algebraic Groups and Related Structures (Code: SS 7A), **Christopher Bendel**, University of Wisconsin-Stout, **Bobbe Cooper**, University of Minnesota, and **Terrell Hodge**, Western Michigan University.

Combinatorial Representation Theory (Code: SS 3A), **Tom Halverson**, Macalester College, and **Victor Reiner**, University of Minnesota.

Commutative Ring Theory (Code: SS 5A), **Michael Axtell**, University of St. Thomas, and **Joe Stickles**, Millikin University.

Differential Equations and Applications (Code: SS 15A), **Nicolai Tarfulea**, Purdue University Calumet, and **Catalin Turc**, Case Western Reserve University.

Fractals, Convolution Measures, and Frames (Code: SS 13A), **Keri Kornelson**, University of Oklahoma, and **Karen Shuman**, Grinnell College.

Geometric Flows, Moving Frames and Integrable Systems (Code: SS 8A), **Gloria Mari-Beffa**, University of Wisconsin-Madison, and **Peter Olver**, University of Minnesota.

Hecke Algebras and Deformations in Geometry and Topology (Code: SS 11A), **Matthew Douglass** and **Anne Shepler**, University of North Texas.

Mathematical Developments in Cell and Systems Biology (Code: SS 14A), **Anastasios Matzavinos**, Iowa State University, and **Nicoleta Eugenia Tarfulea**, Purdue University Calumet.

Matrices and Graphs (Code: SS 9A), **Luz M. DeAlba**, Drake University, **Adam Berliner**, St. Olaf College, **Leslie Hogben**, Iowa State University, and **In-Jae Kim**, Minnesota State University.

Partition Theory and the Combinatorics of Symmetric Functions (Code: SS 6A), **Eric S. Egge**, Carleton College, and **Kristina Garrett**, St. Olaf College.

Pattern Formation in Biological Systems (Code: SS 12A), **Magdalena Skolarska**, University of St. Thomas, and **Chad Topaz**, Macalester College.

Physical Knotting and Linking and its Applications (Code: SS 10A), **Eric Rawden**, University of St. Thomas, **Yuanan Diao**, University of North Carolina at Charlotte, and **Claus Ernst**, Western Kentucky University.

Probabilistic and Extremal Combinatorics (Code: SS 2A), **Ryan Martin** and **Maria Axenovich**, Iowa State University.

Quantum Invariants of 3-manifolds and Modular Categories (Code: SS 1A), **Thang Le**, Georgia Institute of Technology, **Eric Rowell**, Texas A&M University, and **Vladimir Touraev**, Indiana University.

Universal Algebra and Order (Code: SS 4A), **Jeffrey Olson**, Norwich University, **Jeremy Alm**, Illinois College, **Kristi Meyer**, Wisconsin Lutheran College, and **Japheth Wood**, Bard College.

Albuquerque, New Mexico

University of New Mexico

April 17–18, 2010

Saturday – Sunday

Meeting #1059

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: February 2010
Program first available on AMS website: March 4, 2010
Program issue of electronic *Notices*: April 2010
Issue of *Abstracts*: Volume 31, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: December 29, 2009
For abstracts: February 23, 2010

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Kenneth Bromberg, University of Utah, *Title to be announced.*

Danny Calegari, California Institute of Technology, *Title to be announced.*

Ioana Dumitriu, University of Washington, *Title to be announced.*

Steffen Rohde, University of Washington, *Title to be announced.*

Special Sessions

Dyadic and Non-Dyadic Harmonic Analysis (Code: SS 2A), **M. Cristina Pereyra**, University of New Mexico, and **Stephanie A. Salomone**, University of Portland.

Financial Mathematics: The Mathematics of Financial Markets and Structures (Code: SS 4A), **Maria Cristina Mariani**, University of Texas at El Paso, **Ionut Florescu**, Stevens Institute of Technology, and **Maria P. Beccar-Varela**, University of Texas at El Paso.

Function Spaces, PDEs and Nonlinear Analysis (Code: SS 10A), **Osvaldo Mendez**, **Behzad Rouhani**, and **Mohamed Amine Khamsi**, University of Texas at El Paso.

Geometric Combinatorics (Code: SS 6A), **Art M. Duval**, University of Texas at El Paso, and **Jeremy Martin**, University of Kansas.

Geometric Function Theory (Code: SS 14A), **Lukas Geyer**, Montana State University, and **Donald Marshall** and **Steffen Rohde**, University of Washington.

Geometric Structures and PDEs (Code: SS 8A), **Charles Boyer** and **Dimiter Vassilev**, University of New Mexico.

Harmonic Analysis and Partial Differential Equations (Code: SS 5A), **Matthew Blair**, University of New Mexico, and **Hart Smith**, University of Washington.

Kleinian Groups and Teichmueller Theory (Code: SS 15A), **Kasra Rafi**, University of Oklahoma, **Hossein Namaze**, University of Texas, and **Kenneth Bromberg**, University of Utah.

Positivity in Noncommutative Settings (Code: SS 12A), **Roger Roybal**, California State University Channel Islands, and **Terry Loring**, University of New Mexico.

Random Matrix Theory and Applications (Code: SS 13A), **Ioana Dumitriu**, University of Washington, and **Raj Rao**, University of Michigan.

Selected Topics in Analysis and Numerics for PDEs (Code: SS 11A), **Thomas Hagstrom**, Southern Methodist University, and **Stephen Lau** and **Jens Lorenz**, University of New Mexico.

Strongly-nonlinear Phenomena: Theory and Applications to Nonlinear Optics, Hydrodynamics, Bose–Einstein Condensation and Biology (Code: SS 9A), **Alejandro Aceves**, Southern Methodist University, and **Alexander Korotkevich** and **Pavel Lushnikov**, University of New Mexico.

Subjects in between Pure and Applied Mathematics (Code: SS 7A), **Hanna Makaruk** and **Robert Owczarek**, Los Alamos National Laboratory.

Topics in Geometric Group Theory (Code: SS 1A), **Matthew Day**, California Institute of Technology, **Daniel Peter Groves**, University of Illinois at Chicago, **Jason Manning**, SUNY at Buffalo, and **Henry Wilton**, University of Texas.

Trends in Commutative Algebra (Code: SS 3A), **Louiza Fouli**, New Mexico State University, and **Janet Vassilev**, University New Mexico.

Newark, New Jersey

New Jersey Institute of Technology

May 22–23, 2010

Saturday – Sunday

Meeting #1060

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: March 2020
Program first available on AMS website: April 8, 2010
Program issue of electronic *Notices*: May 2020
Issue of *Abstracts*: Volume 31, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: February 2, 2010
For abstracts: March 30, 2010

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Simon Brendle, Stanford University, *Hamilton's Ricci flow and the sphere theorem in geometry.*

Konstantin M. Mischaikow, Rutgers University, *Computational topology applied to the global dynamics of nonlinear systems.*

Ricardo H. Nochetto, University of Maryland, *Curvature driven flows in deformable domains.*

Richard E. Schwartz, Brown University, *Polygonal outer billiards.*

Special Sessions

Automorphic Forms, L-functions, and Applications. (Code: SS 6A), **Ameya Pitale**, American Institute of Mathematics, and **Anantharam Raghuram**, Oklahoma State University.

Expandable Computations, Algorithms, Methodologies and Experiments for Engineering Interpretation. (Code: SS 1A), **Mustapha S. Fofana**, Worcester Polytechnic Institute, **Marie D. Dahleh**, Harvard School of Engineering and Applied Sciences, Harvard University, and **Kenji Kawashima**, Precision and Intelligence Laboratory, Tokyo Institute of Technology.

Groups, Computations, and Applications (Code: SS 2A), **Delaram Kahrobaei**, City University of New York.

Homology Theories for Knots and Skein Modules. (Code: SS 3A), **Mikhail Khovanov**, Columbia University, and **Jozef H. Przytycki** and **Radmila Sazdanovic**, George Washington University.

Invariants of Knots, Links, and 3-Manifolds. (Code: SS 4A), **Abhijit Champanerkar** and **Ilya S. Kofman**, College of Staten Island, CUNY, and **Philip J. P. Ording**, Medgar Evers College, CUNY.

Lie Algebras and Representation Theory (Code: SS 8A), **Gautam Chinta**, City College, City University of New York, **Andrew Douglas**, City College of Technology, City University of New York, and **Bart Van Steirtghem**, Medgar Evers College, City University of New York.

Teichmueller Theory, Hyperbolic Geometry, and Complex Dynamics (Code: SS 5A), **Zheng Huang**, College of Staten Island, CUNY, and **Ren Guo**, University of Minnesota.

Topological and Computational Dynamics (Code: SS 7A), **Jean-Philippe Lessard**, Institute for Advanced Study and Rutgers University, and **Konstantin M. Mischaikow**, Rutgers University.

Berkeley, California

University of California Berkeley

June 2–5, 2010

Wednesday – Saturday

Meeting #1061

Eighth Joint International Meeting of the AMS and the Sociedad Matemática Mexicana.
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: March 2010
Program first available on AMS website: April 22, 2010
Program issue of electronic *Notices*: June 2010
Issue of *Abstracts*: Volume 31, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: February 16, 2010
For abstracts: April 13, 2010

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/internmtgs.html.

Invited Addresses

Alejandro Adem, University of British Columbia and PIMS, *Title to be announced.*

Peter W-K Li, University of California Irvine, *Title to be announced.*

Ernesto Lupercio, CINVESTAV, *Title to be announced.*

Victor Perez Abreu, CIMAT, *Title to be announced.*

Alberto Verjovsky, IM-UNAM, *Title to be announced.*

Maciej Zworski, University of California Berkeley, *Title to be announced.*

Special Sessions

Algebraic Topology and Related Topics (Code: SS 3A), **Alejandro Adem**, University of British Columbia, **Gunnar E. Carlsson** and **Ralph L. Cohen**, Stanford University, and **Ernesto Lupercio**, CINVESTAV.

Analytic Aspects of Differential Geometry (Code: SS 2A), **Nelia Charalambous**, ITAM, **Lizhen Ji**, University of Michigan, and **Jiaping Wang**, University of Minnesota.

Commutative Algebra and Representation Theory (Code: SS 7A), **David Eisenbud** and **Daniel M. Erman**, University of California, Berkeley; **Jose Antonio de la Pena**, UNAM, and **Rafael Villareal**, Cinvestav-IPN.

Dynamical Systems (Code: SS 4A), **Alberto Verjovsky**, IM-UNAM, and **Rodrigo Perez**, Indiana University-Purdue University, Indianapolis.

Harmonic Analysis, Microlocal Analysis, and Partial Differential Equations (Code: SS 1A), **Gunther Uhlmann**, University of Washington, and **Salvador Perez Esteva**, UNAM.

Low Dimensional Topology (Code: SS 8A), **Kenneth L. Baker**, University of Miami, and **Enrique Ramirez Losada**, CIMAT.

Singularity Theory and Algebraic Geometry (Code: SS 6A), **David Eisenbud**, University of California, Berkeley; **Anatoly S. Libgober**, University of Illinois at Chicago; **Jose Seade**, UNAM; and **Xavier Gomez-Mont**, CIMAT.

Toeplitz Operators and Discrete Quantum Models (Code: SS 5A), **Alejandro Uribe**, University of Michigan, and **Maciej Zworski**, University of California, Berkeley.

Syracuse, New York

Syracuse University

October 2–3, 2010

Saturday – Sunday

Meeting #1062

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: To be announced
Program first available on AMS website: August 19, 2010
Program issue of electronic *Notices*: October
Issue of *Abstracts*: Volume 31, Issue 4

Deadlines

For organizers: March 2, 2010
For consideration of contributed papers in Special Sessions: June 15, 2010
For abstracts: August 10, 2010

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Special Sessions

Difference Equations and Applications (Code: SS 2A), **Michael Radin**, Rochester Institute of Technology.

Nonlinear Analysis and Geometry (Code: SS 1A), **Tadeusz Iwaniec**, **Leonid V. Kovalev**, and **Jani Onninen**, Syracuse University.

Several Complex Variables (Code: SS 3A), **Dan F. Coman** and **Evgeny A. Poletsky**, Syracuse University.

Los Angeles, California

University of California Los Angeles

October 9–10, 2010

Saturday – Sunday

Meeting #1063

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: August 2010
Program first available on AMS website: August 26, 2010
Program issue of electronic *Notices*: October 2010
Issue of *Abstracts*: Volume 31, Issue 4

Deadlines

For organizers: March 10, 2010
For consideration of contributed papers in Special Sessions: June 22, 2010
For abstracts: August 17, 2010

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Greg Kuperberg, University of California Davis, *Title to be announced.*

Cris Moore, University of New Mexico, *Title to be announced.*

Stanley Osher, University of California Los Angeles, *Title to be announced.*

Terence Tao, University of California Los Angeles, *Title to be announced* (Einstein Public Lecture in Mathematics).

Melanie Wood, Princeton University, *Title to be announced.*

Special Sessions

Applications of Nonlinear PDE (Code: SS 5A), **Susan J. Friedlander** and **Igor Kukavica**, University of Southern California.

Combinatorics and Probability on Groups (Code: SS 3A), **Jason Fulman** and **Robert Guralnick**, University of Southern California, and **Igor Pak**, University of California Los Angeles.

Extremal and Probabilistic Combinatorics (Code: SS 4A), **Benny Sudakov**, University of California Los Angeles, and **Jacques Verstraete**, University of California San Diego.

Large Cardinals and the Continuum (Code: SS 2A), **Matthew Foreman**, University of California Irvine, **Alekos**

Kechris, California Institute for Technology, **Itay Neeman**, University of California Los Angeles, and **Martin Zeman**, University of California Irvine.

Topology and Symplectic Geometry (Code: SS 1A), **Robert Brown** and **Ciprian Manolescu**, University of California Los Angeles, and **Stefano Vidussi**, University of California Riverside.

Notre Dame, Indiana

Notre Dame University

October 29–31, 2010

Friday – Sunday

Meeting #1064

Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: August 2010
Program first available on AMS website: September 16, 2010
Program issue of electronic *Notices*: October 2010
Issue of *Abstracts*: Volume 31, Issue 4

Deadlines

For organizers: February 19, 2010
For consideration of contributed papers in Special Sessions: July 20, 2010
For abstracts: September 7, 2010

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Laura DeMarco, University of Illinois at Chicago, *Title to be announced.*

Jordan Ellenberg, University of Wisconsin, *Title to be announced.*

David Fisher, Indiana University, *Title to be announced.*

Jared Wunsch, Northwestern University, *Title to be announced.*

Special Sessions

Commutative Algebra and Its Interactions with Algebraic Geometry (Code: SS 2A), **Claudia Polini**, University of Notre Dame, **Alberto Corso**, University of Kentucky, and **Bernd Ulrich**, Purdue University.

Groups, Representations, and Characters (Code: SS 4A), **James P. Cossey**, University of Akron, and **Mark Lewis**, Kent State University.

Hilbert Functions in Commutative Algebra and Algebraic Combinatorics (Code: SS 3A), **Fabrizio Zanello**, Michigan Technological University, **Juan Migliore**, University of Notre Dame, and **Uwe Nagel**, University of Kentucky.

Singularities in Algebraic Geometry (Code: SS 1A), **Nero Budur**, University of Notre Dame, and **Lawrence Ein**, University of Illinois at Chicago.

Richmond, Virginia

University of Richmond

November 6–7, 2010

Saturday – Sunday

Meeting #1065

Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: September
Program first available on AMS website: September 23, 2010
Program issue of electronic *Notices*: November
Issue of *Abstracts*: Volume 31, Issue 4

Deadlines

For organizers: March 8, 2010
For consideration of contributed papers in Special Sessions: July 27, 2010
For abstracts: September 14, 2010

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Matthew H. Baker, Georgia Institute of Technology, *Title to be announced.*

Michael J. Field, University of Houston, *Title to be announced.*

Sharon R. Lubkin, North Carolina State University, *Title to be announced.*

Stefan Richter, University of Tennessee, Knoxville, *Title to be announced.*

Special Sessions

Operator Theory (Code: SS 2A), **Stefan Richter**, University of Tennessee, and **William T. Ross**, University of Richmond.

Pucon, Chile

December 15–18, 2010

Wednesday – Saturday
First Joint International Meeting between the AMS and the Sociedad de Matematica de Chile.
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: June 2010
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

New Orleans, Louisiana

New Orleans Marriott and Sheraton New Orleans Hotel

January 5–8, 2011

Wednesday – Saturday
Joint Mathematics Meetings, including the 117th Annual Meeting of the AMS, 94th 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), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: October 2010
Program first available on AMS website: November 1, 2010
Program issue of electronic *Notices*: January 2011
Issue of *Abstracts*: Volume 32, Issue 1

Deadlines

For organizers: April 1, 2010
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Statesboro, Georgia

Georgia Southern University

March 12–13, 2011

Saturday – Sunday
Southeastern Section
Associate secretary: Matthew Miller
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 12, 2010
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Iowa City, Iowa

University of Iowa

March 18–20, 2011

Friday – Sunday
Central Section
Associate secretary: Georgia Benkart
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: July 16, 2010
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Worcester, Massachusetts

College of the Holy Cross

April 9–10, 2011

Saturday – Sunday
Eastern Section
Associate secretary: Steven H. Weintraub
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 9, 2010
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Las Vegas, Nevada

University of Nevada

April 30 – May 1, 2011

Saturday – Sunday
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

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Special Sessions

Geometric PDEs (Code: SS 1A), **Matthew Gursky**, Notre Dame University, and **Emmanuel Hebey**, Universite de Cergy-Pontoise.

Salt Lake City, Utah

University of Utah

October 22–23, 2011

Saturday – Sunday
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

Boston, Massachusetts

John B. Hynes Veterans Memorial Convention Center, Boston Marriott Hotel, and Boston Sheraton Hotel

January 4–7, 2012

Wednesday – Saturday
Joint Mathematics Meetings, including the 118th Annual Meeting of the AMS, 95th 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), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: October 2011
Program first available on AMS website: November 1, 2011
Program issue of electronic *Notices*: January 2012
Issue of *Abstracts*: Volume 33, Issue 1

Deadlines

For organizers: April 1, 2011
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Diego, California

San Diego Convention Center and San Diego Marriott Hotel and Marina

January 9–12, 2013

Wednesday – Saturday
Joint Mathematics Meetings, including the 119th Annual Meeting of the AMS, 96th 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), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: October 2012
Program first available on AMS website: November 1, 2012
Program issue of electronic *Notices*: January 2012
Issue of *Abstracts*: Volume 34, Issue 1

Deadlines

For organizers: April 1, 2012
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Baltimore, Maryland

Baltimore Convention Center, Baltimore Hilton, and Marriott Inner Harbor

January 15–18, 2014

Wednesday – Saturday
Joint Mathematics Meetings, including the 120th Annual Meeting of the AMS, 97th 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, with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Matthew Miller
Announcement issue of *Notices*: October 2013
Program first available on AMS website: November 1, 2013
Program issue of electronic *Notices*: January 2013
Issue of *Abstracts*: Volume 35, Issue 1

Deadlines

For organizers: April 1, 2013
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Antonio, Texas

Henry B. Gonzalez Convention Center and Grand Hyatt San Antonio

January 10–13, 2015

Saturday – Tuesday
Joint Mathematics Meetings, including the 121st Annual Meeting of the AMS, 98th 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 of Symbolic Logic, with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: October 2014
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2015
Issue of *Abstracts*: Volume 36, Issue 1

Deadlines

For organizers: April 1, 2014
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Seattle, Washington

Washington State Convention & Trade Center and the Sheraton Seattle Hotel

January 6–9, 2016

Wednesday – Saturday
Joint Mathematics Meetings, including the 122nd Annual Meeting of the AMS, 99th 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 of Symbolic Logic, with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: October 2015
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2016
Issue of *Abstracts*: Volume 37, Issue 1

Deadlines

For organizers: April 1, 2015
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Atlanta, Georgia

Hyatt Regency Atlanta and Marriott Atlanta Marquis

January 4–7, 2017

Wednesday – Saturday
Joint Mathematics Meetings, including the 123rd Annual Meeting of the AMS, 100th 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 of Symbolic Logic, with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Georgia Benkart
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Program first available on AMS website: To be announced
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Deadlines

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

San Francisco, California; January 13–16, 2010

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

∗ *Special Session Speaker,* ■ *NAM Invited Lecturer,* ▲ *SIAM Invited Lecturer,* • *AMS Invited Lecturer,* ◦ *MAA Invited Lecturer,* ◇ *Joint Invited Lecturer,* ◊ *ASL Invited Lecturer,* ✠ *AMS Retiring Presidential Address,* □ *AWM Emmy Noether Lecturer,* ► *Graduate Student,* ◄ *Undergraduate Student*

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Program of the Sessions

San Francisco, California, January 13–16, 2010

Monday, January 11

MAA Short Course on Exploring the Great Books of Mathematics, Part I

9:00 AM – 4:30 PM

Organizers: **Amy Shell-Gellasch**, Beloit College
Glen Van Brummelen, Quest University

8:00AM Registration (outside Room 2002, Moscone).
9:00AM (1) *Ptolemy's Almagest: Greek mathematics and the heavenly bodies.*
Alex Jones, New York University
1:30PM (2) *Newton's* Principia.
George Smith, Tufts University

AMS Tutorial on Modeling, Part I: Introduction to Numerical Modeling

9:00 AM – 4:30 PM

Presenter: **Chi-Wang Shu**, Brown University
8:00AM Registration (outside Room 2002, Moscone).

AMS Short Course on Markov Chains and Mixing Times, Part I

9:30 AM – 5:00 PM

Organizers: **David A. Levin**, University of Oregon
Yuval Peres, University of California, Berkeley and Microsoft
Elizabeth L. Wilmer, Oberlin College

8:00AM Registration (outside Room 2002, Moscone).
9:30AM (3) *Simulation and Markov Chain Monte Carlo.*
Elizabeth Wilmer*, Oberlin College, and **Yuval Peres***, University of California, Berkeley
10:30AM Break
11:00AM (4) *Coupling and Variations.*
David Levin, University of Oregon
NOON Problem Session
2:00PM Problem Session: Solutions
2:30PM (5) *Shuffling and Strong Stationary Times.*
Elizabeth Wilmer, Oberlin College
3:30PM Break
4:00PM (6) *Mixing Times and Hitting Times.*
David Aldous, University of California Berkeley

Tuesday, January 12

AMS Department Chairs Workshop

8:00 AM – 6:00 PM

Organizers: **Lawrence F. Gray**, University of Minnesota
Stephen B. Robinson, Wake Forest University

MAA Ancillary Workshop on Statistics: Teaching Introductory Statistics

8:30 AM – 5:00 PM

Presenters: **Carolyn K. Cuff**, Westminster College
Michael A. Posner, Villanova University

MAA Ancillary Workshop on Statistics: Become a Catalyst for Change in Statistics Education

8:30 AM – 5:00 PM

Presenters: **Joan Garfield**, University of Minnesota
Bob delMas, University of Minnesota
Andy Zieffler, University of Minnesota
Allan Rossman, California Polytechnic Institute
Beth Chance, California Polytechnic Institute

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 31, Issue 1 of *Abstracts of papers presented to the American Mathematical Society*, ordered according to the numbers in parentheses following the listings.

AMS Short Course on Markov Chains and Mixing Times, Part II

9:00 AM – 4:30 PM

Organizers: **David A. Levin**, University of Oregon
Yuval Peres, University of California, Berkeley and Microsoft
Elizabeth L. Wilmer, Oberlin College

9:00AM (7) *Lower Bounds.*
Elizabet Wilmer, Oberlin College

10:00AM Break

10:30AM (8) *The Cut-off Phenomenon and the Ising Model.*
Yuval Peres, University of California Berkeley

11:30AM (9) *Markov chain mixing—examples and applications.*
Alistair Sinclair, University of California Berkeley

2:00PM (10) *Dynamics for the Ising Model, and Its Mixing Time.*
David Levin*, University of Oregon, and **Yuval Peres***, University of California, Berkeley

3:00PM Break

3:30PM Panel Discussion: Open Problems

MAA Short Course on Exploring the Great Books of Mathematics, Part II

9:00 AM – 5:00 PM

Organizers: **Amy Shell-Gellasch**, Beloit College
Glen Van Brummelen, Quest University

9:00AM (11) *Cauchy and the* Cours d'analyse.
Robert E. Bradley*, Adelphi University, and **Ed Sandifer**, Western Connecticut State College

1:15PM (12) *How algebra became modern.*
Fernando Q. Gouvêa, Colby College

4:20PM (13) *Tracking the great writings of mathematics.*
Ivor Grattan-Guinness, Middlesex University Business School

AMS Tutorial on Modeling, Part II: Introduction to Statistical Modeling

9:00 AM – 4:30 PM

Presenter: **Wei Zhu**, State University of New York, Stony Brook

MAA Board of Governors

9:00 AM – 5:00 PM

AMS Council

1:30 PM – 10:00 PM

Joint Meetings Registration

3:00 PM – 7:00 PM

MAA New Committee Chairs Workshop

7:00 PM – 9:00 PM

Organizers: **Barbara T. Faires**, Westminster College
Martha J. Siegel, Towson University

Wednesday, January 13

Joint Meetings Registration

7:30 AM – 6:00 PM

AMS-SIAM Special Session on Mathematics of Computation, I

8:00 AM – 10:50 AM

Organizers: **Susanne Brenner**, Louisiana State University
Chi-Wang Shu, Brown University

8:00AM (14) *A Coarsening Algorithm on Adaptive Grids by Newest Vertex Bisection and its Applications.*
Chensong Zhang*, PA, and **Long Chen**, CA (1056-65-1959)

8:30AM (15) *Convergence of Adaptive Finite Element Methods for Nonlinear Partial Differential Equations.* Preliminary report.
Michael Holst, **Gantumur Tsogtgerel** and **Yunrong Zhu***, University of California San Diego (1056-65-2033)

9:00AM ► (16) *Coordinate Descent for L1 Optimization.* Preliminary report.
Yingying Li* and **Stanley Osher**, University of California, Los Angeles (1056-49-345)

9:30AM (17) *Parallel computation with the weakly over-penalized symmetric interior penalty method.*
Andrew T. Barker* and **Susanne C. Brenner**, Louisiana State University (1056-65-1193)

10:00AM ► (18) *Approximation of kernel matrices with multilevel circulant matrices.*
Guohui Song*, Illinois Institute of Technology, and **Yuesheng Xu**, Syracuse University (1056-65-454)

10:30AM (19) *Very fast methods and preconditioners for banded matrices and PDEs on irregular domains.*
Martin Gander, **Sébastien Loisel**, Université de Genève, and **Daniel B Szyld***, Temple University (1056-65-1445)

AMS-ASL Special Session on Surreal Numbers, I

8:00 AM – 10:40 AM

Organizers: **Lou van den Dries**, University of Illinois
Philip Ehrlich, Ohio University

8:00AM (20) *Surreal Numbers, Conway Names, and the Simplicity Hierarchy.*
Philip Ehrlich, Ohio University (1056-03-262)

9:00AM (21) *Surreal numbers and real analysis.*
Ovidiu Costin, The Ohio State University (1056-03-1098)

10:00AM (22) *Recent work on H-fields.*
Lou van den Dries, University of Illinois-Urbana/Champaign (1056-03-987)

AMS Special Session on Degenerate and Singular Elliptic Partial Differential Equations, I

8:00 AM – 10:50 AM

Organizers: **Marian Bocea**, North Dakota State University
Cristina Popovici, North Dakota State University

8:00AM (23) *Multiple solutions for superlinear p-Laplacian Neumann problems.*
Vasile Staicu, University of Aveiro, Portugal (1056-35-2120)

8:30AM (24) *Γ-convergence of power-law functionals with variable exponents.*
Marian Bocea, NDSU (1056-35-1108)

9:00AM (25) *Statistics of p-harmonic functions.* Preliminary report.
Matthew Rudd, University of Idaho (1056-35-1492)

9:30AM (26) *Multiple and sign-changing solutions for nonlinear elliptic problems with p-Laplacian.*
Dumitru Motreanu, University of Perpignan, France (1056-35-878)

10:00AM (27) *Subelliptic regularity in non-nilpotent cases.*
Andras Domokos, California State University at Sacramento (1056-35-661)

10:30AM ► (28) *Near cloaking defeats the anti-cloak.*
Daniel T. Onofrei, University Of Utah (1056-35-1438)

AMS Special Session on Difference Equations and Applications, I

8:00 AM – 10:50 AM

Organizer: **Michael Radin**, Rochester Institute of Technology

8:00AM ► (29) *Open Problems and Conjectures in Difference Equations.* Preliminary report.
Gerasimos E Ladas, University of Rhode Island (1056-39-320)

8:30AM (30) *Applications of number theory to asymptotic behavior of solutions of difference equations.*
Richard T Guy*, **Kenneth S Berenhaut** and **Katherine M Donadio**, Wake Forest University (1056-39-1865)

9:00AM ► (31) *Global convergence of max-type equations.*
Timothy Sauer, George Mason University (1056-39-232)

9:30AM ► (32) *The Z-transform of queuing systems.* Preliminary report.
Mostafa Ghandehari* and **Shahrzad Sheibani**, University of Texas at Arlington (1056-39-34)

10:00AM (33) *Boundary Data Smoothness for Solutions of Nonlocal Boundary Value Problems for nth Order Difference Equations.* Preliminary report.
Jeffrey W Lyons, Baylor University (1056-39-28)

10:30AM ► (34) *On The Global Behavior Of a System Of Rational Difference Equations.* Preliminary report.
E. A. Grove, University of Rhode Island, **Y. Kostorv***, Xavier University of Louisiana, **M. Radin**, Rochester Institute of Technology, and **S. Schultz**, Providence College (1056-39-1290)

AMS Special Session on Harmonic Analysis (Mathematics Research Communities session), I

8:00 AM – 10:50 AM

Organizers: **Kabe Moen**, Washington University
Richard Oberlin, University of California Los Angeles
Betsy Stovall, University of California Los Angeles

8:00AM (35) *On an interesting singular integral operator.* Preliminary report.
Camil Muscalu, Cornell University (1056-42-1207)

8:30AM (36) *Maximal averages along one-variable vector fields.*
Michael Bateman, UCLA (1056-42-1455)

9:00AM (37) *Bilinear Hilbert transforms along curves.*
Xiaochun Li, University of Illinois at Urbana-Champaign (1056-42-1632)

9:30AM (38) *A nonlinear stationary phase method for oscillatory Riemann-Hilbert problems.* Preliminary report.
Q. Yen Do, UCLA (1056-42-1360)

10:00AM (39) *Weak Convergence in multiparameter Hardy spaces.*
Jill Pipher, Brown University (1056-42-280)

10:30AM (40) *An index formula in connection with meromorphic approximation.* Preliminary report.
Alberto A. Condori, Rose-Hulman Institute of Technology (1056-42-1657)

AMS Special Session on Inverse Problems: Analysis and Computations (Mathematics Research Communities session), I

8:00 AM – 10:50 AM

Organizers: **Gaik Ambartsoumian**, University of Texas at Arlington
Raluca Felea, Rochester Institute of Technology
Hongyu Liu, University of Washington
Kui Ren, University of Texas at Austin
Michael VanValkenburgh, University of California Berkeley

8:00AM (41) *Inverse Source Problems for Electromagnetics.* Preliminary report.
Gang Bao*, **Junshan Lin**, Michigan State University, and **Faouzi Triki**, University of Fourier, France (1056-35-1238)

8:30AM (42) *Active exterior cloaking.*
Daniel T Onofrei, University Of Utah (1056-35-1487)

9:00AM (43) *Diffraction at corners for the wave equation on differential forms.*
Andras Vasy, Stanford University (1056-35-798)

9:30AM (44) *Interior Transmission Eigenvalue Problem and its Application in Inverse Scattering Theory.*
Fioralba Cakoni, University of Delaware (1056-35-256)

10:00AM (45) *Local Singularity Reconstruction from Integrals over Curves in $\mathbb{R}^3$ and electron microscopy.* Preliminary report.
Eric Todd Quinto*, Tufts University, and **Hans Rullgard**, University of Stockholm (1056-92-491)

10:30AM ► (46) *Ultrasound modulated electrical impedance and optical tomography.* Preliminary report.
Peter Kuchment*, Texas A&M University, **Leonid Kunyansky**, University of Arizona, **Moritz Allmaras** and **Wolfgang Bangerth**, Texas A&M University (1056-35-1024)

AMS Special Session on the Mathematical Challenges of Relativity (Mathematics Research Communities session), I

8:00 AM – 10:50 AM

Organizers: **Paul T. Allen**, Lewis & Clark College
Michael Eichmair, M.I.T. and Monash University
Gustav Holzegel, Princeton University
Jared Speck, Princeton University
Willie W. Wong, University of Cambridge

8:00AM (47) *Decay Rate for the Linear Wave Equation on a Schwarzschild Black Hole.*
Jonathan Luk, Princeton University (1056-35-1449)

8:30AM (48) *Strichartz estimates for Kerr backgrounds.*
Mihai H Tohaneanu, Purdue University (1056-83-1296)

9:00AM (49) *Strichartz estimates on asymptotically de Sitter spaces.*
Dean R. Baskin, Stanford University (1056-35-1071)

9:30AM (50) *Breakdown Criteria for Nonvacuum Einstein Equations.*
Arick Shao, Princeton University (1056-83-921)

10:00AM (51) *Control of local null geometry by rough CMC initial data.*
Qian Wang, SUNY Stony Brook (1056-83-1910)

10:30AM (52) *Shock Waves in General Relativity.*
Moritz Andreas Reintjes, University of California in Davis (1056-83-633)

AMS Special Session on Algebraic Aspects of Cryptology, I

8:00 AM – 10:50 AM

Organizers: **Jintai Ding**, University of Cincinnati
Chris Christensen, Northern Kentucky

8:00AM ► (53) *Algebraic Attacks on Bivium and Trivium, Accelerated by Cutting the Variable-Sharing Graph.*
Gregory V. Bard, Fordham University (1056-12-1496)

8:30AM (54) *The Effect of Projection on the Symmetry of the SFLASH Attack.*
Daniel C. Smith, Indiana University (1056-12-942)

9:00AM ► (55) *Multivariate Public Key Cryptography.*
Bo-Yin Yang, Academia Sinica (1056-13-1203)

10:00AM (56) *Multivariate Public Key Cryptosystems from Diophantine Equations.*
Raymond A. Heindl, Clemson University (1056-14-982)

10:30AM (57) *Square Encryption Schemes: New Directions in Multivariate Public-Key Cryptography.*
Crystal Lee Clough, Nanyang Technological University, Singapore (1056-12-493)

AMS Special Session on Markov Chains and Their Statistical Applications (Mathematics Research Communities session), I

8:00 AM – 10:50 AM

Organizers: **James Flegal**, University of California Riverside
Radu Herbei, Ohio State University
Jessica Zuniga, Stanford University

8:00AM (58) *Markov Chains, Generalized Wishart distributions and Applications to High Dimensional Statistical Inference.*
Bala Rajaratnam, Stanford University (1056-60-1253)

9:00AM (59) *Improved mixing time bounds for the Thorp shuffle.* Preliminary report.
Ben J Morris, UC Davis (1056-60-1395)

10:00AM (60) *Applicability of drift and minorization condition for finding rate of convergence of finite state space Markov chains.*
Partha Sarathi Dey, UC Berkeley (1056-60-1836)

10:30AM (61) *Using Reversible Markov Chains for Distributional Approximation.* Preliminary report.
Nathan F. Ross, University of California, Berkeley (1056-60-1408)

AMS Special Session on Zonotopal Algebra and Its Applications, I

8:00 AM – 10:40 AM

Organizers: **Olga Holtz**, University of California Berkeley and Technical University Berlin
Amos Ron, University of Wisconsin

8:00AM (62) *Geometry of the Restricted Boltzmann Machine.*
Maria Angelica Cueto, UC Berkeley, **Jason Morton**, Stanford University, and **Bernd Sturmfels***, UC Berkeley (1056-62-423)

9:00AM (63) *Piecewise polynomials and equivariant Chow cohomology of nonsimplicial toric varieties.* Preliminary report.
Hal Schenck, University of Illinois (1056-14-1166)

10:00AM (64) *Spectral Properties of the Transition Operators Associated with Box Splines.* Preliminary report.
Rong-Qing Jia, University of Alberta (1056-41-1114)

AMS Special Session on Applications of Graph Theory, I

8:00 AM – 10:50 AM

Organizers: **Richard Low**, San Jose State University
Ralucca M. Gera, Naval Postgraduate School

8:00AM ► (65) *The Link Graph: a Tool for Word Sense Disambiguation.*
Ralucca M. Gera*, Naval Postgraduate School, **Henry Escuadro**, Juniata College, **Pranav Anand**, Linguistics Department, University of California Santa Cruz, and **Craig Martell**, Computer Science Department, Naval Postgraduate School (1056-05-226)

8:30AM ► (66) *A Generalization of Kundu's k-Factor Theorem.* Preliminary report.
Arthur H. Busch, University of Dayton, **Michael J. Ferrara**, University of Colorado Denver, **Stephen G. Hartke***, University of Nebraska-Lincoln, **Michael S. Jacobson**, University of Colorado Denver, **Hemanshu Kaul**, Illinois Institute of Technology, and **Douglas B. West**, University of Illinois (1056-05-344)

9:00AM ► (67) *Graph invariants from self-assembling nanostructures.*
Joanna Anthony Ellis-Monaghan* and **Greta Pangborn**, Saint Michael's College (1056-05-287)

9:30AM (68) *On k-circuit distance in graphs.*
Ralucca Gera, Naval Postgraduate School, **Grady Bullington**, **Linda Eroh*** and **Steven J Winters**, University of Wisconsin Oshkosh (1056-05-1731)

10:00AM ► (69) *Coding Sequences and Their Applications.* Preliminary report.
Eunjeong Yi, Texas A&M University at Galveston (1056-05-1075)

10:30AM ► (70) *Bonding Tree Models of RNA Structures.* Preliminary report.
Teresa Haynes, **Debra Knisley** and **Denise Koessler***, East Tennessee State University (1056-05-2014)

AMS Special Session on Arithmetic and Nonarchimedean Dynamics, I

8:00 AM – 10:50 AM

Organizers: **Joseph Silverman**, Brown University
Michelle Manes, University of Hawaii
Raphael Jones, College of the Holy Cross

8:00AM (71) *Discriminants and Galois groups for iterated rational functions.* Preliminary report.
Rafe Jones*, College of the Holy Cross, and **Michelle Manes**, University of Hawaii-Manoa (1056-11-1117)

8:30AM (72) *The dynamical Manin-Mumford problem.*
Thomas J Tucker*, University of Rochester, **Dragos Ghioca**, University of Lethbridge, and **Shouwu Zhang**, Columbia University (1056-11-563)

9:00AM (73) *The dynamical Manin-Mumford problem.*
Dragos Ghioca, University of Lethbridge (1056-11-292)

9:30AM (74) *Towards Dynamical Uniform Boundedness for Rational Functions.* Preliminary report.
Robert L. Benedetto, Amherst College (1056-11-658)

10:00AM (75) *Preperiodic points: from algebraic to complex.*
Laura DeMarco*, University of Illinois at Chicago, and **Matt Baker**, Georgia Institute of Technology (1056-37-1206)

10:30AM (76) *Critical Points of Non-Archimedean Dynamical Systems on the Projective Line.* Preliminary report.
Xander Faber, McGill University (1056-11-664)

AMS Session on Group Theory, I

8:00 AM – 10:55 AM

8:00AM (77) *Subgroups of S_{n+1} normalized by and coprime to a regular subgroup of order n.* Preliminary report.
Stephen M. Gagola, Jr., Kent State University (1056-20-122)

8:15AM (78) *The nilpotent product and the nonabelian tensor square of groups.* Preliminary report.
Arturo Magidin, University of Louisiana at Lafayette (1056-20-272)

8:30AM (79) *Finite Groups with Permutable Supplemented Subgroups.* Preliminary report.
Joseph Kirtland, Marist College (1056-20-277)

8:45AM (80) *Open Questions and Conjectures Regarding Near Frattini Subgroups of Generalized Free Products of Groups.* Preliminary report.
Mohammad K. Azarian, University of Evansville (1056-20-371)

9:00AM (81) *A relationship between the property R_∞ and the geometric invariants Ω^n.*
Nic Koban*, University of Maine Farmington, and **Peter Wong**, Bates College (1056-20-474)

9:15AM Break

9:30AM (82) *The Probability that Two Semigroup Elements Commute Can Be Anything.*
Vadim Ponomarenko* and **Natalie Selinski**, San Diego State University (1056-20-497)

9:45AM (83) *Finite Phase Transitions in Countable Abelian Groups.*
Hannah Alpert, University of Chicago (1056-20-499)

10:00AM (84) *L_δ-equivalence of p-local abelian groups with nice decomposition bases.*
Ruediger Goebel, **Katrin Leistner**, University of Duisburg-Essen, Germany, **Peter Loth***, Sacred Heart University, and **Lutz Struengmann**, University of Duisburg-Essen, Germany (1056-20-503)

10:15AM (85) *An interpretation of the LLT algorithm.*
Alexander Kleshchev and **David Nash***, University of Oregon (1056-20-579)

10:30AM (86) *Simply intersecting pairs in the mapping class group.*
Leah Childers, Louisiana State University (1056-20-645)

10:45AM (87) *Zariski closures of linear differential algebraic groups.*
Andrei Minchenko*, Cornell University, and **Alexey Ovchinnikov**, City University of New York (1056-22-1028)

AMS Session on Probability and Statistics, I

8:00 AM – 10:40 AM

8:00AM (88) *MCMC methods for spatial random permutations.* Preliminary report.
John R Kerl, University of Arizona (1056-60-38)

8:15AM (89) *Extracting multiscale information from time series characterizing nanoscale systems.*
Christopher P Calderon, Lawrence Berkeley National Lab (1056-60-91)

8:30AM (90) *Abstract Measure-Dependent Stochastic Evolution Equations in a Hilbert Space with Applications to Nonlinear Diffusion.* Preliminary report.
Mark A McKIbben, Goucher College (1056-60-135)

8:45AM (91) *Self-dual planar hypergraphs and exact bond percolation thresholds.* Preliminary report.
John C. Wierman, Johns Hopkins University (1056-60-452)

9:00AM (92) *Characterizing departure count moments from queueing nodes fed by nonstationary, non-Poisson arrival processes.*
Ira Gerhardt*, Manhattan College, and **Barry L. Nelson**, Northwestern University (1056-60-471)

9:15AM Break

9:30AM (93) *Lanchester SDEs and the probability of the target destruction — a stochastic model of terrorism risk.* Preliminary report.
Michael Powers, Temple University, Department of Risk Management and Insurance, **Wei-Shi Yang** and **Sheng Xiong***, Temple University (1056-60-549)

9:45AM (94) *Completely Simple Semigroups of Real d x d Matrices and Recurrent Random Walks.*
Santanu Chakraborty, University of Texas - Pan American, Edinburg, Texas (1056-60-581)

10:00AM (95) *A Stochastic Approximation Algorithm for Option Pricing Model Calibration with a Switchable Market.*
George Yin, Wayne State University, **Jie Yu***, Roosevelt University, and **Qing Zhang**, University of Georgia, Athens (1056-60-590)

10:15AM (96) *Quantile Hedging for Guaranteed Minimum Death Benefits.* Preliminary report.
Yumin Wang, Wayne State University (1056-60-670)

10:30AM (97) *On Sojourn Times in the Finite Capacity $M/M/1$ Queue with Processor Sharing.*
Qiang Zhen* and **Charles Knessl**, University of Illinois at Chicago (1056-60-758)

AMS Session on Mathematics in the Social Sciences

8:00 AM – 9:40 AM

8:00AM ► (98) *Continuous Time Model of Bifurcations and Related Phenomena in Agent-Based Models.* **Andrew Clark**, Thomson Reuters (1056-91-251)

8:15AM ► (99) *Addiction and Treatment in a rational framework—can lowering health care costs have adverse effects?* Preliminary report. **Tamas Forgacs***, California State University, Fresno, **Attila Cseh**, Valdosta State University, and **Adnan Sabuwala**, Californa State University, Fresno (1056-91-909)

8:30AM ► (100) *Dynamical Analysis in Lucas Framework with Heterogeneous Agents.* Preliminary report. **Yuanying Guan**, Florida State University (1056-91-1129)

8:45AM Break.

9:00AM ► (101) *Two-player envy-free multi-cake division using a polytopal Sperner's lemma.* **John Cloutier**, University of California at Santa Barbara, **Kathryn L. Nyman***, Willamette University, and **Francis Edward Su**, Harvey Mudd College (1056-91-1642)

9:15AM (102) *Option pricing for biomedical firms with predictable price jumps.* Preliminary report. **Jin-Chuan Duan**, Risk Management Institute, National University of Singapore, **Anirban Dutta*** and **Qiji J. Zhu**, Western Michigan University (1056-91-1983)

9:30AM ► (103) *Statistical Modeling of Gang Violence in Los Angeles.* **Kym C Louie***, Harvey Mudd College, **Mike Egesdal**, **Jeremy Neuman**, University of California, Los Angeles, and **Chris Fathauer**, Harvey Mudd College (1056-91-1923)

AMS Session on Complex Analysis

8:00 AM – 9:55 AM

8:00AM ► (104) *Strong and Weak LFCDs: Local Fractional Complex Derivatives.* Preliminary report. **Steve M. Anglin**, Case Western Reserve University (fmr), Mountain View, CA (1056-30-23)

8:15AM (105) *On Janowski starlike functions.* **Rosihan M. Ali**, Universiti Sains Malaysia (1056-30-175)

8:30AM (106) *Subclasses of Meromorphic Functions Associated with Convolution.* **See Keong Lee**, Universiti Sains Malaysia (1056-30-514)

8:45AM (107) *L^p Rational Approximation in the Complex Plane.* Preliminary report. **Erin R Militzer**, University of Kentucky (1056-30-601)

9:00AM (108) *On minimal Rolle's domains for complex polynomials.* **Michael J Miller**, Le Moyne College (1056-30-957)

9:15AM (109) *Poisson Equation with the Robin/Third Boundary Condition.* **Alip Alifu, Maimaiti Mohammed**, York University (1056-30-2128)

9:30AM (110) *Mean Value Theorem for Functions on the Complex Plane.* Preliminary report. **Nasser Dastrange**, Buena Vista University (1056-26-1044)

9:45AM (111) *A residual radial limit zero set.* **Michael C Fulkerson**, University of Central Oklahoma (1056-32-1285)

AMS Session on Geometry and Topology, I

8:00 AM – 10:10 AM

8:00AM (112) *The writhe of oriented polygonal graphs.* **Christian Laing***, Courant Institute of Mathematical Sciences, NYU, and **De Witt Sumners**, Florida State University (1056-54-131)

8:15AM (113) *One-sided Heegaard splittings of 3-manifolds.* **Loretta Bartolini**, Oklahoma State University (1056-57-1255)

8:30AM (114) *Defining Khovanov Homology in 3-Manifolds Using a Diagramless Theory.* **Adam C. McDougall**, The University of Iowa (1056-54-1055)

8:45AM (115) *Unstable Vassiliev Theory.* **Chad D Giusti**, University of Oregon (1056-55-611)

9:00AM (116) *Identifying the Canonical Component for the Whitehead Link.* Preliminary report. **Emily R Landes**, Univeristy of Texas, Austin (1056-54-2096)

9:15AM (117) *The Kauffman bracket skein module of T^3.* **Jeffrey Boerner**, University of Iowa (1056-57-1944)

9:30AM (118) *The Moduli space of singular Euclidean structures on a sphere with 4 cone points whose cone angles are integer multiples of $\frac{2\pi}{3}$ but less than 2π.* Preliminary report. **Aldo-Hilario Cruz-Cota**, Grand Valley State University (1056-54-1389)

9:45AM (119) *Lagrangian representations of the (p, q, r)- triangle group.* Preliminary report. **Paul W Lewis**, University of Tennessee, Knoxville (1056-51-284)

10:00AM ► (120) *Relationships between Bundle Forms in Laguerre Planes.* **Robert D. Knight**, Ohio University-Chillicothe (1056-51-574)

AMS Session on Discrete Mathematics, I

8:00 AM – 10:55 AM

8:00AM ► (121) *Combinatorial Proofs of Certain Identities.* **Akalu Tefera***, Grand Valley State University, **Aklilu Zeleke**, Michigan State University, and **George Grossman**, Central Michigan University (1056-05-912)

8:15AM ► (122) *Playing with Paths: An Introduction to Bijective Combinatorics.* **Paul W.T. Fijn**, University of Melbourne, Australia (1056-05-1424)

8:30AM ► (123) *Some Remarks On Self-Avoiding Walks.* **Shanzhen Gao**, Florida Atlantic University (1056-05-690)

8:45AM (124) *On the Non-existence of* (160, 54, 18) *Difference Sets.* **Adegoke S Osifodunrin***, Georgia Southern University, and **Ken. W Smith**, Sam Houston State University (1056-05-1921)

9:00AM ► (125) *Alternating Permutations and the mth Descents.* **Ae Ja Yee** and **Kagan Kursungoz***, The Pennsylvania State University (1056-05-628)

9:15AM Break

9:30AM ► (126) *The lattice of finite vector space partitions and its Möbius function.* **Fusun Akman*** and **Papa Amar Sissokho**, Illinois State University (1056-06-89)

9:45AM ► (127) *Generating functions for box-counting problems.* **Benjamin J Young**, Centre de Recherches Mathematiques / McGill University (1056-05-1961)

10:00AM (128) *Multi-restrained Stirling numbers.* Preliminary report.
Ji Young Choi, Sippensburg University of PA (1056-05-1813)

10:15AM (129) *A map from chains in the noncrossing partition lattice to polygon dissections.*
Hillary Einziger, The George Washington University (1056-05-1950)

10:30AM (130) *Regular completions of lattices.*
John Harding and **Qin Yang***, New Mexico State University (1056-06-739)

10:45AM ► (131) *How much does a Hamiltonian cycle weigh?* Preliminary report.
Hurlee Gonchigdanzan, University of Wisconsin - Stevens Point (1056-51-323)

MAA Session on General Contributed Papers, I

8:00 AM – 10:55 AM

Organizers: **Eric S. Marland**, Appalachian State University
Daniel J. Curtin, Northern Kentucky University

8:00AM (132) *Analysis of the secondary Flow effects on an open channel with cross stream variation of the bottom roughness.*
Ahmed Kaffel*, Virginia Tech, **Amel Soualmia**, LMHE, and **Masbernat Lucien**, imft (1056-Z1-1423)

8:15AM ► (133) *A Biexponential Model of Electroosmotic Flow.* Preliminary report.
Rachel R Roe-Dale*, **Emese Lipcsey-Magyar** and **Kimberly Frederick**, Skidmore College (1056-Z1-1422)

8:30AM ► (134) *Building on Nature's Inspiration: A NAKFI Synthetic Biology Report.* Preliminary report.
Jeffrey L Poet, Missouri Western State University (1056-Z1-1168)

8:45AM ► (135) *Using Neural Networks for Near-Interpolation of Scattered Data.*
Laurene V Fausett, Texas A&M University-Commerce (1056-Z1-260)

9:00AM ► (136) *Chromatic Methods For Creating A Secure Identification Procurement.*
Timothy Grant Hall, PQI Consulting (1056-Z1-418)

9:15AM ► (137) *Foot to the Pedal: Generalizing Euler's work on constant pedal curves to constant pedal surfaces.* Preliminary report.
Hieu D Nguyen, Rowan University (1056-Z1-653)

9:30AM ► (138) *Turtles, and Lizards, and Snakes, Oh My!* Preliminary report.
Leon Brin, Southern CT State University (1056-Z1-879)

9:45AM (139) *Adapting the Feynman Path Integral for use in a discrete spacetime.*
Douglas B Mathews*, **Jake Askeland**, **Cheuk Wong**, **Miranda Braselton**, **David Von Gunten**, **Jonathan Baptist**, **Duncan McElfresh** and **Slobodan Simic**, San Jose State University (1056-Z1-1670)

10:00AM (140) *Path elongation and r-reduced cutting numbers of cycles.*
Brad Bailey* and **Dianna J. Spence**, North Georgia College & State University (1056-Z1-735)

10:15AM ► (141) *Arcs in the plane.*
Joan E Hart*, University of Wisconsin Oshkosh, and **Kenneth Kunen**, University of Wisconsin – Madison (1056-Z1-52)

10:30AM (142) *On the theory of mixed convex functions.*
Emre Tokgoz, University of Oklahoma (1056-Z1-402)

10:45AM ► (143) *Some Nonlinear Delay Integral Inequalities On Time Scales.* Preliminary report.
Shiojenn Tseng*, **Jen-Chienh Lo**, Tamkang University, and **Wing-Sum Cheung**, The University of Hong Kong (1056-Z1-1516)

MAA Session on The Scholarship of Teaching and Learning in Undergraduate Mathematics, I

8:00 AM – 10:55 AM

Organizers: **Edwin P. Herman**, University of Wisconsin - Stevens Point
Nathan M. Wodarz, University of Wisconsin - Stevens Point

8:00AM (144) *Creating Student Centered, Active Learning Classrooms in a Multi-Section Precalculus Course.*
Paula A. Shorter* and **Mairead K. Greene**, Rockhurst University (1056-Q1-2046)

8:20AM ► (145) *Anatomy of a multi-section calculus semester: A students-eye view.* Preliminary report.
Fabiana Cardetti* and **P. Joseph McKenna**, University of Connecticut (1056-Q1-1594)

8:40AM ► (146) *Calculus Acquisition through a Problem and Activity Based Learning Experience (CAPABLE).* Preliminary report.
Gary Fowler, **Sommer Gentry***, **Amy Ksir** and **Will Traves**, United States Naval Academy (1056-Q1-1773)

9:00AM ► (147) *Peer Led Team Learning in Calculus I: A four-year study.*
John C. Merkel, Morehouse College (1056-Q1-2015)

9:20AM ► (148) *Success in Calculus I: Oral Reviews.*
Mary A Nelson*, University of Colorado, Boulder, and **Monica R Geist**, Front Range Community College (1056-Q1-648)

9:40AM ► (149) *Results of the use of guided notes and lab work in introductory college courses.*
Ellen F Hill, Minnesota State University Moorhead (1056-Q1-1052)

10:00AM ► (150) *Student-Generated Note Cards: Sound Pedagogy?* Preliminary report.
Kenneth Horton, U. S. Air Force Academy (1056-Q1-1695)

10:20AM ► (151) *A Modified Moore Method in Real Analysis: Hearing the Students' Voices.* Preliminary report.
Joy Moore* and **Bernd Rossa**, Xavier University (1056-Q1-1629)

10:40AM (152) *Teaching Abstract Algebra using Technology.* Preliminary report.
Claus Schubert* and **Mary Gfeller**, SUNY Cortland (1056-Q1-342)

MAA Session on Improving a Second Course in Statistics

8:00 AM – 10:55 AM

Organizers: **Nancy J. Boynton**, SUNY Fredonia
Patricia B. Humphrey, Georgia Southern University
Michael A. Posner, Villanova University

8:00AM ► (153) *Teaching Undergraduate Statistics in R.* Preliminary report.
Salil Kumar Das, Prince Georges' Community College (1056-F5-1919)

8:20AM ► (154) *Interdisciplinary Case Studies for an Intermediate Statistics Course.*
Terje Hoim, Wilkes Honors College, Florida Atlantic University (1056-F5-1447)

8:40AM (155) *Finding and Working with Real-World Clients in a Second Statistics Course.*
Cora Neal, Sonoma State University (1056-F5-437)

9:00AM (156) *Experiential Learning of Non-parametric Statistics through a campus-client led survey project.*
K. Scott Alberts, Truman State University (1056-F5-617)

9:20AM (157) *Some More Lab Experiences in Introductory Statistics.*
Patricia B Humphrey, Georgia Southern University (1056-F5-1294)

9:40AM ► (158) *A Second Course for Non-Majors – Relevance is the Key!*
Murray H Siegel, Arizona State University, Polytechnic (1056-F5-264)

10:00AM ► (159) *Stat2 - What Should We Do?* Preliminary report.
Robin H Lock, St. Lawrence University (1056-F5-2031)

10:20AM (160) *An Innovative Second Half-Course in Applied Statistics.*
John D McKenzie, Babson College (1056-F5-1904)

10:40AM ► (161) *A Successful Second Course in Business Statistics.* Preliminary report.
Sue B Schou, Idaho State University (1056-F5-552)

Employment Center

8:00 AM – 7:00 PM

SIAM Minisymposium on Economics and Sustainability

8:05 AM – 11:00 AM

Organizer: **Christian Traeger**, University of California, Berkeley

8:05AM (162) *Preferences Yielding the Precautionary Effect.*
Michel De Lara, Université Paris-Est (1056-91-1065)

8:30AM ► (163) *Mathematical Analysis of Smart Grids Using Randomized Algorithms.*
Kourosh Modarresi, Stanford University (1056-90-2067)

8:55AM (164) *Exact Calibration of Programming Models of Agricultural Supply against Exogenous Sets of Supply Elasticities.*
Pierre R. Merel* and **Santiago Bucaram**, Agricultural and Resource Economics, University of California, Davis (1056-90-1181)

9:20AM Break.

9:35AM ► (165) *Closing the gap between risk estimation and decision-making: efficient management of trade-related invasive species risk.* Preliminary report.
Michael R Springborn*, University of California, Davis, and **Robert Lieli**, University of Texas, Austin (1056-91-1274)

10:00AM (166) *Time perspective and climate change policy.*
Larry S Karp*, Agricultural and Resource Economics, University of California, Berkleley, and **Yacov Tsur**, Hebrew University (1056-91-1196)

10:25AM (167) *Risk, Uncertainty and Climate Change Evaluation.* Preliminary report.
Christian P Traeger, UC Berkeley (ARE) (1056-91-2030)

10:50AM Final discussion.

MAA Session on Mathematical Texts: Famous, Infamous, and Influential, I

8:55 AM – 10:55 AM

Organizers: **Fernando Q. Gouvêa**, Colby College
Amy Shell-Gellasch, Beloit College

8:55AM Welcome.

9:00AM ► (168) Geometry and Algebra in Ancient Civilizations *by B. L. van der Waerden: A Text Exploring the Origin and Development of Ancient Mathematics.*
Toke L Knudsen, SUNY Oneonta (1056-H1-1420)

9:20AM ► (169) *The Elements, its evil influence.* Preliminary report.
Alejandro R. Garciadiego, Universidad Nacional Autónoma de México (UNAM) (1056-H1-836)

9:40AM (170) *Rip-off or Reverence? Hypsicles of Alexandria and the fourteenth book of the Euclid's Elements.*
Clemency J Montelle, University of Canterbury (1056-H1-1140)

10:00AM ► (171) *Conjugate Diameters: Apollonius of Perga and Eutocius of Ascalon.* Preliminary report.
Colin Bryan Powell McKinney, University of Iowa (1056-H1-580)

10:20AM ► (172) *Newton's Principia : What is in it and why should we care?*
Herbert E Kasube, Bradley University (1056-H1-818)

10:40AM ► (173) *Eric Temple Bell's* Men of Mathematics*: From Influential to Infamous.*
V. Frederick Rickey, West Point (1056-H1-1323)

MAA Minicourse #13: Part A

9:00 AM – 11:00 AM

Taking symbols seriously: Teaching form and function in college algebra.

Organizers: **William G. McCallum**, University of Arizona
Deborah Hughes Hallett, University of Arizona and Harvard University
Pat Shure, University of Michigan

MAA Minicourse #4: Part A

9:00 AM – 11:00 AM

Using video-case studies in teaching a proof-based gateway course to the mathematics major.

Organizers: **James T. Sandefur**, Georgetown University
Connie M. Campbell, Millsaps College
Kay B. Somers, Moravian College

MAA Minicourse #7: Part A

9:00 AM – 11:00 AM

Teaching with clickers in the classroom.

Organizers: **Derek Bruff**, Vanderbilt University
Adam Lucas, Saint Mary's College of California

MAA Session on My Most Successful Math Club Activity

9:00 AM – 10:35 AM

Organizers: **Jacqueline A. Jensen**, Sam Houston State University

Deanna B. Haunsperger, Carlton College
Robert W. Vallin, Slippery Rock University and the MAA

9:00AM ► (174) *The most engaging activity in Mathematics/Computer Science Club.* Preliminary report.
Ryo Ohashi, King's College (1056-K5-1587)

9:20AM ► (175) *Lawrence Tech's best Math Club events.*
Ruth Favro, Lawrence Technological University (1056-K5-684)

9:40AM ► (176) *A Revamped Problem-Solving Competition.* Preliminary report.
Pamela A Richardson* and **Natacha C Fontes-Merz**, Westminster College (1056-K5-639)

10:00AM ► (177) *Digital Scavenger Hunts.*
Tom Thompson, Walla Walla University (1056-K5-455)

10:20AM ► (178) *Math Extravaganza!*
Tracii Friedman, Mesa State College (1056-K5-1627)

Student Hospitality Center

9:00 AM – 5:00 PM

MAA CUPM Subcommittee on Mathematics Across the Disciplines Panel Discussion

9:00 AM – 10:20 AM

Mathematical collaborations with other disciplines: Research partnerships and interdisciplinary programs.

Organizer: **Joseph Malkevitch**, York College (CUNY)

Panelists: **Steven Brams**, New York University
Susan L. Ganter, Clemson University
James G. Glimm, SUNY at Stony Brook
Suzanne M. Lenhart, University of Tennessee

MAA Panel Discussion

9:00 AM – 10:20 AM

National Science Foundation's programs supporting learning and teaching in the mathematical sciences.

Organizers: **Henry Warchall**, NSF/DMS
Karen A. Marrongelle, NSF/DRL
Dennis E. Davenport, NSF/DUE
Daniel P. Maki, NSF/DUE
Lee L. Zia, NSF/DUE

MAA Department Liaisons Meeting

9:30 AM – 11:00 AM

AMS Session on Category Theory

10:00 AM – 10:55 AM

10:00AM (179) *A finiteness property for braided fusion categories.*
Deepak Naidu* and **Eric Rowell**, Texas A&M University (1056-18-316)

10:15AM (180) *Blocks in Deligne's $Rep(S_t)$.*
Jonny Comes, University of Oregon (1056-18-983)

10:30AM (181) *Leavitt Algebras and Categories of Modules for Nonunital Rings.* Preliminary report.
Leandro Marin, Universidad de Murcia (Spain) (1056-18-1036)

10:45AM (182) *The First of the Three Homotopy Exact Sequences of a Fibration in Module Theory.*
C. Joanna Su, Providence College (1056-18-1937)

AMS Invited Address

10:05 AM – 10:55 AM

(183) *Chaos and symmetry in partially hyperbolic systems.*
Amie Wilkinson, Northwestern University (1056-37-8)

AMS Session on Matrices and Tensors

10:15 AM – 10:55 AM

10:15AM (184) *On Constructibility Results for a Class of Non-Selfadjoint Analytic Perturbations of Matrices with Degenerate Eigenvalues.*
Aaron Welters, UCI (1056-15-1076)

10:30AM (185) *Factorization Strategies for Tensors.*
Misha Kilmer, Tufts University, and **Carla D Martin***, James Madison University (1056-15-2082)

10:45AM (186) *Spectrally arbitrary patterns of matrices over finite fields.*
Elizabeth J. Bodine* and **Judith J. McDonald**, Washington State University (1056-15-935)

AMS-MAA Invited Address

11:10 AM – NOON

► (187) *The interpolation problem.*
Joseph Harris, Harvard University (1056-14-41)

Exhibits and Book Sales

12:15 PM – 5:30 PM

Come to the Grand Opening at 12:15!

AMS Colloquium Lectures: Lecture I

1:00 PM – 2:00 PM

(188) *Increasing and decreasing subsequences.*
Richard P. Stanley, M.I.T. (1056-05-16)

MAA Invited Address

2:15 PM – 3:05 PM

(189) *The real computation controversy: Is it real?*
Lenore Blum, Carnegie Mellon University (1056-A0-4)

AMS-SIAM Special Session on Mathematics of Computation, II

2:15 PM – 6:05 PM

Organizers: **Susanne Brenner**, Louisiana State University
Chi-Wang Shu, Brown University

2:15PM ► (190) *Bayesian Scientific Computing.*
Daniela Calvetti* and **Erkki J. Somersalo**, Case Westen Reserve University (1056-65-2138)

2:45PM (191) *Global Minimization of Markov Random Fields with Applications to Optical Flow.*
Tom Goldstein*, **Xavier Bresson** and **Stanley Osher**, UCLA (1056-49-1648)

3:15PM (192) *Evaluating expectations of functionals of Brownian motions: a multilevel idea.*
Ben Niu*, **Fred Hickernell**, Illinois Institute of Technology, **Thomas Müller-Gronbach**, Universität Passau, and **Klaus Ritter**, Technische Universität Darmstadt (1056-65-453)

3:45PM (193) *A Dual Iterative Substructuring Method with a Penalty Term in Three Dimensions.*
Eun-Hee Park*, Louisiana State University, and **Chang-Ock Lee**, KAIST (1056-65-616)

4:15PM (194) *A higher order WENO algorithm to solve radiative transfer of photons in the 'early universe'.*
Ishani Roy*, Brown University, **Wen Xu**, University of Arizona, **Jing-Mei Qiu**, Colorado School of Mines, **Chi-Wang Shu**, Brown University, and **Li-Zhi Fang**, University of Arizona (1056-65-691)

4:45PM (195) *Simulation of Surfactant Dynamics using Spectral Method.* Preliminary report.
Yuen Yick Kwan, Tulane University (1056-65-1963)

5:15PM (196) *The Multiscale Discontinuous Galerkin Method for Solving a Class of Second Order Elliptic Problems with Rough Coefficients.*
Wei Wang*, Center for Turbulence Research, Stanford University, **Johnny Guzmán** and **Chi-Wang Shu**, Brown University (1056-65-1623)

5:45PM (197) *Efficient High-Order Methods Using Bandlimited Basis Functions.*
Li-Lian Wang, Nanyang Technological University (1056-65-1507)

AMS-ASL Special Session on Surreal Numbers, II

2:15 PM – 6:05 PM

Organizers: **Lou van den Dries**, University of Illinois
Philip Ehrlich, Ohio University

2:15PM (198) *Transseries, a survey.*
Joris van der Hoeven, University of Paris-Sud, (1056-06-612)

3:15PM (199) *The exponential logarithmic power series fields.*
Salma Kuhlmann*, Universitaet Konstanz, and **Saharon Shelah**, Hebrew University (1056-06-1940)

4:15PM (200) *Surreal numbers as transseries.*
Joris van der Hoeven, University of Paris-Sud, **Salma Kuhlmann** and **Mickaël Matusinski***, University of Konstanz (1056-06-594)

5:15PM (201) *Generalized power series and real closed fields, Part I.*
Julia Knight and **Karen Lange***, University of Notre Dame (1056-03-678)

5:45PM (202) *Generalized power series and real closed fields: Part II.*
Julia F. Knight* and **Karen Lange**, University of Notre Dame (1056-03-649)

AMS Special Session on Difference Equations and Applications, II

2:15 PM – 6:05 PM

Organizer: **Michael Radin**, Rochester Institute of Technology

2:15PM (203) *Global Behavior of Solutions to a Planar System of First-Order Rational Difference Equations.*
Sukanya Basu, Midwestern State University (1056-39-764)

2:45PM (204) *Complex Dynamics and Symbolic Dynamics.*
Elizabeth D Russell, United States Military Academy (1056-37-1039)

3:15PM (205) *Competition Models with Allee effects.* Preliminary report.
N Saber Elaydi, Trinity University (1056-39-1017)

3:45PM (206) *Stability and complexity of small random systems of stochastic linear difference equations.*
Harold M Hastings*, **Michael Bantegui**, **Michael Palmer** and **Thomas Savino**, Hofstra University (1056-39-1070)

4:15PM (207) *The Dynamics of the Periodically Forced Sigmoid Beverton-Holt Model, part I.* Preliminary report.
April Harry, Xavier University of Louisiana, **Candace M Kent**, Virginia Commonwealth University, and **Vlajko L Kocic***, Xavier University of Louisiana (1056-39-916)

4:45PM (208) *The Dynamics of the Periodically Forced Sigmoid Beverton-Holt Model, part II.* Preliminary report.
April Harry, Xavier University of Louisiana, **Candace M Kent***, Virginia Commonwealth University, and **Vlajko L Kocic**, Xavier University of Louisiana (1056-39-917)

5:15PM (209) *The Aging Heart and the Loss of Complexity—a Difference Equation Model.* Preliminary report.
Tamara Eugenia Awerbuch-Friedlander* and **Richard Levins**, Harvard School of Public Health (1056-39-2059)

5:45PM (210) *A difference equation model to measure the length of Latency of HSV1 infections in differential cells.*
Youssef M Dib* and **Mariette Maroun**, University of Louisiana, Monroe (1056-39-1846)

AMS Special Session on Geometric Aspects of Link and 3-manifold Invariants, I

2:15 PM – 6:05 PM

Organizers: **Oliver Dasbach**, Louisiana State University
Effie Kalfagianni, Michigan State University

2:15PM (211) *Heegaard genus, cut number, weak p-congruence, and quantum invariants.*
Patrick M Gilmer, Louisiana State Univiersity (1056-57-619)

2:45PM (212) *A dimer model for the twisted Alexander polynomial.*
Moshe Cohen, **Oliver Dasbach** and **Heather M. Russell***, Louisiana State University (1056-57-1827)

3:15PM (213) *Graph-based methods establishing nontriviality of state cycle Khovanov homology classes.*
Andrew Elliott, Rice University (1056-57-47)

3:45PM (214) *On Khovanov homology and Heegaard Floer homology.*
J. Elisenda Grigsby*, Boston College, and **Stephan M. Wehrli**, Institut de Mathematiques de Jussieu; Universite Paris 7 (1056-51-1342)

4:15PM (215) *Topologically slice knots with non-trivial Alexander polynomial.*
Matthew E Hedden*, Michigan State University, **Charles Livingston**, Indiana University, and **Daniel Ruberman**, Brandeis University (1056-57-1085)

4:45PM (216) *Walks Along Braids and the Colored Jones Polynomial.* Preliminary report.
Cody Armond, Louisiana State University (1056-57-1329)

5:15PM (217) *On Jones polynomials of closed braids with a full twist.* Preliminary report.
Abhijit Champanerkar* and **Ilya Kofman**, College of Staten Island, CUNY (1056-57-1373)

5:45PM (218) *Ribbon-graph tensor products, relative polynomial invariants and applications to links.* Preliminary report.
Neal W. Stoltzfus*, Louisiana State University, and **Brittan Farmer**, University of Michigan (1056-57-1436)

AMS Special Session on Harmonic Analysis (Mathematics Research Communities session), II

2:15 PM – 5:05 PM

Organizers: **Kabe Moen**, Washington University
Richard Oberlin, University of California Los Angeles
Betsy Stovall, University of California Los Angeles

2:15PM (219) *Regularization for Slightly Super Critical Surface Quasi-geostrophic Equation.*
Michael Dabkowski, University of Wisconsin (1056-42-1651)

2:45PM (220) *Sobolev space estimates for a class of bilinear pseudodifferential operators unbounded on Lebesgue spaces.*
Frederic Bernicot, CNRS & Universite Lille 1, Laboratoire de Mathematiques Paul Painleve, France, and **Rodolfo H. Torres***, University of Kansas (1056-42-953)

3:15PM (221) *Sobolev Inequalities for $(0,q)$ forms on CR manifolds of finite type.*
Po Lam Yung, Princeton University (1056-42-291)

3:45PM (222) *Multi-linear integrals associated to sparse subsets of $\mathbb{R}$.*
Izabella Laba and **Malabika Pramanik***, University of British Columbia, Vancouver (1056-42-1003)

4:15PM (223) *Pointwise Divergence of L^1 Ergodic Averages Along the Nth Powers.*
Patrick R. LaVictoire, UC Berkeley (1056-37-1257)

4:45PM (224) *Upper Bounds for Multilinear Sublevel Sets.*
Michael Christ, University of California, Berkeley (1056-42-1513)

AMS Special Session on Inverse Problems: Analysis and Computations (Mathematics Research Communities session), II

2:15 PM – 5:35 PM

Organizers: **Gaik Ambartsoumian**, University of Texas at Arlington
Raluca Felea, Rochester Institute of Technology
Hongyu Liu, University of Washington
Kui Ren, University of Texas at Austin
Michael VanValkenburgh, University of California Berkeley

2:15PM (225) *Reconstruction of the Stefan-Boltzmann coefficients in the heat transfer process.*
Jin Cheng*, Fudan University, Shanghai, China, **Shuai Lu**, Johann Radon Institute for Computational and Applied Mathematics, Austria, and **Masahiro Yamamoto**, University of Tokyo (1056-35-550)

2:45PM (226) *Imaging from Bistatic and Multiply Scattered Waves.*
Clifford J Nolan* and **Thomas Dowling**, University of Limerick (1056-42-1526)

3:15PM (227) *Inverse transport theory and optical tomography for media with varying index of refraction.*
Stephen McDowall, Western Washington University (1056-35-902)

3:45PM (228) *Inverse Spectral Problems for Analytic Domains in $\mathbb{R}^n$.*
Hamid Hezari*, MIT, and **Steve Zelditch**, Johns Hopkins University (1056-35-1009)

4:15PM (229) *A Multilevel, Modified Regularized Total Least Norm Approach to Signal Deblurring.*
Malena Espanol*, California Institute of Technology, and **Misha Kilmer**, Tufts University (1056-65-1021)

4:45PM (230) *On a minimization problem for conductivity imaging.*
Alexandru Tamasan, University of Central Florida (1056-49-938)

5:15PM (231) *Inverse diffusion with internal measurements.*
Guillaume Bal, Columbia University (1056-35-1970)

AMS Special Session on the Mathematical Challenges of Relativity (Mathematics Research Communities session), II

2:15 PM – 5:05 PM

Organizers: **Paul T. Allen**, Lewis & Clark College
Michael Eichmair, M.I.T. and Monash University
Gustav Holzegel, Princeton University
Jared Speck, Princeton University
Willie W. Wong, University of Cambridge

2:15PM (232) *Hypersurfaces in Hyperbolic Poincaré Manifolds and Conformally Invariant PDEs.*
Vincent Bonini*, California Polytechnic State University, **Jie Qing**, University of California, Santa Cruz, and **Jose Espinar**, Universidad de Granada (1056-53-1316)

2:45PM (233) *Global geometry of T^2 symmetric spacetimes with weak regularity.*
Jacques Smulevici*, Max-Planck-Institute for Gravitational Physics, and **Philippe G. LeFloch**, Laboratoire Jacques-Louis Lions and CNRS (1056-83-1198)

3:15PM (234) *On Hamilton's Ricci flow and Bartnik's construction of metrics of prescribed scalar curvature.*
Chen-Yun Lin, Columbia University (1056-83-349)

3:45PM (235) *Optimization problems within a harmonic conformal class.*
Jeffrey L Jauregui, Duke University (1056-53-366)

4:15PM (236) *A gluing construction regarding point particles in general relativity.* Preliminary report.
Iva Stavrov, Lewis and Clark College (1056-83-694)

4:45PM (237) *A Model Problem for Conformal Parameterizations of the Einstein Constraint Equations.*
David Maxwell, University of Alaska Fairbanks (1056-35-663)

AMS Special Session on Algebraic Aspects of Cryptology, II

2:15 PM – 5:35 PM

Organizers: **Jintai Ding**, University of Cincinnati
Chris Christensen, Northern Kentucky

2:15PM ► (238) *Solving multivariate polynomial equations over finite fields.* Preliminary report.
Ding Jintai, University of Cincinnati (1056-12-1621)

3:15PM (239) *Growth of the ideal generated by a quadratic Boolean function.* Preliminary report.
Jintai Ding, **Timothy J Hodges***, and **Victoria Kruglov**, University of Cincinnati (1056-13-1539)

3:45PM (240) *MutantXL: An Efficient Algorithm for Solving Multivariate Polynomial Equations.*
Johannes Buchmann, TU Darmstadt, **Jintai Ding**, University of Cincinnati, **Mohamed Saied Emam Mohamed***, **Wael Said Abd Elmageed Mohamed**, TU Darmstadt, and **Daniel Cabarcas**, University of Cincinnati (1056-14-477)

4:15PM (241) *New Algorithm for Computing Grobner bases.*
Shuhong Gao* and **Yinhua Guan**, Clemson University (1056-13-1705)

4:45PM (242) *Analysis of a Multivariate Internal Perturbation Scheme.*
Lei Hu, Graudate School of Chinese Academy of Sciences (1056-94-1122)

5:15PM ► (243) *A Signature Scheme over Non-commutative Groups Secure Against Existential Forgery.* Preliminary report.
Yesem Kurt-Peker, Randolph College (1056-94-1566)

AMS Special Session on Markov Chains and Their Statistical Applications (Mathematics Research Communities session), II

2:15 PM – 4:55 PM

Organizers: **James Flegal**, University of California Riverside
Radu Herbei, Ohio State University
Jessica Zuniga, Stanford University

2:15PM (244) *Hitting-time Distributions for Markov Chains.* Preliminary report.
James Allen Fill, The Johns Hopkins University (1056-60-1746)

3:15PM (245) *Evaluation of Formal posterior distributions via Markov chain arguments.*
Galin Jones, University of Minnesota (1056-62-1158)

4:15PM (246) *Finding Sparse Cuts Locally Using Evolving Sets.*
Reid Andersen, Microsoft, and **Yuval Peres***, Microsoft Research (1056-60-1993)

AMS Special Session on Zonotopal Algebra and Its Applications, II

2:15 PM – 5:55 PM

Organizers: **Olga Holtz**, University of California Berkeley and Technical University Berlin
Amos Ron, University of Wisconsin

2:15PM (247) *Jump formulae for Multiple Bernoulli polynomials and Verlinde sums.* Preliminary report.
Michele Vergne, Paris, France (1056-52-886)

3:15PM (248) *Hierarchical zonotopal spaces.*
Olga Holtz, University of California-Berkeley, Technische Universitaet Berlin, Institute for Advanced Study, **Amos Ron***, University of Wisconsin-Madison, and **Zhiqiang Xu**, Chinese Academy of Sciences (1056-13-1949)

4:15PM (249) *Multiparking Functions, Graph Search, and Tutte Polynomial.*
Catherine Yan* and **Dimitrije Kostic**, Texas A&M University (1056-05-674)

4:45PM ► (250) *Double Hurwitz numbers as splines.* Preliminary report.
Federico Ardila, San Francisco State University (1056-05-1856)

5:15PM (251) *Power Ideals.*
Alexander Postnikov*, MIT, and **Federico Ardila**, SFSU (1056-05-1785)

AMS Special Session on Applications of Graph Theory, II

2:15 PM – 6:05 PM

Organizers: **Richard Low**, San Jose State University
Ralucca M. Gera, Naval Postgraduate School

2:15PM (252) *An Effective Upperbound on Treewidth Using Partial Fill-in of Separators.*
Martin Charles Golumbic*, Caesarea Rothschild Institute and Department of Computer Science, University of Haifa, and **Boi Faltings**, Artificial Intelligence Laboratory (LIA), Ecole Polytechnique Fédérale de Lausanne (EPFL) (1056-05-576)

2:45PM ► (253) *A new proof of the four-color theorem.*
John Paul Steinberger, Tsinghua University, Beijing (1056-05-253)

3:15PM (254) *On Graham's Tree Reconstruction Conjecture.*
Bill Kay* and **Joshua Cooper**, University of South Carolina (1056-05-326)

3:45PM ► (255) *Non-existence of circulant expander family.* Preliminary report.
Wasin So, San Jose State University (1056-05-313)

4:15PM ► (256) *Detecting a Machine Failure in a Network: Vertex Identifying Codes.*
Daniel W Cranston*, Virginia Commonwealth University, and **Gexin Yu**, College of William & Mary (1056-05-281)

4:45PM (257) *Best Monotone Degree Conditions for the Integrity and Tenacity of Graphs.*
Michael Robert Yatauro, Research Fellow/Stevens Institute of Technology (1056-00-1674)

5:15PM (258) *Toughness and Degree Sequence Conditions.* Preliminary report.
Nathan Kahl*, Seton Hall University, **Douglas Bauer**, Stevens Institute of Technology, **Hajo Broersma**, Durham University, **Ed Schmeichel**, San Jose State University, and **Jan van den Heuvel**, London School of Economics (1056-05-760)

5:45PM (259) *The $L(2,1)$ channel-assignment problem on trees.* Preliminary report.
Patrick Bahls, University of North Carolina, Asheville (1056-05-60)

AMS Special Session on Arithmetic and Nonarchimedean Dynamics, II

2:15 PM – 6:05 PM

Organizers: **Joseph Silverman**, Brown University
Michelle Manes, University of Hawaii
Raphael Jones, College of the Holy Cross

2:15PM (260) *Multipliers of periodic cycles for cubic polynomials.*
Patrick Ingram, University of Waterloo (1056-37-669)

2:45PM (261) *Local and global canonical height functions for affine space regular automorphisms.*
Shu Kawaguchi, Osaka University (1056-11-973)

3:15PM (262) *Rationality of the Space of Morphisms on $\mathbb{P}^1$.*
Alon Levy, Columbia University (1056-37-565)

3:45PM (263) *Torsion points of higher order in the Nottingham group.* Preliminary report.
Jonathan Lubin, Brown University (1056-11-361)

4:15PM (264) *A Dynamical Pairing Between Two Rational Maps.*
Clayton Petsche*, Hunter College, **Lucien Szpiro**, CUNY Graduate Center, and **Thomas J. Tucker**, University of Rochester (1056-11-555)

4:45PM (265) *A Local-Global Criterion for Dynamics on $\mathbb{P}^1$.*
Joseph H. Silverman, Brown University, and **J. Felipe Voloch***, University of Texas at Austin (1056-11-154)

5:15PM (266) *On dynamical zeta functions for polynomial maps over p-adic fields.* Preliminary report.
Liang-Chung Hsia, National Central University, Taiwan (1056-11-568)

5:45PM ► (267) *On the Number of Rational Pre-Images Under Quadratic Dynamical Systems.*
Benjamin Hutz, Amherst College (1056-11-575)

MAA Invited Paper Session on Online Delivery of Mathematics

2:15 PM – 5:35 PM

Organizer: **Bernd S. W. Schroeder**, Louisiana Tech University

2:15PM ► (268) *On-Line Delivery of Differential Equations: (How) Does It Work?*
Bernd S. W. Schroeder, Louisiana Tech University (1056-BD-248)

2:45PM ► (269) *Electronic Study Guide – Maplets for Calculus.*
Philip B Yasskin*, Texas A&M University, and **Douglas B Meade**, University of South Carolina (1056-BD-1115)

3:15PM ► (270) *Successful on-line Math course: myth or reality?*
Larissa Williamson, University of Florida (1056-BD-270)

3:45PM (271) *Online Delivery and the Use of Technology in the Classroom.*
Michael Speed* and **Simon Sheather**, Texas A&M University College Station (1056-BD-96)

4:15PM (272) *Computational Discrete Mathematics: Computation versus Bourbaki.*
Klaus Sutner, Computer Science Department, Carnegie Mellon University (1056-BD-1252)

4:45PM ► (273) *WeBWorK: Open source on-line homework system for mathematics.*
Michael E. Gage, University of Rochester (1056-BD-584)

5:15PM ► (274) *Evidence Based Course Design – The Open Learning Initiative at Carnegie Mellon.*
Candace M Thille, Carnegie Mellon University (1056-BD-1824)

MAA Minicourse #11: Part A

2:15 PM – 4:15 PM

The mathematics of Islam and its use in the teaching of mathematics.

Organizer: **Victor J. Katz**, University of the District of Columbia

MAA Minicourse #12: Part A

2:15 PM – 4:15 PM

Learning discrete mathematics via historical projects.

Organizers: **Jerry M. Lodder**, New Mexico State University
Guram Bezhanishvili, New Mexico State University
David Pengelley, New Mexico State University

MAA Minicourse #6: Part A

2:15 PM – 4:15 PM

Developing departmental self-studies.

Organizers: **Donna L. Beers**, Simmons College
Nancy Baxter Hastings, Dickinson College

AMS Session on Group Theory, II

2:15 PM – 5:55 PM

2:15PM (275) *Complete Groups: The Automorphism Tower and Some Characterizations.*
Elizabeth Wilcox, Binghamton University (1056-20-733)

2:30PM ► (276) *Representations of the Iwahori-Hecke algebra of the symmetric group.*
Charles E Buehrle, Lehigh University (1056-20-1061)

2:45PM (277) *On the nonabelian tensor product of finite groups of relatively prime order.* Preliminary report.
Luise-Charlotte Kappe and **Viji Thomas***, Binghamton University (1056-20-1265)

3:00PM (278) *On $\mathcal{Z}$-Structures of Groups.* Preliminary report.
Carrie Jean Tirel, University of Wisconsin - Milwaukee (1056-20-1376)

3:15PM (279) *Some Coxeter groups of CAT(0) dimension three.*
Cody L Patterson, University of Texas at Austin (1056-20-1381)

3:30PM Break.

3:45PM (280) *Central Extensions of Divisible Groups.*
Jason Elliot, University of Illinois at Urbana-Champaign (1056-20-1461)

4:00PM (281) *Stable Commutator Length in Braid Groups.* Preliminary report.
Joel Louwsma, California Institute of Technology (1056-20-1483)

4:15PM (282) *Enumerating Nilpotent Loops.*
Daniel A Daly*, Southeast Missouri State University, and **Petr Vojtechovsky**, University of Denver (1056-20-1598)

4:30PM (283) *The free metabelian product of a free nilpotent group with a free abelian group.*
Margaret H. Dean, Borough of Manhattan Community College of CUNY (1056-20-1655)

4:45PM (284) *Localization and extraction of roots in nilpotent R-powered groups.* Preliminary report.
Marcos Zyman*, Borough of Manhattan Community College, CUNY, and **Stephen Majewicz**, Kingsborough Community College, CUNY (1056-20-1659)

5:00PM Break.

5:15PM (285) *An introduction to the Bieri-Neumann-Strebel Invariant for finitely generated groups.*
Keith Michael Jones, Binghamton University (SUNY) (1056-20-1740)

5:30PM ► (286) *On Some Conjectures Concerning Groups With Perfect Order Subsets.* Preliminary report.
Lenny Jones and **Kelly Toppin***, Shippensburg University (1056-20-1782)

5:45PM (287) *Computing the Projective Indecomposable Modules of large Finite Groups.*
Selin Kalaycioglu, Kenyon College (1056-20-2114)

AMS Session on Probability and Statistics, II

2:15 PM – 5:55 PM

2:15PM (288) *The Density Function of the First Occurrence of a Binary Pattern.*
Michael J.J. Barry, Allegheny College (1056-60-785)

2:30PM (289) *Central Limit Theorems for Hilbert-space Valued Random Fields Satisfying a Strong Mixing Condition.*
Cristina Tone, Indiana University (1056-60-981)

2:45PM (290) *A method for finding exact site percolation critical thresholds for a class of lattices.* Preliminary report.
Matthew R. A. Sedlock* and **John C. Wierman**, Johns Hopkins University (1056-60-1080)

3:00PM (291) *On Dynamic Scheduling of a Parallel Server System with Certain Graph Structure.* Preliminary report.
Vladimir Pesic* and **Ruth Williams**, UCSD (1056-60-1367)

3:15PM (292) *Asymptotic behavior of the finite-size magnetization as a function of the speed of approach to criticality.*
Richard S Ellis, **Jonathan Machta**, University of Massachusetts, Amherst, and **Peter T Otto***, Willamette University (1056-60-1379)

3:30PM Break

3:45PM (293) *Two related integrals over spaces of continuous functions, revisited.* Preliminary report.
Ian Pierce, University of Nebraska - Lincoln (1056-60-1744)

4:00PM ► (294) *Phases in the Mixing of Gases via the Ehrenfest Urn Model.*
Srinivasan Balaji* and **Hosam M Mahmoud**, George Washington University (1056-60-1920)

4:15PM (295) *Further results on statistical significance of ranking paradoxes.* Preliminary report.
Anna E. Bargagliotti, University of Memphis, and **Raymond N. Greenwell***, Hofstra University (1056-62-59)

4:30PM ► (296) *Statistical Inference for Computer Models with Multidimensional Output.* Preliminary report.
Dorin Drignei, Oakland University (1056-62-329)

4:45PM (297) *The Use of Skew-Normal Distribution for Dose-Response Modeling in Toxicological Experiments.*
Mehdi Razzaghi, Bloomsburg University (1056-62-521)

5:00PM Break

5:15PM (298) *Graph ranking on gene network.*
Cuilan Gao*, **Xin Dang**, **Yixin Chen** and **Dawn Wilkins**, University of Mississippi (1056-62-711)

5:30PM ► (299) *Estimation of the Convolution of Distributions Under Different Censoring Models of Survival Data.*
Ke Wu, California State University, Fresno (1056-62-738)

5:45PM (300) *Improving an existing estimator of the unknown input function.*
Eun-Joo Lee*, Millikin University, and **Frits Ruymgaart**, Texas Tech University (1056-62-931)

AMS Session on Geometry and Topology, II

2:15 PM – 5:55 PM

2:15PM (301) *Another look at Euler's parallel oblique-angled diameters.*
Thomas J Osler, Rowan University (1056-51-863)

2:30PM (302) *Translation planes admitting a linear Abelian group of order* $(q+1)^2$.
Oscar E Vega*, California State University, Fresno., and **Esteban M Diaz**, University of Connecticut (1056-51-1119)

2:45PM ► (303) *A Characterization Of the Finite Affine Translation Planes Of Odd Order.* Preliminary report.
Ricardo Enrique Rojas, Northern State University (1056-51-1305)

3:00PM (304) *A proof of the Kauffman–Harary Conjecture.*
Thomas W Mattman*, California State University, Chico, and **Pablo Solis**, UC, Berkeley (1056-57-358)

3:15PM ► (305) *Representations of arrangement groups.*
Daniel C. Cohen, Louisiana State University, **Michael J. Falk***, Northern Arizona University, and **Richard Randell**, University of Iowa (1056-57-556)

3:30PM Break

3:45PM (306) *Rigidity of Hyperbolic Orbifolds.*
Philip C Huling, Saint Louis University (1056-57-615)

4:00PM (307) *Alpha-Sloped Thin Position for 3-manifolds.*
Marion Moore, UC Davis (1056-57-918)

4:15PM ► (308) *A dictionary for defining key concepts in plasma Physics in terms of Clebsch charts in contact geometry.* Preliminary report.
P. Robert Kotiuga, Boston University, ECE Dept. (1056-57-1313)

4:30PM ► (309) *New twisted dimer model for the twisted Alexander polynomial.* Preliminary report.
Moshe Cohen*, **Oliver Dasbach** and **Heather M. Russell**, Louisiana State University (1056-57-1573)

4:45PM (310) *Fundamental Groups of Solenoid Complements.*
Mark H. Meilstrup*, **Gregory Conner**, Brigham Young University, and **Dusan Repovs**, University of Ljubljana (1056-57-1652)

5:00PM Break

5:15PM (311) *The Structure of Combinatorial Geodesics in* $CAT(0)$ *Simplicial* 3*-Complexes.*
Rena M. H. Levitt, Pomona College (1056-57-1875)

5:30PM ► (312) *Shifts on compact metric o-dimensional spaces.* Preliminary report.
Rajagopalan Minakshisundaram, Tennessee State University (1056-54-1264)

5:45PM (313) *Generalizations to Coarse Geometry.* Preliminary report.
Jared R. Bunn, University of Tennessee (1056-51-275)

AMS Session on Discrete Mathematics, II

2:15 PM – 5:40 PM

2:15PM ► (314) *The Strength of the Grätzer-Schmidt Theorem.*
Paul Steven Brodhead*, Virginia State University, and **Bjørn Kjos-Hanssen**, University of Hawaii at Manoa (1056-06-768)

2:30PM (315) *Results on the Order Between Orbits in the Conjugacy Decomposition of a Canonical Monoid.* Preliminary report.
Ryan K Therkelsen, North Carolina State University (1056-06-1000)

2:45PM ► (316) *A gap theorem for the poset of sequential degrees.* Preliminary report.
Benjamin Wells, University of San Francisco (1056-06-1283)

3:00PM ► (317) *The Toothpick Sequence and Other Sequences from Cellular Automata.* Preliminary report.
Neil J. A. Sloane, AT&T Shannon Labs (1056-05-230)

3:15PM (318) *Symmetry and Log-Concavity Results for the Fibmaj Statistic.* Preliminary report.
Kendra Killpatrick, Pepperdine University (1056-05-428)

3:30PM Break

3:45PM *Lower Bounds for Balanced Simplicial Complexes.*
► (319) **Steven Klee**, University of Washington (1056-05-467)

4:00PM *Packing Degree Sequences.* Preliminary report.
► (320) **Tyler Seacrest**, University of Nebraska – Lincoln (1056-05-506)

4:15PM *Thin Lehman Matrices and Their Graphs.*
(321) **Jonathan Wang**, Harvard University (1056-05-533)

4:30PM Break

4:45PM *Extremal 2-supereulerian graphs.* Preliminary
(322) report.
Hong-Jian Lai, West Virginia University, and **Huiya Yan***, University of Wisconsin-La Crosse (1056-05-536)

5:00PM *The optimal t-rubbling number of the complete*
(323) *m-ary tree.* Preliminary report.
Lisa Danz, Massachusetts Institute of Technology (1056-05-586)

5:15PM *Simultaneous and non-simultaneous Bulgarian*
► (324) *Exchange.* Preliminary report.
Suzanne I Doree, Augsburg College, Minneapolis (1056-05-651)

5:30PM *Supereulerian Graphs and Hamiltonian Line*
(325) *Graphs.*
Yanting Liang, West Virginia University (1056-05-731)

4:30PM *An Action Research Proposal: Does the Ability to*
► (335) *Purchase a Week's Worth of Groceries for under One Dollar Influence the Chance that a Student will make an "Innumeracy Type" Statistical Error?* Preliminary report.
Larry Wayne Lewis, Spalding University (1056-Z1-1605)

4:45PM *Using Proofs without Words to Explore Rules of*
(336) *Differentiation.*
Tom McMillan and **Jim Fulmer***, University of Arkansas at Little Rock (1056-Z1-1601)

5:00PM *The Blip of the Blop: A Successful Mathematics*
► (337) *Major Seminar.* Preliminary report.
Gerald M. Higdon, Fitchburg State College (1056-Z1-1311)

5:15PM *Statistics-Based Calculus?*
► (338) **Patti Frazer Lock**, St. Lawrence University (1056-Z1-1241)

5:30PM *Mathematics across the Curriculum: A Twenty-year*
► (339) *Retrospective.*
Frank Anthony Cerreto, The Richard Stockton College of NJ (1056-Z1-1309)

5:45PM *Visualizing and Utilizing the Symmetry Method for*
► (340) *Differential Equations.*
S. L. Yap, California State University East Bay (1056-Z1-1443)

MAA Session on General Contributed Papers, II

2:15 PM – 5:55 PM

Organizers: **Eric S. Marland**, Appalachian State University
Daniel J. Curtin, Northern Kentucky University

2:15PM *Huppert's Conjecture and* $\mathrm{PSp}_4(q)$.
(326) **Thomas Philip Wakefield**, Youngstown State University (1056-Z1-336)

2:30PM *Lobb's Generalization of Catalan's Parenthesization*
► (327) *Problem and Forder's Catalan Triangle.*
Thomas Koshy, Framingham State College (1056-Z1-974)

2:45PM *Why is $PSL(2,7) \cong GL(3,2)$?*
► (328) **Ezra Brown*** and **Nicholas A. Loehr**, Virginia Tech (1056-Z1-379)

3:00PM *The Harmonic Series and Biconvergence: One step*
► (329) *forward, two steps back.*
Christopher M Davis, George Mason University, and **David G Taylor***, Roanoke College (1056-Z1-387)

3:15PM *Polynomial Root Motion.*
► (330) **Christopher S Frayer**, University of Wisconsin-Platteville (1056-Z1-636)

3:30PM *Mathematics in Signal Processing.*
► (331) **Mohamed Allali**, Chapman University (1056-Z1-646)

3:45PM *A Two-Course Sequence on Mathematical*
► (332) *Programming for Undergraduates.*
Paul E. Fishback, Grand Valley State University (1056-Z1-604)

4:00PM *Bridging Policy and Practice Through*
► (333) *Ethnomathematics in the Pacific.*
Linda Furuto, University of Hawai'i (1056-Z1-39)

4:15PM *Just-in-Time Calculus.* Preliminary report.
► (334) **Katherine S. Kelm**, California State University, Fresno (1056-Z1-1805)

MAA Session on Developmental Mathematics Education: Helping Under-Prepared Students Transition to College-Level Mathematics, I

2:15 PM – 4:10 PM

Organizers: **Kimberly J. Presser**, Shippensburg University
J. Winston Crawley, Shippensburg University

2:15PM *College Mathematical Readiness of the Senior High*
(341) *School Students of the Public Schools in District I of Davao City, Philippines.*
Melanie Joyno Orig, University of Mindanao, Davao City, Philippines (1056-D1-223)

2:35PM *Developmental Mathematics and Assessment:*
(342) *Where have we come from? Where are we now? Where are we going?* Preliminary report.
Kimberly J Presser, Shippensburg University (1056-D1-809)

2:55PM *"Rock Math" a Successful Implementation of a*
► (343) *Curriculum Designed to Help Under-prepared Students make the Transition to College Mathematics.*
Robert E Burks* and **Eric W. Drake**, United States Military Academy (1056-D1-233)

3:15PM *Online Interdisciplinary Mathematics: Project MESH.*
(344) **Suzanne Galayda*** and **Kathleen Berver**, New Mexico State University (1056-D1-1413)

3:35PM *Beginning Behind: The Effect of Background*
► (345) *Knowledge and Mathematical Self Image on University Precalculus Students' Success.*
Christine L. Ebert, **Donna A. Mark*** and **Rachael M. Todd**, University of Delaware (1056-D1-881)

3:55PM *Understanding and addressing the social/emotional*
(346) *needs of learners with histories of difficulty in mathematics.*
Michael H Davis, UC Berkeley Lawrence Hall of Science (1056-D1-794)

MAA Session on Experiences that Enrich the Education of Mathematics Majors, I

2:15 PM – 5:50 PM

Organizers: **Suzanne M. Lenhart**, University of Tennessee
Steven J. Schlicker, Grand Valley State University
J. Douglas Faires, Youngstown State University
Michael J. Dorff, Brigham Young University

2:15PM ► (347) *REU and REV program at the new institute, NIMBioS.* Preliminary report.
Suzanne Lenhart*, University of Tennessee, and **Sarah Duncan**, National Institute for Mathematical and Biological Synthesis (1056-E5-263)

2:35PM ► (348) *Enhancing teaching and learning of undergraduate mathematics majors through transformative research and training in biological and bio-inspired systems.* Preliminary report.
Kris Kappmeyer, H-B Woodlawn, Arlington Public Schools, VA, **Sarah Minerva Venuti**, George Mason University, VA, **Courtney Marie Chancellor**, Southern Methodist University, TX, and **Padmanabhan Seshaiyer***, George Mason University, VA (1056-E5-246)

2:55PM ► (349) *Collaborative Synthetic Biology Research for Undergraduates.*
Jeffrey L Poet*, Missouri Western State University, and **Laurie J Heyer**, Davidson College (1056-E5-1164)

3:15PM ► (350) *Enriching the Major through a Comprehensive Scholarship Program.* Preliminary report.
Deborah Lawrence* and **Tina Alves Mancuso**, The Sage Colleges (1056-E5-1603)

3:35PM ► (351) *Integrating Civic Engagement in an Integral Calculus Course.* Preliminary report.
Barbara P. Gonzalez-Arevalo* and **Melanie Pivarski**, Roosevelt University (1056-E5-480)

3:55PM ► (352) *Undergraduate Research as Resource.* Preliminary report.
Michael E McDaniel, Aquinas College (1056-E5-266)

4:15PM ► (353) *From Inquiry to Research—Fostering Research with Undergraduates.*
David A. Brown, Ithaca College (1056-E5-211)

4:35PM (354) *An undergraduate original research experience: Mathematical modeling with graph theory.*
Faun C. C. Doherty, Washington and Jefferson College (1056-E5-97)

4:55PM ► (355) *"Introduction to Being a Math Major" seminar.*
Michael Dorff, Brigham Young University (1056-E5-1200)

5:15PM (356) *Bio-Math Connection in Undergraduate Mathematics.* Preliminary report.
Urmi Ghosh-Dastidar, New York City College of Technology, CUNY (1056-E5-2016)

5:35PM (357) *Expanding Opportunities in Mathematics across the Curriculum.*
Joyati Debnath, Winona State University, Winona, MN (1056-E5-763)

MAA Session on Preparing K–12 Teachers to Teach Algebra, I

2:15 PM – 6:10 PM

Organizers: **Elizabeth Burroughs**, Montana State University
Angela M. Hodge, North Dakota State University
William G. McCallum, University of Arizona

2:15PM (358) *Developing a Comprehensive and Balanced Perspective on School Algebra Among Practicing Secondary School Mathematics Teachers.*
Xuhui Li, California State University - Long Beach (1056-N1-2062)

2:35PM (359) *Helping teachers develop algebraic reasoning skills through investigation of algebraic proofs and mathematical discourse experiences.*
Tina Louise Johnston*, **Henry Gillow-Wiles** and **Margaret L. Niess**, Oregon State University (1056-N1-2058)

2:55PM ► (360) *Extending from Multiplication of Two-Digit Numbers to Multiplication of Binomials and Beyond: Understanding the Learning Trajectory.* Preliminary report.
Trisha A. Bergthold, San Jose State University (1056-N1-2057)

3:15PM (361) *Guiding Teachers to See Opportunities for Algebraic Reasoning in the Curriculum.* Preliminary report.
Dale R Oliver, Humboldt State University (1056-N1-1927)

3:35PM (362) *Connecting Mathematics and Pedagogy in Courses for Future Algebra Teachers.*
Rebecca H McGraw* and **William McCallum**, University of Arizona (1056-N1-1804)

3:55PM ► (363) *The Concept of Variable and the Logic of Solving Equations and Inequalities.*
Susanna Epp, DePaul University (1056-N1-1800)

4:15PM ► (364) *Measuring the World: Preparing Elementary Teachers to Prepare Students for Algebra.*
Susan L. Addington, California State University, San Bernardino (1056-N1-1786)

4:35PM ► (365) *A course in Mathematical Knowledge for Teaching for pre-service secondary teachers.*
Diana White, University of Colorado Denver (1056-N1-1699)

4:55PM ► (366) *An Innovative Course in Elementary Number Theory for Preservice Teachers.* Preliminary report.
Agnes M Rash, Saint Joseph's University, Philadelphia, PA (1056-N1-1643)

5:15PM ► (367) *On Line Number and Algebra for In-Service Middle School Math Teachers.*
Michael Mays* and **David Miller**, West Virginia University (1056-N1-1477)

5:35PM ► (368) *Dihedral Groups for Preservice Elementary Teachers.*
Leah Bridgers, SUNY Oneonta (1056-N1-1475)

5:55PM ► (369) *Place Value—the Link Between Arithmetic and Success in Algebra.*
Murray H Siegel, Arizona State University, Polytechnic (1056-N1-265)

MAA Session on The Scholarship of Teaching and Learning in Undergraduate Mathematics, II

2:15 PM – 5:10 PM

Organizers: **Edwin P. Herman**, University of Wisconsin - Stevens Point

Nathan M. Wodarz, University of Wisconsin - Stevens Point

2:15PM ► (370) *Retention Benefits of Refocused College Algebra.* **Bernadette F. Turner*** and **Donna Stallings**, Lincoln University Jefferson City, MO (1056-Q1-1748)

2:35PM ► (371) *Teaching Reform in College Algebra.* Preliminary report. **Jinfeng Wei***, **Guangwei Fan** and **Min Deng**, Maryville University of St. Louis (1056-Q1-1177)

2:55PM ► (372) *Beliefs of Liberal Arts Mathematics Students Regarding the Nature of Mathematics.* Preliminary report. **Stephen D. Szydlik**, University of Wisconsin-Oshkosh (1056-Q1-1549)

3:15PM ► (373) *Mathematics Teachers' Circles.* Preliminary report. **Harold B Reiter*** and **Anthony Fernandes**, University of North Carolina Charlotte (1056-Q1-1267)

3:35PM (374) *Helping Pre-Service Teachers Address their Tendency of Overgeneralizing Proportionality: Using Non-proportional Situations and Focusing on Quantities and Relationships.* **Kien H. Lim**, University of Texas at El Paso (1056-Q1-243)

3:55PM ► (375) *How Prospective Mathematics Teachers Define Mathematical Definitions.* **Nermin Tosmur-Bayazit**, Georgia State University (1056-Q1-1803)

4:15PM ► (376) *What Do Students Hear in Statistics Classes: Empirical Results from a Study of Lexical Ambiguity.* Preliminary report. **Diane Fisher***, University of Louisiana at Lafayette, **Jennifer Kaplan**, Michigan State University, and **Neal Rogness**, Grand Valley State University (1056-Q1-1060)

4:35PM ► (377) *Do discussion boards improve statistical reasoning skills?* Preliminary report. **Edwin Prine Herman**, University of Wisconsin-Stevens Point (1056-Q1-1732)

4:55PM (378) *Strategies that worked for me in Teaching and Learning Undergraduate Mathematics.* **Joyati Debnath**, Winona State University, Winona, MN (1056-Q1-2007)

MAA Session on The MAA SUMMA Program Turns 20—A Retrospective

2:15 PM – 5:30 PM

Organizers: **William A. Hawkins Jr**, MAA and the University of the District of Columbia
Efraim Armendariz, University of Texas at Austin
Camille A. McKayle, University of the Virgin Islands
Robert E. Megginson, University of Michigan, Ann Arbor

2:15PM ► (379) *The San Antonio Prefreshman Engineering Program Turns 30—A Retrospective.* **Manuel P. Berriozábal**, University of Texas at San Antonio (1056-G5-438)

2:35PM ► (380) *Minorities and the MAA, Initial Steps.* **Lida K. Barrett**, Knoxville, TN (1056-G5-282)

2:55PM ► (381) *Stengthening Underrepresented Minority Mathematics Achievement Intervention Programs.* **Florence Fasanelli**, AAAS (1056-G5-87)

3:15PM ► (382) *Starting and Running an REU for Minorities and Women.* **Dennis Davenport***, National Science Foundation, and **Bonita Porter**, Miami University (1056-G5-2139)

3:35PM ► (383) *Successful Intervention Programs in Mathematics for Undergraduates Historically Underrepresented in the Mathematics-based Disciplines.* **James A. Mendoza Epperson**, The University of Texas at Arlington (1056-G5-1938)

3:55PM ► (384) *Some Challenges to Broadening Participation in Mathematics at the Undergraduate Level.* **Sylvia T. Bozeman**, Spelman College (1056-G5-1054)

4:15PM ► (385) *Speed Bumps and Potholes in the Road to Strengthening Underrepresented Minority Mathematics Achievement, Past, Present, and Future.* **Robert E. Megginson**, University of Michigan (1056-G5-1176)

4:35PM (386) *Exploration of a Mathematics Enrichment Summer Camp for Underrepresented High School Students.* **Sandra L. Richardson***, Lamar University, and **David S. Torain**, Hampton University (1056-G5-1647)

4:55PM ► (387) *AIM Math Teachers' Circle Immersion Workshop.* **Wade Ellis***, West Valley College, and **Tatiana Shubin**, San Jose State University (1056-G5-1653)

5:15PM ► (388) *The Director of SUMMA looks at SUMMA past, present, and future.* **William A. Hawkins**, MAA/University of the District of Columbia (1056-G5-1324)

MAA Session on Mathematical Texts: Famous, Infamous, and Influential, II

2:15 PM – 4:30 PM

Organizers: **Fernando Q. Gouvêa**, Colby College
Amy Shell-Gellasch, Beloit College

2:15PM ► (389) *For the good-hearted reader: Joost Bürgi, the history of logarithms, and a work that should have been famous.* **Kathleen M Clark**, Florida State University (1056-H1-1401)

2:35PM ► (390) *Parallel Insight, Priority, and Pre-eminence: John Napier, Joost Bürgi, and Famous Works on Logarithms.* **Clemency J Montelle**, University of Canterbury (1056-H1-1018)

2:55PM ► (391) *Bougainville's Tratie du Calcul-Integral.* Preliminary report. **James J Tattersall**, Providence College (1056-H1-495)

3:15PM (392) *Warren Colburn's "First Lessons in Arithmetic".* **Andrew B. Perry**, Springfield College (1056-H1-1095)

3:35PM ► (393) *"The Method of Rates": The Books of Rice and Johnson.* **George M. Rosenstein**, Franklin & Marshall College (1056-H1-553)

3:55PM ► (394) *Osgood's Theory of Functions.* **Lawrence A. D'Antonio**, Ramapo College of New Jersey (1056-H1-234)

4:15PM ► (395) *The Historian and the Mathematician: The Reception of the Biography by Michael Sean Mahoney of Pierre de Fermat.* **Thomas Drucker**, University of Wisconsin–Whitewater (1056-H1-1842)

SIAM Minisymposium on Frontiers in Geomathematics

2:15 PM – 6:30 PM

Organizers: **Willi Freeden**, University of Kaiserslautern
M. Zuhair Nashed, University of Central Florida
Thomas H. Sonar, Technical University of Braunschweig

2:15PM (396) *Geomathematics—Role, Aims, and Potential.*
Willi Freeden, University of Kaiserslautern, Geomathematics Group (1056-86-1128)

3:15PM ► (397) *Modeling the Geomagnetic Field by Locally Supported Wavelets.* Preliminary report.
Christian Gerhards, TU Kaiserslautern (1056-86-1134)

3:45PM ► (398) *Modeling of Geothermal Flow.* Preliminary report.
Isabel Ostermann, TU Kaiserslautern (1056-86-1135)

4:15PM (399) *Slepian Functions for Signal Estimation and Spectral Analysis.*
Frederik J Simons, Princeton University (1056-86-1546)

4:45PM (400) *Spherical Harmonics, Splines and Wavelets — What Comes Next?*
Michel Volker, Geomathematics Group Siegen (1056-65-1132)

5:15PM (401) *Eulerian-Lagrangian methods for multiphase multicomponent transport.*
Thomas F. Russell, National Science Foundation (1056-65-1849)

5:45PM (402) *Randomizing the time in the heat equation and blind deconvolution of galaxy images.*
Alfred S. Carasso, National Institute of Standards and Technology, Gaithersburg, MD

6:10PM (403) *Moment Problems in Reproducing Kernel Hilbert Spaces.*
M. Zuhair Nashed, University of Central Forida (1056-65-2123)

MAA-Young Mathematicians' Network Poster Session

2:15 PM – 4:15 PM

Organizers: **Kim Roth**, Juniata College
Michael C. Axtell, University of St. Thomas

MAA Panel Discussion

2:15 PM – 3:25 PM

Cultivating mathematical interest and talent of precollege students: Outreach through summer math camps and academies.

Organizer: **Michelle L. Ghrist**, U.S. Air Force Academy

Panelists: **David Boliver**, University of Central Oklahoma
Peter Kuchment, Texas A&M University
Lisa Rezac, University of St. Thomas
Hortensia Soto-Johnson, University of Northern Colorado
Max L. Warshauer, Texas State University

AWM Panel Discussion

2:15 PM – 3:40 PM

Dual careers or dueling careers? Jobs and the two-body problem.

Moderator: **Georgia Benkart**, University of Wisconsin-Madison

Panelists: **Christine Min Wotipka**, Stanford University
Ellen Spertus, Mills College and Google
David C. Manderscheid, University of Nebraska-Lincoln
Maia Averett, Mills College

MAA Session on General Contributed Papers, III

2:30 PM – 4:25 PM

Organizers: **Eric S. Marland**, Appalachian State University
Daniel J. Curtin, Northern Kentucky University

2:30PM (404) *Proving in the Right Circles.*
Linda McGuire, Muhlenberg College (1056-Z1-315)

2:45PM ► (405) *Algebra in the K-5 Mathematics Curriculum: Keeping the Promise of Algebra for Every Age.*
Judith Lynn Gieger, Oglethorpe University (1056-Z1-1538)

3:00PM ► (406) *Uncovering Buffon's Essai d'Arithmetique Morale.* Preliminary report.
Dominic W Klyve*, Carthage College, and **Anna Lauren**, Abbot Laboratories (1056-Z1-1613)

3:15PM Break.

3:30PM ► (407) *Comparison of Inquiry-Based Class Sessions and Lecture in the Context of Computer-Assisted Algebra Instruction.* Preliminary report.
John C. Mayer, University of Alabama at Birmingham (1056-Z1-1739)

3:45PM ► (408) *Open, online, homework help forums: Fostering a culture in which communication reflects a conceptual orientation toward the attainment of quantitative reasoning and literacy skills.* Preliminary report.
Carla Currin van de Sande* and **Frank S. Marfai**, Arizona State University (1056-Z1-1362)

4:00PM (409) *Teaching For Transfer And High Cognitive Demand Through The Use Of Discourse In Algebra.*
Kimberly M Vincent, Washington State University (1056-Z1-1892)

4:15PM ► (410) *Closing the Gap: How Can Mathematics Instructors Empower Students for Academic Success in Future Mathematics Courses—Insights From the Developmental Psychology of Personal Mathematical Comprehension*
Clyde L. Greeno, MALEI Mathematics Institute (1056-Z1-2012)

MAA Section Officers

2:30 PM – 5:00 PM

MAA Invited Address

3:20 PM – 4:10 PM

(411) *The factorial function, integer-valued polynomials, and p-adic calculus.*
Manjul Bhargava, Princeton University

AWM Business Meeting

3:45 PM – 4:15 PM

MAA Committee on Graduate Students-Young Mathematicians' Network Panel Discussion

3:50 PM – 5:10 PM

How to interview for a job in the mathematical sciences.

Organizer: **David C. Manderscheid**, University of Nebraska-Lincoln

Panelists: **Allen Butler**, Daniel H. Wagner Associates, Inc.
James Freeman, Cornell College
David C. Manderscheid
Sharon Mosgrove, Concordia University
Sarah Ann Stewart, Belmont University

Reception for Undergraduate Students

4:00 PM – 5:00 PM

MAA Session on General Contributed Papers, IV

4:30 PM – 5:40 PM

Organizers: **Eric S. Marland**, Appalachian State University
Daniel J. Curtin, Northern Kentucky University

4:30PM (412) *Using Clickers in a Refocused College Algebra Course – Part II.*
Kathryn T Ernie* and **Maren Gebhard**, University of Wisconsin - River Falls (1056-Z1-1990)

4:45PM (413) *Click and Tell.*
Benjamin J Galluzzo, Shippensburg University (1056-Z1-915)

5:00PM (414) *Promoting Clickers in Mathematics Courses at Virginia Military Institute.*
Aprillya Lanz*, **Vonda K Walsh** and **Daniel Joseph**, Virginia Military Institute (1056-Z1-1893)

5:15PM ► (415) *Overcoming Pre-Calculus Misconceptions in Calculus Using Clickers.*
Daniel Joseph*, **Aprillya Lanz** and **Vonda Walsh**, Virginia Military Institute (1056-Z1-540)

5:30PM ► (416) *Improving Mathematical Practices to Prepare K-12 Teachers on Algebraic Connections and Technology.* Preliminary report.
Seshaiyer Padmanabhan*, George Mason University, Fairfax, VA, and **Suh Jennifer**, George Mason University, VA (1056-Z1-1286)

AMS-MAA Special Presentation

4:30 PM – 6:00 PM

4:30PM (417) *Elementary school teachers as mathematicians: As the twig is bent the tree grows.*
Kenneth I. Gross, University of Vermont

SIGMAA on the History of Mathematics Business Meeting, Reception, and Guest Lecture

5:30 PM – 7:30 PM

6:30PM (418) *The Archimedes Palimpsest and its infinite possibilities.*
Reviel Netz, Classics Department, Stanford University (1056-A0-68)

SIGMAA on Math Circles for Students and Teachers Business Meeting

5:30 PM – 6:30 PM

Reception for Graduate Students and First-Time Participants

5:30 PM – 6:30 PM

AMS Josiah Willard Gibbs Lecture

8:30 PM – 9:30 PM

(419) *Quantum channels and their capacities.*
Peter W. Shor, Massachusetts Institute of Technology (1056-81-12)

Thursday, January 14

Joint Meetings Registration

7:30 AM – 4:00 PM

AMS Special Session on Arithmetic of Function Fields, I

8:00 AM – 11:50 AM

Organizers: **Allison Pacelli**, Williams College
Michael Rosen, Brown University

8:00AM (420) *Fourier Coefficients, Relations, and Ranks in the Space of Eisenstein Series of a Function Field of a Finite Field.*
Michael J. Daniel, Drexel University (1056-11-538)

8:30AM (421) *Ramification in iterated towers for rational functions.*
John T Cullinan, Bard College (1056-11-365)

9:00AM (422) *Tate sequences and applications.* Preliminary report.
Cristian D Popescu, University of California, San Diego (1056-11-373)

9:30AM (423) *Explicit points on elliptic curves over function fields.* Preliminary report.
Douglas Ulmer, Georgia Institute of Technology (1056-11-1161)

10:00AM (424) *On generators of arithmetic groups over function fields.*
Mihran Papikian, Pennsylvania State University (1056-11-1014)

10:30AM (425) *Ramification Groups and Differents in Artin-Schreier Composita.*
Renate Scheidler* and **Qingquan Wu**, University of Calgary (1056-11-757)

11:00AM ► (426) *Symmetries of characteristic p L-series.*
David Goss, The Ohio State University (1056-11-668)

11:30AM (427) *Values of Goss L-functions for Dirichlet characters at positive integers.* Preliminary report. **Matthew Papanikolas**, Texas A&M University (1056-11-431)

AMS Special Session on Commutative Algebra, I

8:00 AM – 11:50 AM

Organizers: **Susan Cooper**, University of Nebraska-Lincoln
Graham Leuschke, Syracuse University
Sean M. Sather-Wagstaff, North Dakota State University

8:00AM (428) *What is a system of parameters?* Preliminary report. **Craig Huneke***, University of Kansas, and **Louiza Fouli**, New Mexico St. University (1056-13-721)

8:30AM (429) *Syzygy Theorem via Comparison of Order Ideals.* **Phillip A. Griffith** and **Alexandra Seceleanu***, University of Illinois at Urbana-Champaign (1056-13-1439)

9:00AM (430) *Hochster's Theta invariant and the Hodge-Riemann bilinear relations.* **W. Frank Moore**, Cornell Univ., **Greg Piepmeyer***, Univ. of Missouri-Columbia, **Sandra Sprioff**, Univ. of Mississippi, and **Mark E Walker**, Univ. of Nebraska, Lincoln (1056-13-1484)

9:30AM (431) *Test ideals in non-Q-Gorenstein rings.* **Karl Schwede**, University of Michigan (1056-13-774)

10:00AM (432) *On the Behavior of Test Ideals Under Generically Separable Finite Morphisms.* **Kevin Tucker*** and **Karl Schwede**, University of Michigan (1056-13-1480)

10:30AM (433) *A numerical condition for equisingularity.* Preliminary report. **Steven Kleiman**, MIT, **Bernd Ulrich**, Purdue University, and **Javid Validashti***, University of Kansas (1056-13-835)

11:00AM (434) *Beyond Numerics in Boij-Soederberg Theory.* **Daniel Erman**, University of California, Berkeley (1056-13-599)

11:30AM (435) *Sheaves on $P^1 \times P^1$.* **David Eisenbud***, University of California, Berkeley, and **Frank-Olaf Schreyer**, Universitaet des Saarlandes (1056-14-1743)

AMS Special Session on Geometric Aspects of Link and 3-manifold Invariants, II

8:00 AM – 11:50 AM

Organizers: **Oliver Dasbach**, Louisiana State University
Effie Kalfagianni, Michigan State University

8:00AM (436) *Reidemeister Torsion and the A-polynomial.* **Charles Frohman***, The University of Iowa, and **Joanna Kania-Bartoszynska**, National Science Foundation (1056-57-999)

8:30AM (437) *Quantum form of the Reidemeister torsion of a knot complement.* **Charles D Frohman**, The University of Iowa, and **Joanna Kania-Bartoszynska***, National Science Foundation (1056-57-1173)

9:00AM (438) *Higher Mahler measures.* **Matilde N Lalin**, University of Alberta (1056-11-442)

9:30AM ▶ (439) *First coefficient of the Conway polynomial of virtual links.* Preliminary report. **Sergei Chmutov**, Ohio State University, Mansfield (1056-57-705)

10:00AM (440) *Turaev genus, knot signature, and the knot homology concordance invariants.* **Oliver Dasbach**, Louisiana State University, and **Adam Lowrance***, University of Iowa (1056-57-427)

10:30AM (441) *Geometry of Lorenz knots.* **Ilya Kofman**, College of Staten Island, City University of New York (1056-57-1710)

11:00AM (442) *Adequate knots, guts, and volumes I: surfaces and polyhedra.* **David Futer**, Temple University, **Efstratia Kalfagianni**, Michigan State University, and **Jessica S Purcell***, Brigham Young University (1056-57-1825)

11:30AM (443) *Adequate knots, guts, and volumes II: volume and Jones polynomial.* **David Futer***, Temple University, **Efstratia Kalfagianni**, Michigan State University, and **Jessica S Purcell**, Brigham Young University (1056-57-1913)

AMS Special Session on Graph Algebras in Analysis and Algebra, I

8:00 AM – 11:50 AM

Organizers: **Gene Abrams**, University of Colorado at Colorado Springs
Mark Tomforde, University of Houston

8:00AM (444) *Isomorphism and Morita equivalence of graph algebras I.* **Gene Abrams**, University of Colorado at Colorado Springs, and **Mark Tomforde***, University of Houston (1056-46-959)

8:30AM (445) *Isomorphism and Morita equivalence of graph algebras II.* Preliminary report. **Gene Abrams***, University of Colorado at Colorado Springs, and **Mark Tomforde**, University of Houston (1056-16-943)

9:00AM (446) *Leavitt path algebras and graph C*-algebras of separated graphs, I.* Preliminary report. **Pere Ara***, Universitat Autonoma de Barcelona, and **Kenneth R. Goodearl**, University of California at Santa Barbara (1056-16-787)

10:00AM (447) *Leavitt path algebras and graph C*-algebras of separated graphs, II.* Preliminary report. **P. Ara**, Universitat Autònoma de Barcelona, and **K. R. Goodearl***, University of California at Santa Barbara (1056-16-828)

10:30AM (448) *Nevanlinna-Pick interpolation for the Schur class associated with a directed graph.* **Joseph A. Ball***, Virginia Tech, and **Sanne ter Horst**, Utrecht University (1056-47-328)

11:00AM (449) *Leavitt Path Algebras with Coefficients in a Noncommutative Ring.* **Jennifer Firkins Nordstrom**, Linfield College (1056-16-1106)

11:30AM (450) *Explicit isomorphisms of purely infinite simple Leavitt path algebras.* Preliminary report. **Chris Smith*** and **Gene Abrams**, University of Colorado, Colorado Springs (1056-16-866)

AMS Special Session on Interactions of Inverse Problems, Signal Processing, and Imaging, I

8:00 AM – 11:40 AM

Organizer: **M. Zuhair Nashed**, University of Central Florida

8:00AM (451) *Cramer-Rao Bound for Estimating Non-linear Parameters in a Model for Chemical Species Separation using Magnetic Resonance Imaging.* **Emily K. Bice***, California State University, Fullerton, **Venkata V. Chebrolu**, Department of Biomedical Engineering, University of Wisconsin, Madison, **Huanzhou Yu**, Global MR Applied Science Laboratory, GE Healthcare, Menlo Park, CA, **Jean H Brittain**, Global MR Applied Science Laboratory, GE Healthcare, Madison, WI, **Scott B. Reeder**, Department of Radiology, University of Wisconsin, Madison, and **Angel R. Pineda**, California State University, Fullerton (1056-62-1387)

8:30AM (452) *Sequential Lower Semi-Continuity of Non-Local Functionals.* **Peter Elbau**, Johann Radon Institute for Computational and Applied Mathematics (1056-49-1514)

9:00AM (453) *On detection of small low emission sources.* **Peter Kuchment***, Texas A&M University, **David Darrow**, UT Medical Branch at Galveston, **Yulia Hristova** and **Guido Kanschat**, Texas A&M University (1056-35-1029)

9:30AM (454) *Compressed sensing via information theoretic methods.* **Akram Aldroubi*** and **Haichao Wang**, Vanderbilt University (1056-94-843)

10:00AM (455) *Multiscale elasticity imaging.* **Pierre Garapon***, Stanford University, **Habib Ammari**, Ecole Polytechnique, and **François Jouve**, University Denis Diderot, PARIS VII (1056-35-1378)

10:30AM (456) *Reconstruction of Piecewise Constant Images Using Nonsmooth Nonconvex Minimization.* **Mila Nikolova**, Centre de Mathematiques et de Leurs Applications (1056-49-2145)

11:00AM (457) *Beyond the Shannon-Nyquist Theorem.* **Yves Meyer**, Centre de Mathematiques et de Leurs Applications (1056-41-2143)

AMS Special Session on Algebraic Methods in Signal Processing, I

8:00 AM – 11:50 AM

Organizers: **Shamgar Gurevich**, University of California Berkeley
Ronny Hadani, University of Chicago
Olga Holtz, University of California Berkeley and Technical University Berlin
Oded Schwartz, Technical University Berlin
Nir Sochen, Tel Aviv University

8:00AM ► (458) *Desired properties of identity codes.* Preliminary report. **Anant Sahai*** and **Kristen Ann Woyach**, UC Berkeley (1056-94-1688)

9:00AM ► (459) *Group-Theoretic Algorithms for Matrix Multiplication.* **Chris Umans**, Caltech (1056-68-1303)

9:30AM ► (460) *Polyphase Sequence Families with Low Correlation from the Bounds of Character Sums.* Preliminary report. **Gong Guang***, Department of Electrical and Computer Engineering, University of Waterloo, and **Zilong Wang**, Beijing University (1056-94-1550)

10:00AM (461) *Near Shannon limit low Peak to Average Power Ratio Turbo Block Coded OFDM.* **Vahid Tarokh***, **Maryam Sabbaghian**, Harvard University, **Besma Smida**, Purdue University, and **Yongjun Kwak**, Harvard University (1056-05-1043)

11:00AM (462) *Algebra and Multi-Camera Networks.* **Nigel Boston**, University of Wisconsin - Madison (1056-94-1747)

11:30AM (463) *On applications of non-commutative Fourier analysis in computational science.* **Hans Z Munthe-Kaas**, University of Bergen, Norway (1056-65-1148)

AMS Special Session on The Mathematics of Information and Knowledge, I

8:00 AM – 11:40 AM

Organizers: **Naoki Saito**, University of California Davis
Ronald R. Coifman, Yale University
James G. Glimm, SUNY at Stony Brook
Peter W. Jones, Yale University
Mauro Maggioni, Duke University
Jared Tanner, University of Edinburgh

8:00AM (464) *Harmonic Analysis and Geometries of Digital Data Bases.* **Ronald R. Coifman***, Yale, and **Matan Gavish**, Stanford University (1056-65-1160)

9:00AM (465) *Nonparametric Manifold Learning and Compressive Sensing.* **Lawrence Carin**, Duke University (1056-41-1525)

10:00AM (466) *Affine-invariant Principal Components.* **Santosh S Vempala***, Georgia Tech, and **S Charles Brubaker**, Pace Academy (1056-68-853)

11:00AM (467) *Construction of a Large Class of Deterministic Sensing Matrices that Satisfy a Statistical Isometry Property.* **Robert Calderbank***, Princeton University, **Stephen D Howard**, Defence Science and Technology Organisation, and **Sina Jafarpour**, Princeton University (1056-41-852)

AMS Special Session on Voting Theory, I

8:00 AM – 11:50 AM

Organizers: **Michael Jones**, Mathematical Reviews
Brian Hopkins, Saint Peter's College
Tommy Ratliff, Wheaton College

8:00AM ► (468) *Minimal Requirements for Representation in the Democratic Primary.* **Jennifer M Wilson***, Eugene Lang College the New School for Liberal Arts, and **Michael A Jones**, Mathematical Reviews (1056-91-732)

8:30AM ► (469) *The Evaluation and Comparison of Thresholds for Divisor Methods.* **Michael A Jones***, Mathematical Reviews, and **Jennifer M. Wilson**, Eugene Lang College of the New School University (1056-91-714)

9:00AM (470) *Analysis of Cumulative Voting's Potential to Yield Fair Representation.* **Duane Cooper**, Morehouse College (1056-91-2017)

9:30AM (471) *Algebraic Voting Theory.*
Michael E. Orrison, Harvey Mudd College (1056-20-756)

10:00AM (472) *Statistical Inconsistencies of Ranked Data.*
Anna E Bargagliotti*, The University of Memphis, and **Michael Orrison**, Harvey Mudd College (1056-91-780)

10:30AM ► (473) *Manipulating Profiles in Nonparametric Statistics: Stacking and Switching.* Preliminary report.
Sarah Berube and **Karl-Dieter Crisman***, Gordon College (1056-91-84)

11:00AM (474) *Frequency of violations of monotonicity.*
Robert Z. Norman, Dartmouth College (1056-91-1858)

11:30AM ► (475) *Concensus among Concensus Methods.* Preliminary report.
Anna Popova* and **Michel Regenwetter**, University of Illinois at Urbana-Champaign, Psychology (1056-91-620)

AMS Special Session on Analysis and Control Under Uncertainty, I

8:00 AM – 11:50 AM

Organizers: **Xioaming Wang**, Florida State University
Yanzhao Cao, Auburn University
Catalin Trenchea, University of Pittsburgh

8:00AM (476) *The Estimation of functional uncertainty using Polynomial Chaos and adjoint equations.*
Ionel Michael Navon*, Dept of Scientific Computing/ Florida State University, **K Alekseev Aleksey** and **M E Zelentsov**, Moscow Institute of Physics and Technology (1056-93-1622)

8:30AM (477) *Long Time Behavior of Stochastically Forced PDEs.*
Jonathan C. Mattingly, Duke University (1056-37-1929)

9:00AM (478) *Stochastic Analysis, Control and Nonlinear Filtering of Fluid Dynamic Models.*
S. S. Sritharan, Naval Postgraduate School (1056-60-507)

9:30AM (479) *Optimal Parameter Tuning for Stability under Uncertainty.*
Wolfgang Kliemann, Iowa State University (1056-93-741)

10:00AM ► (480) *A Non-Stochastic Talk on Stochastic Optimization / Control.*
Ana-Maria Croicu, Kennesaw State University (1056-49-1724)

10:30AM ► (481) *Groundwater Reactive Transport Modeling under Uncertainty.*
Ming Ye, Department of Scientific Computing, Florida State University (1056-62-1564)

11:00AM (482) *An Efficient Spectral Method for Acoustic Scattering from Rough Surfaces.*
Jie Shen, Purdue University (1056-65-1716)

11:30AM (483) *Approximating long time statistical properties of large chaotic systems.*
Xiaoming Wang, Florida State University (1056-76-1971)

AMS Special Session on Applications of Time Scales to Biology, Economics, and Engineering, I

8:00 AM – 11:50 AM

Organizers: **Martin Bohner**, Missouri University of Science and Technology
Billur Kaymakcalan, Georgia Southern University-Statesboro
Allan Peterson, University of Nebraska-Lincoln

8:00AM (484) *Eigenvalue intervals for a system of generalized second order three point nonlinear boundary value problems on a time scale.*
Johnny Henderson, Baylor University (1056-34-27)

8:30AM (485) *Higher order singular multi-point boundary value problems on time scales.*
Abdulkadir Dogan, University of Nigde, Nigde, Turkey, **John R Graef*** and **Lingju Kong**, The University of Tennessee at Chattanooga (1056-39-746)

9:00AM (486) *The Existence of Multiple Nontrivial Solutions of Boundary Value Problems of Second-Order Dynamic Equations on a Time Scale.* Preliminary report.
Heidi A Berger, Simpson College (1056-39-1540)

9:30AM (487) *Positive periodic solutions of functional differential equations on time scales and population models.*
Youssef Naim Raffoul*, University of Dayton, and **Joan Hoffacker**, Clemson University (1056-37-806)

10:00AM (488) *Implications of time scales to spraying mosquitoes for West Nile prevention.*
Joan Hoffacker, Clemson University (1056-34-1269)

10:30AM (489) *A predator-prey system on a time scale.* Preliminary report.
Nickolai Kosmatov, University of Arkansas at Little Rock (1056-39-1491)

11:00AM ► (490) *A Ratio Dependent Predator-Prey System on a Time Scale.* Preliminary report.
Eric R. Kaufmann, University of Arkansas at Little Rock (1056-92-1325)

11:30AM ► (491) *Model for antibiotic resistant bacteria in a river.* Preliminary report.
Bonita A Lawrence* and **Anna Mummert**, Marshall University (1056-34-1456)

AMS Special Session on Arithmetic Geometry, I

8:00 AM – 11:50 AM

Organizers: **Bo-Hae Im**, Chung-Ang University
Jennifer Johnson-Leung, University of Idaho
Jennifer Paulhus, Kansas State University

8:00AM (492) *Generalizing a Theorem of Richard Brauer.*
Bo-Hae Im*, Chung-Ang University, Seoul, and **Michael Larsen**, Indiana University (1056-11-1179)

8:30AM (493) *Numerical evidence for Bruinier-Yang conjecture and comparison with denominators of Igusa class polynomials.*
Kristin E. Lauter*, Microsoft Research, **Bianca Viray**, University of California at Berkeley, **Jennifer Johnson-Leung**, University of Idaho, **Adriana Salerno**, Bates College, **Erika Frugoni**, University of Colorado, and **Helen Grundman**, Bryn Mawr College (1056-11-1633)

9:00AM (494) *Bounds for the torsion subgroup of elliptic curves over fields with bounded ramification.*
Álvaro Lozano-Robledo*, University of Connecticut - Storrs, and **Benjamin Lundell**, Cornell University (1056-11-1092)

9:30AM (495) *The growth of Mordell-Weil ranks on tower of Jacobians.* Preliminary report.
Guillermo Mantilla, University of Wisconsin, Madison (1056-11-1083)

10:00AM (496) *Points on Quadratic Twists of $X_0(N)$.*
Ekin Ozman, University of Wisconsin-Madison (1056-11-1529)

10:30AM (497) *Anti-Hasse Principles for Algebraic Curves.*
Pete L. Clark, University of Georgia (1056-11-470)

11:00AM (498) *Cox rings of big rational surfaces.*
Damiano Testa, University of Oxford, **Anthony Varilly-Alvarado***, Rice University, and **Mauricio Velasco**, University of California at Berkeley (1056-14-1723)

11:30AM ► (499) *Equations of curves with automorphisms.* Preliminary report.
David J Swinarski, University of Georgia (1056-14-642)

MAA Invited Paper Session on Environmental Modeling

8:00 AM – 9:50 AM

Organizers: **Karen D. Bolinger**, Clarion University
Ben Fusaro, Florida State University

8:00AM ► (500) *Warming, Non-linearity & Civilization's Decline.*
Courtney Brown, Dept of Political Science Emory University (1056-BA-1672)

8:30AM ► (501) *Evolution of Competitive Co-existence.*
Jim M. Cushing, University of Arizona (1056-BA-1678)

9:00AM (502) *Environmental Modeling & Big Projects: Lessons from Everglades Restoration Planning.*
Louis J. Gross, Natl. Inst. for Math. & Biol. Synthesis University of Tennessee Knoxville (1056-BA-2121)

9:30AM ► (503) *Endangered Salmon in the Columbia River Basin.*
Roland H. Lamberson, Humboldt State University (1056-BA-1714)

MAA Minicourse #3: Part A

8:00 AM – 10:00 AM

Educating about the state of the planet and sustainability while enhancing calculus.
Organizer: **Thomas J. Pfaff**, Ithaca College

MAA Minicourse #8: Part A

8:00 AM – 10:00 AM

The Fibonacci and Catalan numbers.
Organizer: **Ralph Grimaldi**, Rose-Hulman Institute of Technology

AMS Session on Biomathematics, I

8:00 AM – 11:55 AM

8:00AM (504) *Enhancement of cargo processivity by cooperating molecular motors.*
Filippo Posta*, UCLA, **Maria R. D'Orsogna**, Cal State Northridge, and **Tom Chou**, UCLA (1056-92-58)

8:15AM ► (505) *Influence of inhalation injury on mortality of burn patients.*
Fatemeh Emdad*, The University of Texas Medical Branch, **Clarisse Djukom**, The University of Texas Medical Branch, **David N. Herndon**, UTMB, and **Marc G. Jeschke**, UTMB (1056-92-170)

8:30AM (506) *A fixed point theorem for a general epidemic model.*
Adam R. Lucas, Saint Mary's College of California (1056-92-227)

8:45AM (507) *Additive damage model for anti-cancer drug combinations.*
Ardith W El-Kareh, Arizona Research Laboratories-Microcirculation, University of Arizona, **Leslie B. Jones***, University of Arizona, and **Timothy W Secomb**, Department of Physiology, University of Arizona (1056-92-244)

9:00AM (508) *Two-Layer Human Right Ventricle Models with Patch and Anisotropic Material Properties for Ventricle Remodeling and Pulmonary Valve Replacement Surgical Optimization: Flow and Stress Analysis.*
Dalin Tang*, Worcester Polytechnic Institute, **Chun Yang**, Beijing Normal University, **Tal Geva** and **Pedro del Nido**, Harvard Medical School, Children's Hospital, Boston (1056-92-409)

9:15AM (509) *Human Carotid Plaque Progression Correlated Positively with Flow Shear Stress and Negatively with Plaque Wall Stress: 3D FSI Models Using Multi-Year Patient-Tracking In Vivo MRI.*
Chun Yang*, Beijing Normal University, **Dalin Tang**, Worcester Polytechnic Institute, **Gador Canton**, **Thomas S. Hatsukami** and **Chun Yuan**, University of Washington, Seattle (1056-92-417)

9:30AM (510) *Existence and stability of steady states of a reaction convection diffusion equation modeling microtubule formation.* Preliminary report.
Shantia Yarahmadian*, Mississippi State University, **Sidney L. Shaw**, **Kevin Zumbrun** and **Blake Barker**, Indiana University (1056-92-531)

9:45AM (511) *Stochastic Modeling of The Loss of Telomere Sequences.*
V Arunachalam, University of Los Andes (1056-92-627)

10:00AM ► (512) *Numerical Modeling of Intracranial Aneurysms.* Preliminary report.
Lisa M Melanson, Northwestern University (1056-76-1703)

10:15AM (513) *The effects of boundary transport and anti-oxidants on stability of a model of atherogenesis.*
L. R. Ritter*, Southern Polytechnic State University, **A. I. Ibragimov**, Texas Tech University, and **J. R. Walton**, Texas A&M University (1056-92-701)

10:30AM (514) *A Reaction-Diffusion Model of Cartilage Regeneration in Cell-Seeded Scaffolds.* Preliminary report.
Janine M. Haugh* and **Mansoor A. Haider**, North Carolina State University (1056-92-817)

10:45AM ► (515) *An algorithm for predicting minimal paths between genomes.* Preliminary report.
Elinor Velasquez, University of California, Santa Cruz (1056-92-933)

11:00AM (516) *The consequences of ant behavior for the spatial population dynamics of a southern wildflower.*
Judith E Canner*, **Robert R Dunn**, North Carolina State University, **Itamar Giladi**, Ben-Gurion University, Israel, and **Kevin Gross**, North Carolina State University (1056-92-985)

11:15AM (517) *Replicator equations and the principle of minimal production of information: some applications to biological models.*
Georgiy P. Karev, Lockheed Martin MSD; National Institute of Health (1056-92-1153)

11:30AM ► (518) *Geometry and Dynamics of Activity-Dependent Homeostatic Regulation in Neurons.*
Andrey V. Olypher* and **Astrid A. Prinz**, Emory University (1056-92-1180)

11:45AM ► (519) *Coexistence of Ecotypes in a Quasilinear Size-Structured Population Model.* Preliminary report.
Azmy S Ackleh, **Paul Leonard Salceanu*** and **Baoling Ma**, University of Louisiana at Lafayette (1056-92-1197)

AMS Session on Differential and Difference Equations, I

8:00 AM – 11:55 AM

8:00AM (520) *Correctors and Field Fluctuations for the $p_\epsilon(x)$-Laplacian with Rough Exponents.*
Silvia Jimenez* and **Robert Lipton**, Louisiana State University (1056-35-93)

8:15AM (521) *Maximizing distinguishability in optical tomography through selection of an optimal source: Function spaces and inner products.*
Bonnie C Jacob, Clemson University (1056-35-190)

8:30AM Break.

8:45AM (522) *A variational principle associated with a certain class of boundary value problems.*
Abbas Momeni, Queen's University (1056-35-436)

9:00AM (523) *Solutions for 2-Dimensional Coupled Kuramoto-Sivashinsky-KdV Equations.*
Maomao Cai*, Weber State University, **Dening Li**, West Virginia University, and **Chontita Rattanakul**, Mahidol University, Thailand (1056-35-490)

9:15AM (524) *On Nonlinear Evolution of Convective Flow in an Active Mushy Layer.*
Dambaru Bhatta*, The University of Texas-Pan American, **Mallikarjunaiah S. Muddamallappa**, Texas A&M University, and **Daniel N. Riahi**, The University of Texas-Pan American (1056-35-1213)

9:30AM (525) *A Finite Difference Approximation for an Amphibian Juvenile-adult Migration System.*
Azmy S. Ackleh, **Keng Deng*** and **Qihua Huang**, University of Louisiana at Lafayette (1056-35-667)

9:45AM (526) *Stratified steady water waves.*
Samuel Walsh, Division of Applied Mathematics, Brown University (1056-35-681)

10:00AM (527) *Stability of spherically propagating thermal frontal polymerization waves.* Preliminary report.
Vladimir A. Volpert and **Esteban Urdiales***, Northwestern University (1056-35-685)

10:15AM ► (528) *Fractional differential equations for modeling anomalous diffusion in porous medium.*
Sergei Fomin*, Khalifa University of Science, Technology and Research, and **Vladimir Chugunov**, Kazan State University (1056-35-807)

10:30AM (529) *Asymptotic analysis for the 3D primitive equations in a channel.*
Chang-Yeol Jung*, Ulsan National Institute of Science and Technology, **Roger Temam**, Indiana University, and **Makram Hamouda**, Dept. of Mathematics, Bizerte, Tunisia (1056-35-842)

10:45AM (530) *The refractor problem with loss of energy and Monge - Ampère type of Equation.*
Cristian E Gutierrez and **Henok Z Mawi***, Temple University (1056-35-920)

11:00AM (531) *Norm Estimates for Composite Operators Applied to Harmonic Forms.* Preliminary report.
Shusen Ding, Seattle University (1056-35-978)

11:15AM (532) *Symbolic Computation of Conservation Laws of Nonlinear Partial Differential Equations.*
L. Douglas Poole* and **Willy Hereman**, Colorado School of Mines (1056-35-1414)

11:30AM (533) *The Kawahara equation in weighted Sobolev spaces.*
Netra P. Khanal*, University of Wisconsin - Washington County, **Jiahong Wu**, Oklahoma State University, and **Juan-Ming Yuan**, Providence University, Taiwan (1056-35-1100)

11:45AM (534) *The Generation and Propagation of Water Waves on a Running Stream.*
Lokenath Debnath, University of Texas-Pan American (1056-35-1191)

AMS Session on Geometry and Topology, III

8:00 AM – 9:40 AM

8:00AM (535) *Surfaces in generic toroidal 3-manifolds.*
Ryan Derby-Talbot, Quest University Canada (1056-57-1742)

8:15AM (536) *A_∞-Bialgebras of Type (m, n).*
Ainhoa Berciano, Universidad del País Vasco-Euskal Herriko Unibertsitatea, **Sean Evans**, University of Pittsburgh, and **Ronald Umble***, Millersville University of Pennsylvania (1056-55-161)

8:30AM (537) *Homomorphisms of L_∞ Modules.*
Michael P. Allocca, North Carolina State University (1056-55-544)

8:45AM (538) *A Metric for Homotopy Types.* Preliminary report.
Nicholas A Scoville, Dartmouth College (1056-55-923)

9:00AM (539) *Stabilization of Homotopy Limits.*
Eric L Finster, University of Virginia (1056-55-1616)

9:15AM ► (540) *The Third Torus Complex is Simply Connected.*
Brie A Finegold, University of California at Santa Barbara (1056-55-1666)

9:30AM (541) *Location of Zeros of Polynomials.*
C. Affane-Aji*, Tuskegee University, **N. Agarwal** and **N. K. Govil**, Auburn University, AL (1056-32-1230)

AMS Session on Number Theory, I

8:00 AM – 11:55 AM

8:00AM ► (542) *Triangular arrays induced from trigonometric functions.*
Hung-ping Tsao, Novato, CA (1056-11-10)

8:15AM (543) *Gross-Zagier subgroups of elliptic curves over $\mathbb{Q}$.*
William A Stein, University of Washington (1056-11-22)

8:30AM (544) *Construction of Even Length Binary Sequences with High Asymptotic Merit Factor.* Preliminary report.
Tingyao Xiong* and **Hall I. Jonathan**, Michigan State University (1056-94-537)

8:45AM (545) *The Value of the Zeta Function at an Odd Argument.*
Badih N. Ghusayni, Lebanese University (1056-11-133)

9:00AM ► (546) *Arithmetic Progressions on Curves of Degree Five.*
Alejandra Alvarado, University of Arizona (1056-11-171)

9:15AM ► (547) *On Generalization of Lambert Series.*
Tom Osler, Rowan University, and **Abdul Hassen***, Rowan Univeristy (1056-11-1400)

9:30AM (548) *The fluctuations in the number of points on a family of curves over a finite field.*
Maosheng Xiong, Pennsylvania State University (1056-11-200)

9:45AM (549) *More Sums than Differences Sets and Beyond.*
Yufei Zhao, Massachusetts Institute of Technology (1056-11-343)

10:00AM (550) *Minimal product sets sizes in nonabelian groups.* **Yakov I Berchenko-Kogan**, California Institute of Technology (1056-11-360)

10:15AM (551) *An Infinite Family of Recursive Formulas Generating Power Moments of Kloosterman Sums with Trace One Arguments: $O(2n+1, 2^r)$ Case.* **Dae San Kim**, Sogang University (1056-11-430)

10:30AM ► (552) *Perfect Parallelepipeds Exist.* **Jorge F Sawyer*** and **Clifford A Reiter**, Lafayette College (1056-11-500)

10:45AM ► (553) *On the Convergence of Maximum Roots of a Fibonacci Type Polynomial Sequence.* **Robert Molina**, Alma College, and **Aklilu Zeleke***, Michigan State University (1056-40-1660)

11:00AM (554) *On the zeros of Epstein zeta functions.* **Yoonbok Lee**, Yonsei University (1056-11-570)

11:15AM ► (555) *Galois theory for tame dodecic local fields.* **Chad Awtrey**, Arizona State University (1056-11-631)

11:30AM (556) *Arithmetic of Curves and Error-Correction.* **Radoslav M Kirov*** and **Iwan M Duursma**, University of Illinois at Urbana-Champaign (1056-11-697)

11:45AM (557) *Two Identities Involving Generalized Fibonacci Numbers.* **Curtis N. Cooper**, University of Central Missouri (1056-11-1210)

MAA Session on Mathematics Experiences in Business, Industry, and Government

8:00 AM – 11:55 AM

Organizers: **Philip Gustafson**, Mesa State College
Michael Monticino, University of North Texas

8:00AM ► (558) *A Robust, Multi-Criteria Modeling Approach for Optimizing Aeromedical Evacuation Asset Emplacement.* **Nathaniel D Bastian**, United States Army (1056-J5-113)

8:20AM (559) *The U.S. blood supply, bioterrorism and mathematics.* **Sonja Sandberg**, Framingham State College (1056-J5-1600)

8:40AM (560) *Using Radar to Identify Persons Carrying Wires.* **William P Fox***, Naval Postgraduate School, **John Vesecky**, University of CA-Santa Cruz, and **Kip Laws**, University of CA, Santa Cruz (1056-J5-750)

9:00AM ► (561) *Probability in Solutions for Assembly in Earth Orbit of a NASA Spacecraft for Travel to Mars.* **Richard D Jarvinen**, Winona State University (1056-J5-583)

9:20AM (562) *A Green's Function Technique for Radiation Transport in Three Dimensions.* **Candice Rockell*** and **John Tweed**, Old Dominion University (1056-J5-788)

9:40AM ► (563) *Why companies need mathematicians even during rough times.* **Carla D Martin**, James Madison University (1056-J5-2085)

10:00AM (564) *Movie Recommendation Systems.* **Erich Kreutzer**, Davidson College (1056-J5-1711)

10:20AM ► (565) *Searching for the home base of a serial criminal.* **Mike O'Leary**, Towson University (1056-J5-811)

10:40AM ► (566) *Statistical Inconsistency in the Audit Risk Model.* Preliminary report. **Richard J Cleary**, Bentley University (1056-J5-1736)

11:00AM ► (567) *Scoring line of best fit test questions.* **James H Fife**, Educational Testing Service (1056-J5-783)

11:20AM ► (568) *An Alternative Distributional Model for Control of Process Particle Counts in the Semiconductor Industry.* **Robert K. Henderson**, Stephen F. Austin State University, Nacogdoches, TX (1056-J5-1384)

11:40AM (569) *Calculating the Greeks via Malliavin Calculus for Variance Gamma Process in Poisson-Wiener Space.* **Dervis Bayazit*** and **Craig A Nolder**, Florida State University (1056-J5-1727)

MAA Session on General Contributed Papers, V

8:00 AM – 11:55 AM

Organizers: **Eric S. Marland**, Appalachian State University
Daniel J. Curtin, Northern Kentucky University

8:00AM ► (570) *When uniformity must be replaced by non-uniformity: on finite difference approximations of the Black-Scholes equation on non-uniform grids.* Preliminary report. **Daniel D. Sheng***, Westwood High School, and **Myles D. Baker**, Baylor University (1056-Z1-1094)

8:15AM (571) *A Lagrage Interpolation Mean Convergence.* **Javad Namazi**, FDU (1056-Z1-332)

8:30AM (572) *L_∞ Algebras and Symmetric Braces.* **Mindy Beth Capaldi**, North Carolina State University (1056-Z1-610)

8:45AM ► (573) *Fibonacci Numbers and Collections of Mutually Disjoint Convex Subsets of a Totally Ordered Set.* **Tyler Clark***, Western Kentucky University Honors College, and **Tom Richmond**, Western Kentucky University (1056-Z1-1279)

9:00AM ► (574) *Generating Pythagorean Triples.* **Constance C Edwards**, California University of Pennsylvania (1056-Z1-1307)

9:15AM ► (575) *A New Characterization of Dimension Zero.* Preliminary report. **Jay Stine**, Misericordia University (1056-Z1-451)

9:30AM ► (576) *A Lesson Study in Real Analysis.* Preliminary report. **Brigitte Lahme***, **Jerry Morris** and **Elaine Newman**, Sonoma State University (1056-Z1-1762)

9:45AM ► (577) *Inquiry-Based Learning for Middle and High School Mathematics Teachers - Part I.* Preliminary report. **Shing S. So*** and **Mahmoud Yousef**, University of Central Missouri (1056-Z1-1214)

10:00AM ► (578) *Inquiry-Based Learning for Middle and High School Mathematics Teachers—Part II.* Preliminary report. **Mahmoud Yousef*** and **Shing S. So**, University of Central Missouri (1056-Z1-1217)

10:15AM (579) *A model for high-school teacher professional development and student learning.* **Galen E. Turner***, **James D. Nelson**, **Kelly B. Crittenden** and **Jane A. Petrus**, Louisiana Tech University (1056-Z1-1152)

10:30AM (580) *Middle Mathematics Mobilization Program for Middle School Teachers.* **Aaron K Trautwein**, Carthage College, Kenosha Wisconsin (1056-Z1-1292)

10:45AM ► (581) *Being a Student Again: My Summer in a Research Experience for K-12 Teachers.* **Erin Elizabeth Pitney**, Beaverton School District (1056-Z1-1941)

11:00AM (582) *How Might We Prepare Pre-Service High School Teachers to Teach Using Computer Algebra Systems?*
Tom Fox, University of Houston-Clear Lake (1056-Z1-2080)

11:15AM (583) *Mathematics workshops for parents and children as hybrid spaces.*
Jose Maria Menendez, Radford University (1056-Z1-827)

11:30AM ► (584) *Projects to Enhance Revised Algebra and Functions.*
Kenneth J Bernard, Virginia State University (1056-Z1-1192)

11:45AM ► (585) *A Classroom Project on Protecting Social Security Numbers from Identity Theft.*
Yajun Yang*, Farmingdale State College, State University of New York, and **Katherine Zhu**, Massachusetts Institute of Technology (1056-Z1-1458)

MAA Session on Mathematics, Equity, Diversity, and Social Justice, I

8:00 AM – 11:55 AM

Organizers: **Patricia Hale**, California State Polytechnic University Pomona
Shandy Hauk, University of Northern Colorado
Dave Kung, St. Mary's College, Maryland

8:00AM ► (586) *A First Year Seminar on Exploring Data for Social Change.* Preliminary report.
Maria G Fung, Worcester State College (1056-H7-2081)

8:20AM ► (587) *Teaching Mathematics and Democracy.* Preliminary report.
Maura Mast, University of Massachusetts Boston (1056-H7-1989)

8:40AM ► (588) *Gender Inequity in the National Merit Scholarship Program.*
Bryan Nankervis, Texas State University-San Marcos (1056-H7-940)

9:00AM ► (589) *Keeping the Doors Open: A Summer Algebra Camp for Under-represented Minority Middle School Students.*
J B Fink* and **E D Nordmoe**, Kalamazoo College (1056-H7-300)

9:20AM ► (590) *Changing Teachers' Concept of Mathematics with the Goal of Providing Equal Opportunity for All Students to Succeed in Learning Algebra.*
Judith M. Kysh* and **Diane Resek**, San Francisco State University (1056-H7-991)

9:40AM ► (591) *Creative Mathematics for All? A Survey of Preservice Teachers' Attitudes about Students' Capabilities.* Preliminary report.
Deborah E Berg, University of Nebraska-Lincoln (1056-H7-1558)

10:00AM ► (592) *Service Learning in Support of Financial Literacy.*
Andrew Miller, Belmont University (1056-H7-885)

10:20AM ► (593) *Mathematics as a Subversive Activity—Questioning Authority and Promoting Independent Thinking.*
Jack Bookman, Duke University (1056-H7-486)

10:40AM ► (594) *Math and Social Issues.* Preliminary report.
Mouchumi Bhattacharyya, **Christopher Goff** and **Larry J Langley***, University of the Pacific (1056-H7-1696)

11:00AM (595) *Social justice in the classroom through real-world examples.*
Lily S. Khadjavi, Loyola Marymount University (1056-H7-1450)

11:20AM ► (596) *A Pan-African Model for Developing Mathematical Talent in Africa.*
Josephine Davis Davis*, Quality Education for Minorities/Fort Valley State University, and **Monica Mitchell**, Quality Education for Minorities (1056-H7-1932)

11:40AM ► (597) *Teaching Numerical Analysis in Cambodia.*
Angel R. Pineda, California State University, Fullerton (1056-H7-1663)

MAA Session on Experiences that Enrich the Education of Mathematics Majors, II

8:00 AM – 9:15 AM

Organizers: **Suzanne M. Lenhart**, University of Tennessee
Steven J. Schlicker, Grand Valley State University
J. Douglas Faires, Youngstown State University
Michael J. Dorff, Brigham Young University

8:00AM ► (598) *Creating a Departmental Culture of Enriching Experiences.*
G. Daniel Callon, Franklin College (1056-E5-1979)

8:20AM ► (599) *Engaging math majors in education research.*
Diana White, University of Colorado Denver (1056-E5-1708)

8:40AM ► (600) *Enriching the education of mathematics majors with career seminars, undergraduate student research, and student events at MAA sectional meetings.* Preliminary report.
Katarzyna Potocka, Ramapo College of New Jersey (1056-E5-561)

9:00AM ► (601) *Combining Mathematics History with a Greece Tour.* Preliminary report.
Sharon S. Emerson-Stonnell, Longwood University (1056-E5-573)

MAA Session on Mathematics Courses for the Liberal Arts Students, I

8:00 AM – 11:35 AM

Organizer: **Reva Kasman**, Salem State College

8:00AM ► (602) *Using CLA in the Classroom Performance Tasks for Assessment in a Quantitative Reasoning Course.* Preliminary report.
Gerald W. Kruse, Juniata College (1056-J1-1118)

8:20AM ► (603) *Egyptian Fractions.* Preliminary report.
Bill Linderman, King College (1056-J1-1907)

8:40AM ► (604) *Ethnomathematics as an Interdisciplinary Outreach Course.*
Darrah Chavey, Beloit College (1056-J1-1481)

9:00AM ► (605) *The Mystical Math Room.*
Mairead K Greene, Rockhurst University (1056-J1-2040)

9:20AM ► (606) *The Mathematics of Powered Flight. The airplane course revisited.*
George Rublein, College of William and Mary (1056-J1-1756)

9:40AM (607) *How to Include More of the Arts in Mathematics for Liberal Arts.*
Julian F Fleron*, **Volker Ecke**, **Christine von Renessee** and **Philip K Hotchkiss**, Westfield State College (1056-J1-2008)

10:00AM ► (608) *The Whole Truth about Whole Numbers.* Preliminary report.
Agnes M Rash, Saint Joseph's University, Philadelphia, PA (1056-J1-1584)

10:20AM (609) *Liberal Arts Math—An Activity Based Class.*
Ann C Hanson, Columbia College Chicago (1056-J1-1618)

10:40AM ► (610) *Borrowing literary structures for mathematics lessons.* Preliminary report.
Teresa E. Moore*, Ithaca College, and **L. Christine Kinsey**, Canisius College (1056-J1-1630)

11:00AM ► (611) *Geometry and Renaissance Paintings.*
Daniel F Pinzon, University of Arkansas at Fort Smith (1056-J1-2055)

11:20AM ► (612) *Applications of Mathematics: Using Multi-Media Curriculum to Teach Mathematics to Liberal Arts Majors.* Preliminary report.
Barbara L Hess, California University of Pennsylvania (1056-J1-964)

MAA Session on Using Computer Algebra Systems in the Calculus Sequence

8:00 AM – 10:35 AM

Organizer: **William Marion**, Valparaiso University

8:00AM ► (613) *Related Rates.*
Leon Brin, Southern CT State University (1056-R1-880)

8:20AM ► (614) *Interactive Chaos Mathlets for Calculus I.* Preliminary report.
Karl-Dieter Crisman, Gordon College (1056-R1-1288)

8:40AM ► (615) *Exploratory Labs in Multivariable Calculus.* Preliminary report.
William E Fenton, Bellarmine University (1056-R1-1382)

9:00AM ► (616) *Why do we need intervals for the First Derivative Test?* Preliminary report.
Daniel Maxin, Valparaiso University (1056-R1-317)

9:20AM ► (617) *Gabriel's Other Equipment.* Preliminary report.
Melvin G. Royer, Indiana Wesleyan University (1056-R1-255)

9:40AM ► (618) *Exploring Velocity and Acceleration Vectors Visually.* Preliminary report.
Paul E. Seeburger, Monroe Community College (1056-R1-1779)

10:00AM ► (619) *In search of the big bubble.*
Andrew J Simoson, King College (1056-R1-410)

10:20AM ► (620) *Illustrating Gradients.*
Robert P. Webber, Longwood University (1056-R1-488)

MAA Session on Engaging Students with Classroom Voting

8:00 AM – 11:55 AM

Organizers: **Derek Bruff**, Venderbilt University
Kien Lim, University of Texas at El Paso
Kelly Cline, Carroll College

8:00AM ► (621) *Use of Classroom Voting In Liberal Arts College Classes (Small and Large).* Preliminary report.
Ron Buckmire, Occidental College (1056-E1-279)

8:20AM ► (622) *Clickers in the Classroom.*
Kimberly Jordan Burch, Indiana University of Pennsylvania (1056-E1-268)

8:40AM ► (623) *Classroom Voting: Using Students' Responses to Write Better Questions.*
M. McGivney-Burelle Jean, University of Hartford (1056-E1-1619)

9:00AM ► (624) *Utilizing Personal Response Systems (Clickers) in Liberal Arts Mathematics Courses to Support a Lecture Format.* Preliminary report.
Janet A White, Millersville University of PA (1056-E1-1348)

9:20AM (625) *Using Clickers in a Refocused College Algebra Course—Part I.*
Erick B Hofacker* and **Kay Shager**, University of Wisconsin - River Falls (1056-E1-1985)

9:40AM ► (626) *Preservice Elementary Teachers' Perceptions of Clicker Use in their College Mathematics Course.*
Travis K Miller, Millersville University of Pennsylvania (1056-E1-682)

10:00AM ► (627) *Using Classroom Response Systems in Mathematics to Facilitate Discourse, Reasoning, and Representations in the Development of Mathematical Content Teacher Knowledge.*
Sherrie J Serros*, University of Wisconsin - Eau Claire, **Kathryn T Ernie** and **Erick B Hofacker**, University of Wisconsin - River Falls (1056-E1-2009)

10:20AM ► (628) *Using Classroom Voting to Address Students' Probability Misconceptions.*
Tami K. Dashley, University of Texas at El Paso (1056-E1-618)

10:40AM (629) *A randomized experiment exploring features of clicker use and their impact on undergraduate students' engagement and learning in statistics.*
Herle M. McGowan*, North Carolina State University, **Brenda K. Gunderson** and **Vijay N. Nair**, University of Michigan (1056-E1-414)

11:00AM (630) *Classroom voting in an introductory real analysis course.*
L Pedro Poitevin, Salem State College (1056-E1-1053)

11:20AM ► (631) *Clicker examples versus board examples in Calculus: how are they different?*
Kim Roth*, Juniata College, and **Lynn Cockett**, Juniata College, Communications Department (1056-E1-1759)

11:40AM ► (632) *Using Clickers in Advanced Undergraduate Mathematics Courses.*
Patti Frazer Lock, St. Lawrence University (1056-E1-1248)

SIAM Minisymposium on High School Outreach to Introduce Students to Applied Mathematics

8:00 AM – 10:55 AM

Organizer: **Peter Turner**, Clarkson University

8:00AM ► (633) *Applied Mathematics for High School Outreach.*
Peter R Turner, Clarkson University (1056-97-386)

8:35AM ► (634) *Soap and Slope: Exploration of gradients through hands-on experiments with surfactants (outreach module for grades 7-12).*
Rachel Levy, Harvey Mudd College (1056-97-840)

9:25AM ► (635) *Probability and Determinism at the Battle of Trafalgar.*
Daniel J Teague, NC School of Science and Mathematics (1056-97-606)

10:10AM (636) *K-12 Outreach with Integrated Math and Physics for Roller Coaster Design.*
Kathleen R Fowler*, **Peter Turner**, **David Wick** and **Michael Ramsdell**, Clarkson University (1056-97-871)

MAA-Project NExT Panel Discussion

8:00 AM – 9:15 AM

Teaching calculus to students who have had AP calc: Challenges and solutions.

Organizers: **Timothy P. Chartier**, Davidson College
Stephanie Salomone, University of Portland

Panelists: **Michael E. Boardman**, Pacific University
David M. Bressoud, Macalester College
Stephen L. Davis, Davidson College
Deborah Hughes-Hallett, University of Arizona
Francis E. Su, Harvey Mudd College

Employment Center

8:00 AM – 7:00 PM

MAA Invited Address

9:00 AM – 9:50 AM

(637) *Reasonable effectiveness: Trigonometry, ancient astronomy, and the birth of applied mathematics.*
Glen Van Brummelen, Quest University (1056-A0-2)

MAA Minicourse #10: Part A

9:00 AM – 11:00 AM

The hitchhiker's guide to mathematics.

Organizers: **Dan Kalman**, American University
Bruce F. Torrence, Randolph Macon College

Student Hospitality Center

9:00 AM – 5:00 PM

MAA Committee on Technology in Mathematics Education Panel Discussion

9:00 AM – 10:20 AM

Online articles from JOMA to Loci.

Organizers: **Thomas E. Leathrum**, Jacksonville State University
Lawrence Moore, Duke University

Panelists: **Nathaniel Miller**, University of Northern Colorado
Kady Schneiter, Utah State University
Lee Stemkoski, Adelphi University

MAA Session for Department Chairs

9:00 AM – 10:20 AM

Assessment of student learning outcomes: Opportunity and challenge.

Organizers: **Daniel P. Maki**, Indiana University
Catherine M. Murphy, Purdue University Calumet

Panelists: **Jay A. Malmstrom**, Oklahoma City Community College
Catherine M. Murphy
Nalsey B. Tinberg, Occidental College

MAA Committee on the Participation of Women/Women in Mathematics Network Poster Session

9:00 AM – 11:00 AM

Mathematical outreach programs for underrepresented populations.

Organizer: **Elizabeth G. Yanik**, Emporia State University

AMS Special Presentation

9:30 AM – 11:00 AM

Who Wants to Be a Mathematician—National Contest.

Organizers: **Michael A. Breen**, AMS
William T. Butterworth, DePaul University

MAA-Project NExT Panel Discussion

9:30 AM – 10:50 AM

How one can become a referee/reviewer.

Organizers: **Joseph A. Gallian**, University of Minnesota-Duluth
Aparna W. Higgins, University of Dayton
T. Christine Stevens, Saint Louis University

Panelists: **Matthias Beck**, San Francisco State University
Frederick Hoffman, Florida Atlantic University
Carl Pomerance, Dartmouth College
Brigitte Servatius, Worcester Polytechnic Institute

Exhibits and Book Sales

9:30 AM – 5:30 PM

MAA Invited Paper Session on Gems of Number Theory

10:00 AM – 11:55 AM

Organizers: **Thomas Koshy**, Framingham University
Shannon Lockard, Bridgewater State College

10:00AM ► (638) *Ramanujan Reaches His Hand from His Grave to Snatch Your Theorems From You.*
Bruce C Berndt, University of Illinois (1056-BB-530)

10:30AM (639) *Combinatorial Proofs of Congruences.*
Ira M. Gessel, Brandeis University (1056-BB-632)

11:00AM ► (640) *Counting points on elliptic curves, from Gauss to the present.*
Alice Silverberg, University of California, Irvine (1056-BB-607)

11:30AM ► (641) *Sage: Creating a Viable Free Open Source Alternative to Magma, Maple, and Mathematica for Number Theory.*
William A Stein, University of Washington (1056-BB-510)

AMS Session on Probability and Statistics, III

10:00 AM – 11:55 PM

10:00AM (642) *Coherent risk measure for multivariate Pareto distributed losses.* Preliminary report.
Li Zhu* and **Haijun Li**, Washington State University (1056-62-2147)

10:15AM (643) *Spatial Birth-Death-Swap Chains.*
Mark L Huber, Claremont McKenna College (1056-60-1068)

10:30AM ► (644) *A Stochastic Approach to the Bonus-Malus System.* Preliminary report.
Kumer Pial Das, Lamar University (1056-60-980)

10:45AM (645) *Proper quantization of multiplexer circuits, history dependent Parrondo games, and certain Markov processes.*
Steven A. Bleiler and **Faisal Shah Khan***, Portland State University (1056-81-766)

11:00AM (646) *Quantum Walks with Decoherence on the N-Cycle.* Preliminary report.
Chaobin Liu* and **Nelson Petulante**, Bowie State University (1056-81-968)

11:15AM (647) *Computing a Penalized Maximum Quasi-Likelihood Estimator of the Diffusion Coefficient.*
Jeff Hamrick*, Rhodes College, **Yifei Huang**, **Kostas Kardaras** and **Murad S Taqqu**, Boston University (1056-62-1452)

11:30AM ► (648) *Underrecording in Domestic Violence Data Using Count Data Regression Models.*
Mavis Pararai, Indiana University of Pennsylvania (1056-62-1848)

11:45AM (649) *Statistical Sampling in High Dimensional Inverse Problems.*
Jean Marie Linhart* and **Wolfgang Bangerth**, Texas A&M University (1056-62-1851)

AMS-ASL-MAA Panel Discussion

10:00 AM – NOON

Hilbert's Tenth Problem.

Organizers: **Jeremy Avigad**, Carnegie Mellon University
Penelope Maddy, University of California Irvine
Charles Steinhorn, Vassar College

AWM Emmy Noether Lecture

10:05 AM – 10:55 AM

(650) *You can't hear the shape of a manifold.*
Carolyn S. Gordon, Dartmouth College (1056-58-49)

MAA Minicourse #1: Part A

10:30 AM – 12:30 PM

Remodeling data analysis.

Organizers: **Daniel Kaplan**, Macalester College
Vittorio Addona, Macalester College

MAA Minicourse #5: Part A

10:30 AM – 12:30 PM

Active learning approaches for the foundational mathematics for elementary teachers courses.

Organizers: **Laurie J. Burton**, Western Oregon University
Cheryl Beaver, Western Oregon University
Klay Thomas Kruczek, Western Oregon University

SIGMAA Officers Meeting

10:30 AM – NOON

MAA-YMN Panel Discussion

10:40 AM – NOON

Graduate school: Choosing one, getting in, staying in.

Organizers: **Kristi Meyer**, Wisconsin Lutheran College
Aaron Luttman, Clarkson University

Panelists: **Richard McGehee**, University of Minnesota
Scott A. Lambert, Colby College

MAA Workshop

10:40 AM – NOON

Proposal writing workshop for grant applications to the NSF Division of Undergraduate Education.

Organizers: **Dennis E. Davenport**, NSF/DUE
Daniel P. Maki, NSF/DUE
Lee L. Zia, NSF/DUE

SIAM Invited Address

11:10 AM – NOON

(651) *Optimization Inside: The use of mathematical methods in business processes.*
Brenda Dietrich, IBM (1056-90-33)

AMS Colloquium Lectures: Lecture II

1:00 PM – 2:00 PM

(652) *Alternating permutations.*
Richard P. Stanley, M.I.T. (1056-05-17)

AMS Special Session on Nonlinear Hyperbolic Equations and Control Systems in Physics and Engineering, I

1:00 PM – 3:50 PM

Organizers: **Petronela Radu**, University of Nebraska-Lincoln
Daniel Toundykov, University of Nebraska-Lincoln

1:00PM (653) *Well-posedness of weak and strong solutions in nonlinear flow of gas and structure interactions.*
Irena Lasiecka, University of Virginia (1056-35-960)

1:30PM (654) *Boundary regularity for Maxwell's equation with applications to shape optimization.*
Matthias Eller, Georgetown University (1056-35-640)

2:00PM (655) *Stability and stabilization of a multilayer beam system.*
Scott W. Hansen, Iowa State University (1056-93-675)

2:30PM (656) *Bolza boundary control problem for a fluid-structure interaction model.*
Irena Lasiecka, University of Virginia, and **Amjad Tuffaha***, University of Southern California (1056-35-1327)

3:00PM (657) *L^1 Well Posedness of Euler Equations With Dynamic Phase Boundaries.*
Chunguang Chen* and **Harumi Hattori**, West Virginia University (1056-35-403)

3:30PM (658) *Boundary stabilization of nonlinear structural acoustic interactions with interface on a Reissner-Mindlin plate.*
George Avalos and **Daniel Toundykov***, University of Nebraska-Lincoln (1056-35-1089)

AMS Special Session on Degenerate and Singular Elliptic Partial Differential Equations, II

1:00 PM – 3:50 PM

Organizers: **Marian Bocea**, North Dakota State University
Cristina Popovici, North Dakota State University

1:00PM (659) *Δ_∞ is well defined—a new proof.*
Robert R Jensen, Loyola University Chicago (1056-35-837)

1:30PM (660) *Studying the infinity Laplace equation via a finite difference approximation.*
Scott N Armstrong, Louisiana State University (1056-35-1575)

2:00PM (661) *Numerical methods for the infinity Laplace equation.*
Charles K Smart, University of California, Berkeley (1056-35-1626)

2:30PM (662) *A remark on C^2 infinity harmonic functions.*
Yifeng Yu, University of California at Irvine (1056-35-2005)

3:00PM (663) *Limits as $p(x) \to \infty$ of $p(x)$-harmonic functions.*
Jose Miguel Urbano, University of Coimbra (1056-35-1228)

3:30PM (664) *Homogenization in L^∞.* Preliminary report.
Changyou Wang, University of Kentucky (1056-35-1031)

AMS Special Session on Graph Algebras in Analysis and Algebra, II

1:00 PM – 3:50 PM

Organizers: **Gene Abrams**, University of Colorado at Colorado Springs
Mark Tomforde, University of Houston

1:00PM ► (665) *Structure theory for k-graph C^*-algebras.*
Aidan Sims, University of Wollongong (1056-46-515)

2:00PM (666) *Desingularization technique for higher-rank graphs.*
Cynthia Farthing, Creighton University (1056-46-911)

2:30PM (667) *Labeled Graph C^*-algebras with Group Actions.*
Teresa Bates, University of New South Wales, **David Pask**, University of Wollongong, and **Paulette N. Willis***, The University of Iowa (1056-47-1062)

3:00PM ► (668) *The role of the socle in the classification of Leavitt path algebras.*
Mercedes Siles Molina, University of Malaga (Spain) (1056-16-1023)

3:30PM (669) *Weakly regular and self-injective Leavitt path algebras.*
Gonzalo Aranda Pino*, University of Málaga, Spain, **Kulumani Rangaswamy**, University of Colorado at Colorado Springs, and **Mercedes Siles Molina**, University of Málaga, Spain (1056-16-339)

AMS Special Session on Algebraic Methods in Signal Processing, II

1:00 PM – 3:40 PM

Organizers: **Shamgar Gurevich**, University of California Berkeley
Ronny Hadani, University of Chicago
Olga Holtz, University of California Berkeley and Technical University Berlin
Oded Schwartz, Technical University Berlin
Nir Sochen, Tel Aviv University

1:00PM (670) *Algebraic Constructions for Communication Sequences.*
Solomon W Golomb, University of Southern California (1056-00-1867)

1:30PM (671) *Multilinear Algebra in Signal Processing.*
Lek-Heng Lim, University of California, Berkeley (1056-15-1823)

2:00PM (672) *Group representation patterns in digital signal processing.*
Ronny Hadani*, Utexas at Austin, **Shamgar Gurevich**, IAS, and **Nir Sochen** (1056-42-1758)

2:30PM ► (673) *Spectral Methods and Semidefinite Programming for Cryo-EM, NMR Spectroscopy, Low-Rank Matrix Completion and Computer Vision.*
Amit Singer, Princeton University and PACM (1056-00-1037)

3:00PM ► (674) *Group theoretical aspects of Gabor Analysis.* Preliminary report.
Hans G. Feichtinger, University of Vienna (1056-43-1059)

AMS Special Session on Representation Theory and Nonassociative Algebras, I

1:00 PM – 4:20 PM

Organizer: **Andrew Douglas**, City University of New York

1:00PM ► (675) *The quasi-jordan algebras.* Preliminary report.
Raul Felipe, CIMAT (1056-17-672)

1:30PM ► (676) *Special identities for quasi-Jordan algebras.*
Murray R Bremner*, University of Saskatchewan, Canada, and **Luiz A Peresi**, University of Sao Paulo, Brazil (1056-17-229)

2:00PM (677) *Lie-Yamaguti algebras and related structures.* Preliminary report.
Pilar Benito, Universidad de La Rioja (1056-17-1147)

2:30PM (678) *Locally Nilpotency in Commutative Right Nilalgebras.*
Alicia Labra, Universidad de Chile (1056-17-489)

3:00PM ► (679) *Special Bol Identities.* Preliminary report.
Murray Bremner, University of Saskatchewan, **Ivan Correa**, Universidad Metropolitana of Santiago, Chile, **Irvin Hentzel***, Iowa State University, and **Luiz Peresi**, Universidade de Sao Paulo, Brazil (1056-17-1172)

3:30PM (680) *Gradings on exceptional Lie superalgebras.* **Cristina Draper***, Universidad de Málaga (Spain), **Alberto Elduque**, Universidad de Zaragoza (Spain), and **Cándido Martín**, Universidad de Málaga (Spain) (1056-17-1130)

4:00PM (681) *Group gradings on Lie algebras in positive characteristic.* **Mikhail V Kotchetov**, Memorial University of Newfoundland (1056-17-1333)

AMS Special Session on Use of Technology in Modern Complex Analysis Research, I

1:00 PM – 3:50 PM

Organizers: **Beth Schaubroeck**, U.S. Air Force Academy
Michael Dorff, Brigham Young University
James Rolf, U.S. Air Force Academy

1:00PM ► (682) *Applets to Explore Research Topics in Complex Variables.* Preliminary report. **James S Rolf***, United States Air Force Academy, and **Michael Dorff**, Brigham Young University (1056-30-1625)

1:30PM ► (683) *Research in Complex Dynamics using Java Applets.* **Rich L Stankewitz**, Ball State University (1056-30-1048)

2:00PM ► (684) *Julia Sets and Graphing Iterates of Quadratic Polynomials.* Preliminary report. **Julia A Barnes***, Western Carolina University, **Clinton Curry**, Stony Brook University, and **Beth Schaubroeck**, U.S. Air Force Academy (1056-37-1685)

2:30PM ► (685) *Modeling Fluid Flow in the Complex Plane.* **Michael A. Brilleslyper**, U.S. Air Force Academy (1056-30-1352)

3:00PM ► (686) *Experimental Complex Function Theory via Circle Packing.* Preliminary report. **Ken Stephenson**, University of Tennessee, Knoxville (1056-30-1968)

3:30PM (687) *Use of computer technology for insight and proof.* **Roger W. Barnard**, Texas Tech University. (1056-30-810)

AMS Special Session on Voting Theory, II

1:00 PM – 3:50 PM

Organizers: **Michael Jones**, Mathematical Reviews
Brian Hopkins, Saint Peter's College
Tommy Ratliff, Wheaton College

1:00PM ► (688) *On the ordinal equivalence of power indices.* **Josep Freixas***, **Xavier Molinero**, **Montserrat Pons**, Technical University of Catalonia (Campus Manresa), and **Dorota Marciniak**, Polish Academy of Sciences and National Institute of Telecommunications (1056-91-1202)

1:30PM ► (689) *A Smallest Tournament Not Realizable by $\frac{2}{3}$-Majority Voting, and Some Open Problems in Spatial Voting Theory.* **Craig A. Tovey***, Georgia Institute of Technology, and **Dylan Shepardson**, Mt. Holyoke College (1056-91-2025)

2:00PM (690) *The agreement number of tree societies.* **Sarah Fletcher**, Georgia Institute of Technology, **Christopher S. Hardin**, Union College, and **Francis Edward Su***, Harvey Mudd College (1056-52-1416)

2:30PM (691) *Selecting Diverse Committees.* **Thomas C. Ratliff***, Wheaton College, and **Donald G. Saari**, University of California, Irvine (1056-91-1533)

3:00PM ► (692) *Approval Balloting for Multi-Winner Elections.* **D. Marc Kilgour**, Wilfrid Laurier University (1056-91-710)

3:30PM (693) *Satisfaction Approval Voting.* **Steven J. Brams***, New York University, and **D. Marc Kilgour**, Wilfrid Laurier University (1056-91-752)

AMS Special Session on Analysis and Control Under Uncertainty, II

1:00 PM – 3:20 PM

Organizers: **Xioaming Wang**, Florida State University
Yanzhao Cao, Auburn University
Catalin Trenchea, University of Pittsburgh

1:00PM (694) *Balancing a dissipative linear SDE with uncertain parameters.* **Sundeep Samson*** and **James A Reneke**, Clemson University (1056-90-597)

1:30PM (695) *Frequency-Domain Criteria for Robust Stability for a Class of Linear Time-Periodic Systems.* **Dmitry Altshuller**, Crane Aerospace & Electronics (1056-34-720)

2:00PM (696) *Coderivatives in Parametric Optimization in Asplund Spaces.* **Yen-Nhi Nguyen-thi***, **Boris Mordukhovich**, Wayne State University, and **Nam Mau Nguyen**, The University of Texas-Pan American (1056-49-1335)

2:30PM (697) *Weighted Composition Operators on Bergman Spaces in the Unit Ball.* **Waleed Khaled Al-Rawashdeh**, Central Michigan University (1056-47-1417)

3:00PM (698) *Gibbs measure and the quantization dimension function.* **Mrinal Kanti Roychowdhury**, The University of Texas-Pan American (1056-37-656)

AMS Special Session on Applications of Time Scales to Biology, Economics, and Engineering, II

1:00 PM – 4:20 PM

Organizers: **Martin Bohner**, Missouri University of Science and Technology
Billur Kaymakcalan, Georgia Southern University-Statesboro
Allan Peterson, University of Nebraska-Lincoln

1:00PM (699) *Lyapunov-Based Methods for Designing Stable Switched Systems.* Preliminary report. **John M Davis**, Baylor University (1056-93-1258)

1:30PM (700) *An exploration of the numerical approximations of dynamic derivatives for adaptive computations.* Preliminary report. **Qin Sheng*** and **Anzhong Wang**, Baylor University (1056-65-545)

2:00PM ► (701) *Global Stability of Complex-Valued Neural Networks on Time Scales.* **Suman Sanyal**, Marshall University (1056-60-1167)

2:30PM (702) *Linear and nonlinear cobweb models on time scales.* **Julius Heim*** and **Martin Bohner**, Missouri University of Science and Technology (1056-00-1928)

3:00PM (703) *Probability on time scales.*
Thomas Matthews* and **Dr. Martin J. Bohner**, Missouri University of Science and Technology (1056-00-1370)

3:30PM ► (704) *Asymptotic Behavior of Linear Dynamic Systems on Time Scales.* Preliminary report.
Gro Hovhannisyan, Kent State University (1056-34-405)

4:00PM ► (705) *On second order nonoscillatory scalar linear dynamic equations on time scales.* Preliminary report.
Sigrun Bodine*, University of Puget Sound, and **D. A. Lutz**, San Diego State University (1056-34-1721)

AMS Special Session on Arithmetic Geometry, II

1:00 PM – 3:50 PM

Organizers: **Bo-Hae Im**, Chung-Ang University
Jennifer Johnson-Leung, University of Idaho
Jennifer Paulhus, Kansas State University

1:00PM (706) *Non-optimal levels of reducible two-dimensional mod ℓ representations of the Galois group of* **Q**.
Kenneth A. Ribet, University of California, Berkeley (1056-11-1219)

1:30PM (707) *Reduction of crystalline representations and generalized Serre weights.*
Hui June Zhu, SUNY at Buffalo (1056-11-1237)

2:00PM (708) *Mod 7 and 7-adic Galois representations of elliptic curves.*
Ralph Greenberg, University of Washington, **Karl Rubin** and **Alice Silverberg***, University of California, Irvine (1056-11-1004)

2:30PM (709) *A formula for the special L-value of a modular abelian variety.*
Amod Agashe, Florida State University (1056-11-1109)

3:00PM (710) *Siegel modular forms of degree two attached to Hilbert modular forms.*
Jennifer Johnson-Leung* and **Brooks Roberts**, University of Idaho (1056-11-1111)

3:30PM (711) *The Gauss higher relative class number problem.*
John Voight, University of Vermont (1056-11-346)

MAA-AMS-MER Invited Paper Session on Mathematics and Education Reform, I: Guided Discovery Learning

1:00 PM – 3:50 PM

Organizers: **William H. Barker**, Bowdoin College
William G. McCallum, University of Arizona
Bonnie S. Saunders, University of Illinois at Chicago
Michael Starbird, University of Texas at Austin

1:00PM ► (712) *The Power of Guided Discovery Analysis.* Preliminary report.
William Barker, Bowdoin College (1056-BC-1121)

1:30PM (713) *Guided Discovery: Matters Mathematical and Beyond.* Preliminary report.
Michael Starbird, The University of Texas at Austin (1056-BC-1250)

2:00PM (714) *The Development of Pedagogical Content Knowledge about Early Algebra: A Comparative Study.* Preliminary report.
Bill Jacob*, **Sarah Hough**, **Kyunghee Moon** and **Monica Guzman**, University of California, Santa Barbara (1056-BC-1427)

2:30PM ► (715) *A comparison of Inquiry-Based Learning at the Undergraduate and Secondary Levels.* Preliminary report.
Stephanie R Nichols, Washington-Lee High School; Arlington, VA (1056-BC-1693)

3:00PM ► (716) *Inquiry Based Learning at Chicago.* Preliminary report.
Paul J Sally, University of Chicago (1056-BC-826)

3:30PM ► (717) *Panel Session: Guided Discovery Learning.* Preliminary report.
Michael Starbird*, The University of Texas at Austin, and **William Barker**, Bowdoin College (1056-BC-1356)

MAA Minicourse #2: Part A

1:00 PM – 3:00 PM

Using GeoGebra to create activities and applets for visualization and exploration.
Organizer: **Michael K. May**, Saint Louis University

MAA Minicourse #9: Part A

1:00 PM – 3:00 PM

Getting students involved in undergraduate research.
Organizers: **Aparna W. Higgins**, University of Dayton
Joseph A. Gallian, University of Minnesota Duluth

AMS Session on Number Theory, II

1:00 PM – 3:55 PM

1:00PM (718) *Solutions to $xyz = x + y + z = 1$ in algebraic integers of bounded degrees.* Preliminary report.
Helen G Grundman, Bryn Mawr College (1056-11-823)

1:15PM ► (719) *An elementary Proof of a Ramanujan's Congruence Identity.*
Syrous Marivani, LSUA (1056-11-844)

1:30PM ► (720) *Explicit construction of integral bases of radical function fields.*
Qingquan Wu* and **Renate Scheidler**, University of Calgary (1056-11-858)

1:45PM (721) *Flat Cyclotomic Polynomials: A New Approach.*
Sam Elder, California Institute of Technology (1056-11-936)

2:00PM (722) *Bounds on the order function of certain p-adic numbers.*
Brian C. Dietel, Oregon State University (1056-11-939)

2:15PM Break

2:30PM ► (723) *The number of nonzero binomial coefficients modulo p^α.*
Eric S. Rowland, Tulane University (1056-11-956)

2:45PM (724) *On the density of discriminants of abelian extensions of a number field.*
Behailu Mammo, Hofstra University (1056-11-1035)

3:00PM (725) *The Erdos-Moser equation* $1^n + 2^n + \cdots + (m-1)^n = m^n$*, related congruences, and primary pseudoperfect numbers.*
Jonathan Sondow*, New York, NY, and **Kieren MacMillan**, Toronto, Ontario (1056-11-1047)

3:15PM (726) *Prime Tuples.*
David C. Torney, Round Ideas Institute (1056-11-1056)

3:30PM (727) *On the Structure of Witt-Burnside rings over pro-p groups.*
Lance Edward Miller, University of Connecticut (1056-11-1154)

3:45PM (728) *Tetranomial Thue Equations.* Preliminary report.
Daniel P. Wisniewski, Bryn Mawr College (1056-11-1169)

AMS Session on Biomathematics, II

1:00 PM – 4:10 PM

1:00PM (729) *Synchronous versus Asynchronous Oscillations for an Antigenically Varying* Plasmodium falciparum *Infection with Host Immune Response.* Preliminary report.
Jonathan L Mitchell, Southern Methodist University (1056-92-1215)

1:15PM (730) *Evolutionary dynamics on undirected graphs—the effect of graph structure and initial placement on mutant spread.*
Jan Rychtar, University of North Carolina at Greensboro (1056-92-1240)

1:30PM (731) *Combining immunological and epidemiological models.* Preliminary report.
Laurentiu Mircea Sega*, Purdue University, and **Fabio Augusto Milner**, Arizona State University (1056-92-1295)

1:45PM (732) *Outbreak control through voluntary first-order and second-order ring vaccination.* Preliminary report.
Michel Tchuenche*, University of Guelph, **A. P. Galvani**, Yale University School of Medicine, **L. Ancel-Meyers**, The University of Texas at Austin, and **Chris Bauch**, University of Guelph (1056-92-1411)

2:00PM (733) *A moment closure method for stochastic biochemical networks.*
Chang Hyeong Lee, Ulsan National Institute of Science and Technology (UNIST) (1056-92-1412)

2:15PM (734) *Simulation of flagellar motion near a rigid surface.*
Ricardo Ortiz*, Center for Computational Science at Tulane University, and **Ricardo Cortez**, Tulane University (1056-76-1493)

2:30PM (735) *A Statistical Method for Environmental Prediction in Metagenomic Samples.* Preliminary report.
Katherine Isaacs, San Jose State University (1056-92-1415)

2:45PM (736) *Estimating Vital Coral Population Parameters.* Preliminary report.
Kristie Llera*, Florida Institute of Technology, and **Elif Demirci**, University of Ankara (1056-92-1567)

3:00PM (737) *A Systems Biology Approach to Modeling Alzheimer's Disease.* Preliminary report.
Christina Rose Kyrtsos*, Fischel Dept. of Bioengineering, University of Maryland, and **John S Baras**, Professor, A James Clark School of Engineering, University of Maryland (1056-92-1570)

3:15PM (738) *Development of a Model of Erythropoiesis in Patients with Chronic Kidney Disease.*
Karen Bliss*, **H T Tran**, North Carolina State University, **H T Banks**, North Carolina State University, and **Peter Kotanko**, Renal Research Institute, New York (1056-92-1583)

3:30PM (739) *Asymptotic formulas for the equilibria in a model of suppression of pest resistance to insecticidal genetically modified crops.*
Prasanth George, Michigan Technological University, and **John Ringland***, University at Buffalo (1056-92-1649)

3:45PM (740) *Biological Neronal Networks on Nvidia Cuda Graphics Processors.* Preliminary report.
Joseph A. Rhoads*, Florida State University, **Richard Bertram**, Florida State University, **Joel Tabak**, Florida State University, Department of Biology, **Michael Mascagni**, Florida State University, Department of Computer Science, and **Gordon Erlebacher**, Florida State University, Department of Scientific Computing (1056-92-1667)

4:00PM (741) *An integrated muscle mechanic-fluid dynamic model of lamprey swimming.*
Chia Yu Hsu*, Center for Computational Science, Dept. of Math. Tulane University, **Eric Tytell**, Dept. of Biology, Univ. of Maryland, College Park, and **Lisa Fauci**, Tulane University (1056-76-1105)

AMS Session on Differential and Difference Equations, II

1:00 PM – 4:10 PM

1:00PM (742) *On the symmetry and existence of solutions of some floating drop problems.*
Ray Treinen, Kansas State University (1056-35-1233)

1:15PM (743) *Scattering Due to a Medium Density Change.* Preliminary report.
Nezam Iraniparast, Western Kentucky University (1056-35-1300)

1:30PM (744) *Fundamental solutions of the wave equation in the Einstein-de Sitter spacetime.*
Anahit Galstyan*, University of Texas-Pan American, **Tamotu Kinoshita**, University of Tsukuba, Tsukuba, Japan, and **Karen Yagdjian**, University of Texas-Pan American (1056-35-1337)

1:45PM (745) *Corrector analysis for homogenization of stationary linear transport equations in random media.*
Guillaume Bal and **Wenjia Jing***, Columbia University (1056-35-1388)

2:00PM (746) *The 2D Boussinesq Equations with vertical viscosity and vertical diffusivity.* Preliminary report.
Dhanapati Adhikari*, Oklahoma State University, **Chongsheng Cao**, Florida International University, and **Jiahong Wu**, Oklahoma State University (1056-35-1390)

2:15PM (747) *Optimality Conditions for Control Systems of Neutral Type.*
Lianwen Wang, University of Central Missouri (1056-93-1006)

2:30PM (748) *Mechanisms of the Instabilities of Ideal Diffusion Flames.*
Joseph E Hibdon, Jr*, Northwestern University, and **Moshe Matalon**, University of Illinois Urbana-Champaign (1056-35-1442)

2:45PM ► (749) *An Analytical and Numerical Study of Optical Soliton Propagation through Photorefractive Media governed by Logarithmic Law Nonlinearity.* **Dawn A. Lott***, Delaware State University, **Auris Henriquez-Fernandez**, University of Puerto Rico, Rio Piedras, PR, **Bryan Moore**, Michigan State University, **Benjamin Sturdevant**, University of Wisconsin, Madison, and **Anjan Biswas**, Delaware State University (1056-35-1559)

3:00PM ► (750) *On the solution of the coupled Navier-Stokes and Darcy equations.* **Prince Chidyagwai*** and **Beatrice Riviere**, Rice University (1056-35-1576)

3:15PM (751) *Sub-Wavelength Plasmonic Crystals: Dispersion Relations and Effective Properties.* **Santiago P. Fortes***, **Robert P. Lipton** and **Stephen P. Shipman**, Louisiana State University (1056-35-1579)

3:30PM (752) *Multiple positive solutions for a class of p-q-Laplacian systems with multiple parameters and combined nonlinear effects.* **Jaffar Ali***, Florida Gulf Coast University, and **Ratnasingham Shivaji**, Mississippi State University (1056-35-1615)

3:45PM (753) *The blowup for the semilinear Klein-Gordon equation in de Sitter spacetime.* **Karen Yagdjian**, University of Texas-Pan American (1056-35-1628)

4:00PM (754) *Lyapunov Functionals vs Lyapunov Functions in Stability Analysis for Stochastic Parabolic Differential Equations of Ito Type.* Preliminary report. **J Mahmoud Anabtawi**, American University of Sharjah (1056-35-1681)

AMS Session on Computational Mathematics, I

1:00 PM – 4:10 PM

1:00PM (755) *Numerical techniques for 3-D Vortex Rings Motion and Collision.* **Leon Kaganovskiy***, New College of Florida, **Robert Krasny**, University of Michigan, Ann Arbor, and **Feng Hualong**, Nanjing University of Science and Technology (1056-65-30)

1:15PM (756) *Local Numerical Representation of Algebraic Sets.* **Yun Guan*** and **Jan Verschelde**, University of Illinois at Chicago (1056-65-123)

1:30PM ► (757) *Chemotaxis and Numerical Methods for Chemotaxis Models.* **Yekaterina Epshteyn**, Carnegie Mellon University (1056-65-151)

1:45PM (758) *A stability study of a new explicit numerical scheme for a system of differential equations with a large skew-symmetric component.* **Katharine F. Gurski***, Howard University, and **Stephen O'Sullivan**, Dublin City University (1056-65-504)

2:00PM (759) *C^0 interior penalty methods for fully nonlinear Monge-Ampère type equations.* **Michael Joseph Neilan***, **Susanne C. Brenner**, **Thirupathi Gudi** and **Li-yeng Sung**, Louisiana State University (1056-65-518)

2:15PM ► (760) *On the convergence of a generalized modified Newton scheme.* Preliminary report. **Livinus U Uko**, Johnson C. Smith University (1056-65-1280)

2:30PM (761) *On the Convergence of Fully-discrete High-Resolution Schemes with van Leer's flux limiter for Conservation laws.* Preliminary report. **Nan Jiang**, University of South Dakota (1056-65-554)

2:45PM ► (762) *The Domain Decomposition Method Applied to Hyperbolic Network Problems.* **James B Collins**, North Carolina State University (1056-65-796)

3:00PM (763) *Kernel Based Function Approximation in High Dimensions.* **Fred J. Hickernell**, Illinois Institute of Technology (1056-65-845)

3:15PM (764) *Analysis and simulation of a multiphysics and a multiphase problem.* **Aycil Cesmelioglu**, Rice University (1056-65-925)

3:30PM (765) *Retrieving Economic Parameters in Asset-Flow Equations.* **Marlene Willie-Aymone Ouayoro**, George Mason University (1056-65-951)

3:45PM ► (766) *A comparison of algorithms for subset selection.* Preliminary report. **Martin Brown***, University of California - Berkeley, **Mary Broadbent**, Amherst College, and **Kevin Penner**, University of Pittsburgh (1056-65-986)

4:00PM (767) *A High Accuracy Algorithm for 3D Periodic Electromagnetic Scattering.* **Michael J Nicholas**, Tulane University (1056-78-1760)

AMS Session on Fields and Commutative Algebra

1:00 PM – 4:10 PM

1:00PM (768) *On the Irreducibility of Cauchy-Mirimanoff Polynomials.* Preliminary report. **Brian C Irick**, University of Tennessee (1056-12-271)

1:15PM (769) *Forcing the appearance of Galois groups: new automatic realization results for p-groups.* **Andrew C Schultz**, University of Illinois, Urbana-Champaign (1056-12-850)

1:30PM (770) *Observations on Primitive, Normal, and Subnormal Elements of Field Extensions.* **Steven H. Weintraub**, Lehigh Univ. (1056-12-257)

1:45PM (771) *Prime Ideals in Birational Extensions of Two-Dimensional Power Series Rings.* **Christina Eubanks-Turner***, University of Louisiana at Lafayette, **Melissa Luckas**, Madison, Wisconsin, and **Serpil Saydam**, University of Louisiana at Monroe (1056-13-370)

2:00PM ► (772) *Irreducible Divisor Graphs.* Preliminary report. **M Axtell**, University of Saint Thomas, **N Baeth***, University of Central Missouri, and **J Stickles**, Milikin University (1056-13-655)

2:15PM (773) *Abstract Factorization into Relatively Prime Elements.* Preliminary report. **Jeremiah N. Reinkoester**, University of Iowa (1056-13-896)

2:30PM (774) *Krull dimension of a power series ring over a one-dimensional nondiscrete valuation domain.* Preliminary report. **Byung Gyun Kang*** and **Toan**, POSTECH (1056-13-1515)

2:45PM (775) *A general theory of almost splitting sets.* **Byung Gyun Kang** and **Jung Wook Lim***, POSTECH (1056-13-1522)

3:00PM (776) *The Linear Strand of Path Ideals of Trees.* Preliminary report.
Rachelle R. Bouchat*, Slippery Rock University, **Tài Hà** and **Augustine O'Keefe**, Tulane University (1056-13-1730)

3:15PM (777) *Comparing the Sizes of the Lower Bass Numbers of a Cohen Macaulay Local Ring.* Preliminary report.
Jared L Painter, University of Texas at Arlington (1056-13-1830)

3:30PM (778) *Characterizing rings which admit non-trivial totally reflexive modules.* Preliminary report.
Kristen A Beck, The University of Texas at Arlington (1056-13-1984)

3:45PM (779) *Building Indecomposable Modules.* Preliminary report.
Andrew Crabbe, Syracuse University (1056-13-2054)

4:00PM ► (780) *On the Integral Closure of an Antimatter Domain.*
William Travis Trentham, North Dakota State University (1056-13-1857)

AMS Session on Discrete Mathematics, III

1:00 PM – 3:55 PM

1:00PM ► (781) *Enumeration Of Bipartite Graphs.*
Shanzhen Gao, Florida Atlantic University (1056-05-715)

1:15PM (782) *Graphs in which each independent dominating set intersects each minimum dominating set.*
David R. Prier* and **Peter D. Johnson**, Auburn University (1056-05-706)

1:30PM ► (783) *C_4-Factorizations with Two Associate Classes.*
Chris Rodger and **Michael Tiemeyer***, Auburn University (1056-05-629)

1:45PM ► (784) *Deletion relations of graphs.* Preliminary report.
Stephen G Hartke, University of Nebraska-Lincoln, **Hannah Kolb**, Illinois Institute of Technology, **Jared Nishikawa**, Willamette University, and **Derrick Stolee***, University of Nebraska-Lincoln (1056-05-498)

2:00PM (785) *Star-Avoiding Ramsey Numbers.*
Jonelle Hook, Lehigh University (1056-05-485)

2:15PM (786) **p-Capacity $\mathbb{Z}^n$ and Zeta function.**
Lucio M. G. Prado, BMCC - The City University of New York (1056-31-1798)

2:30PM ► (787) *Promotion acting on Standard Young Tableaux of staircase shape.* Preliminary report.
Qiang Wang* and **Steven Pon**, UC Davis (1056-05-2141)

2:45PM ► (788) *On extremal cycle-free subgraphs of the hypercube.*
Lale Özkahya, University of Illinois at Urbana-Champaign (1056-05-838)

3:00PM (789) *Group Colorability of Graphs.*
Hao Li, West Virginia University (1056-05-898)

3:15PM (790) *Oriented Incidence and a Generalization of Hypergraphs.*
Lucas J. Rusnak, Binghamton University (1056-05-1465)

3:30PM ► (791) *Irreducible No-Hole $L(2,1)$ labelings of some classes of graphs.*
Jobby Jacob*, Rochester Institute of Technology, and **Renu Laskar**, Clemson University (1056-05-1466)

3:45PM (792) *A Parallel Algorithm for finding Maximum Critical Independent Sets in Graphs.*
Ermelinda Delavina, University of Houston-Downtown, and **Craig Eric Larson***, Virginia Commonwealth University (1056-05-1774)

MAA Session on Developmental Mathematics Education: Helping Under-Prepared Students Transition to College-Level Mathematics, II

1:00 PM – 4:15 PM

Organizers: **Kimberly J. Presser**, Shippensburg University
J. Winston Crawley, Shippensburg University

1:00PM ► (793) *Transition Mathematics: A Professional Learning Community Approach.*
Stuart Boersma* and **Aaron Montgomery**, Central Washington University (1056-D1-567)

1:20PM ► (794) *How ideas from therapy can help developmental mathematics students with anxiety, motivation, and performance: Successes from two pilot tests.* Preliminary report.
K. Scott Alberts*, Truman State University, and **Jane Roads**, Moberly Area Community College (1056-D1-602)

1:40PM ► (795) *An alternative to intermediate algebra for liberal arts majors.* Preliminary report.
Jeffery D. Sykes, Ouachita Baptist University (1056-D1-941)

2:00PM ► (796) *Preparing students for Elementary Statistics or Math for Liberal Arts.* Preliminary report.
Mary R Parker, Austin Community College (1056-D1-1821)

2:20PM ► (797) *A successful model for teaching developmental math at CSU-Monterey bay.*
Lipika Deka, California State University, Monterey Bay (1056-D1-1332)

2:40PM ► (798) *Blending Inquiry-Based Class Sessions with Computer-Assisted Instruction.* Preliminary report.
William O. Bond* and **John C. Mayer**, University of Alabama at Birmingham (1056-D1-1778)

3:00PM ► (799) *The Quantitative Learning Center at UConn, and the effects of online homework in the study habits of students.* Preliminary report.
Álvaro Lozano-Robledo* and **Tom Roby**, University of Connecticut - Storrs (1056-D1-1150)

3:20PM ► (800) *Developmental Mathematics Program Assessment: A Case Study.* Preliminary report.
Frank Anthony Cerreto, The Richard Stockton College of NJ (1056-D1-1321)

3:40PM ► (801) *Proportional Reasoning Models in Developmental Mathematics Education: Enhancing Under-Prepared Students' Transition at the College-Level.* Preliminary report.
Jack A Carter*, California State University East Bay, **Beverly J Ferrucci**, Keene State College, and **Ngan Hoe Lee**, National Institute of Education, Singapore (1056-D1-224)

4:00PM ► (802) *Transitions: Helping Under-Prepared Students Find Success at Dominican University.*
Paul R. Coe, Dominican University (1056-D1-2061)

MAA Session on Mathematics Courses for the Liberal Arts Students, II

1:00 PM – 3:55 PM

Organizer: **Reva Kasman**, Salem State College

1:00PM ► (803) *Your Financial Future.*
Yu-Ju Kuo, Indiana University of Pennsylvania (1056-J1-816)

1:20PM (804) *Games and Critical Thinking.*
Volker Ecke*, **Christine von Renesse**, **Julian Fleron** and **Philip Hotchkiss**, Westfield State College (1056-J1-1866)

1:40PM ► (805) *Teaching Non-Mathematics Majors using 'Group Topic Books'.* Preliminary report.
Caroline P Lubert, James Madison University (1056-J1-1034)

2:00PM ► (806) *Quantitative Approaches to Problems in Democracy.*
Karen Saxe, Macalester College (1056-J1-247)

2:20PM (807) *Symmetry and Design Portfolios Showcase Mathematics for Liberal Arts Students.*
Penny H. Dunham, Muhlenberg College (1056-J1-391)

2:40PM ► (808) *Service-based learning projects in statistics courses.*
Brad Bailey* and **A. Robb Sinn**, North Georgia College & State University (1056-J1-736)

3:00PM (809) *A New Course for Liberal Arts Math: The Mathematics of Calendars and Timekeeping.*
Daniel E. Otero, Xavier University (1056-J1-830)

3:20PM (810) *Mathematical ways of reasoning and knowing through geometry.*
James Morrow, Mount Holyoke College (1056-J1-174)

3:40PM ► (811) *Fun Projects and Activities for Poets and Mathematicians Alike.*
Ioana Mihaila, Cal Poly Pomona (1056-J1-946)

MAA Session on Online Homework—Innovation and Assessment, I

1:00 PM – 4:15 PM

Organizers: **Michael E. Gage**, University of Rochester
Arnold K. Pizer, University of Rochester
Vicki Roth, University of Rochester

1:00PM (812) *An Interactive Approach to Discrete Math Using WeBWorK and Flash Applets.* Preliminary report.
Nathan M. Wodarz, University of Wisconsin - Stevens Point (1056-M1-35)

1:20PM (813) *Using WeBWorK, A Web-Based Homework Delivery And Grading System, To Help Prepare Students For Peer Instruction.*
Adam R. Lucas, Saint Mary's College of California (1056-M1-228)

1:40PM ► (814) *Geometry on a wiki.* Preliminary report.
Michael E McDaniel, Aquinas College (1056-M1-267)

2:00PM ► (815) *The relationship between online homework, test grades, and persistence in calculus.*
H Smith Risser, Montana Tech (1056-M1-298)

2:20PM ► (816) *The Effect of an Online Homework System on Student Outcomes in a First-Year Mathematics Course.*
Laurie Lenz, Marymount University (1056-M1-324)

2:40PM ► (817) *WebAssign: "It's How Math Homework is Done!".* Preliminary report.
Denise J LeGrand, University of Arkansas at Little Rock (1056-M1-367)

3:00PM ► (818) *Communicating through Online Assessment.* Preliminary report.
Edward D Smith, Pima Community College (1056-M1-539)

3:20PM ► (819) *Embedding applets into WeBWorK questions.* Preliminary report.
Michael E. Gage, University of Rochester (1056-M1-585)

3:40PM ► (820) *The Impact of Implementing Web Homework in Calculus II.*
P. Gavin LaRose, University of Michigan (1056-M1-703)

4:00PM ► (821) *A Successful Approach in Designing Online Courses for Freshman Mathematics Courses.* Preliminary report.
A. Serpil Saydam*, **A. Dale Magoun** and **Charlotte H. Owens**, University of Louisiana at Monroe (1056-M1-832)

MAA Session on Preparing K–12 Teachers to Teach Algebra, II

1:00 PM – 3:55 PM

Organizers: **Elizabeth Burroughs**, Montana State University
Angela M. Hodge, North Dakota State University
William G. McCallum, University of Arizona

1:00PM (822) *An algebra course for middle school teachers.*
Ji Li* and **Virginia Bohme**, The University of Arizona (1056-N1-1338)

1:20PM ► (823) *Visualizing Algebraic Relationships: Solving Combined Rate Problems with Pattern Blocks.* Preliminary report.
Dianna Spence* and **A. Robb Sinn**, North Georgia College & State University (1056-N1-865)

1:40PM ► (824) *Inquiry as an Outcome of Algebra.* Preliminary report.
David Fowler, University of Nebraska-Lincoln (1056-N1-803)

2:00PM (825) *Big Ideas in Algebra: Materials to Foster Mathematical Thinking.*
Carol E Seaman*, University of North Carolina Greensboro, and **Jennifer Earles Szydlik**, University of Wisconsin Oshkosh (1056-N1-481)

2:20PM ► (826) *Calculus: A Gateway to Algebra?!* Preliminary report.
Steve Benson, Lesley University (1056-N1-478)

2:40PM ► (827) *Using modified materials from The Algebra Project with pre-service K-8 mathematics teachers.* Preliminary report.
Steve Blair, Eastern Michigan University (1056-N1-383)

3:00PM ► (828) *Teachers, Mathematicians, and Educators Making Sense of Algebra Content.*
Joshua D Chesler, California State University, Long Beach (1056-N1-954)

3:20PM ► (829) *Bridging Proportional Reasoning and Algebraic Reasoning: A Focus on Co-variation and Invariance Using Contextualized Problems.*
Kien H. Lim, University of Texas at El Paso (1056-N1-242)

3:40PM ► (830) *Algebra for Algebra Teachers.* Preliminary report.
Ira J Papick* and **Jim Lewis**, University of Nebraska-Lincoln (1056-N1-36)

MAA Session on How Assessment Results Changed Our Program

1:00 PM – 3:35 PM

Organizers: **Dick Jardine**, Keene State College

Barbara Edwards, Oregon State University

1:00PM ► (831) *Faculty Development Through Assessment.* Preliminary report. **Dick Jardine**, Keene State College (1056-F1-1175)

1:20PM ► (832) *Assessment of Mathematical Reasoning Courses for Business Students and Liberal Arts Students.* **Vesna Kilibarda**, Indiana University Northwest (1056-F1-557)

1:40PM ► (833) *Assessing Critical Thinking Throughout the Mathematics Curriculum.* Preliminary report. **Miriam Harris-Botzum**, Lehigh Carbon Community College (1056-F1-1308)

2:00PM ► (834) *Readiness Assessment and Course Placement through Introductory Calculus.* **Alison Ahlgren***, University of Illinois, and **Marc Harper**, UCLA (1056-F1-1349)

2:20PM (835) *Assessment: If It Ain't Useful, Don't Do It.* Preliminary report. **J. Winston Crawley**, Shippensburg University of Pennsylvania (1056-F1-1033)

2:40PM ► (836) *Using a knowledge survey for course and program level assessment in mathematics.* **Jacqueline M Dewar**, Loyola Marymount University (1056-F1-443)

3:00PM ► (837) *An Assessment Loop (or How I Learned to Stop Worrying and Love the Rubric).* Preliminary report. **Jenn D Berg**, Fitchburg State College (1056-F1-900)

3:20PM ► (838) *The Impact of Pair Quizzes on Mathematics Achievement and Mathematics Attitude.* **Harrison W. Straley*** and **Lauren Dupee**, Wheaton College (1056-F1-637)

MAA Session on Wavelets in Undergraduate Education

1:00 PM – 4:15 PM

Organizers: **Caroline Haddad**, SUNY Geneseo
Catherine Beneteau, University of South Florida
David Ruch, Metropolitan State College of Denver
Patrick Van Fleet, University of St. Thomas

1:00PM (839) *Teaching a Wavelets Course at a Liberal Arts College.* **Beth M. Campbell Hetrick**, Gettysburg College (1056-S1-1998)

1:20PM ► (840) *Teaching a Wavelets course in May term.* **Janine Wittwer**, Westminster College, UT (1056-S1-231)

1:40PM ► (841) *Portable Haar Wavelet Projects with MATLAB.* Preliminary report. **Phil Gustafson**, Mesa State College (1056-S1-1334)

2:00PM ► (842) *A Wavelet-Based Unsupervised Learning Algorithm to Cluster Diabetics Based on Continuous Glucose Monitoring Data.* Preliminary report. **Edward Aboufadel***, Grand Valley State University, **Robert Castellano**, Stony Brook University, and **Derek Olson**, Drake University (1056-S1-528)

2:20PM ► (843) *Authentication Using Wavelets, part I.* **Jill E. Guerra***, University of Arkansas - Fort Smith, **John C. Merkel, III**, Morehouse College, **Eric A. Bickerton**, University of Arkansas - Fort Smith, and **Warren Chancellor**, Morehouse College (1056-S1-1263)

2:40PM ► (844) *Authentication Using Wavelets, part II.* **John C. Merkel, III***, Morehouse College, **Jill E. Guerra**, University of Arkansas - Fort Smith, **Warren Chancellor**, Morehouse College, and **Eric A. Bickerton**, University of Arkansas - Fort Smith (1056-S1-1270)

3:00PM (845) *A Module for the Construction of Scaling Functions using the Cascade Algorithm.* **John A Rock***, California State University, Stanislaus, **David Ruch**, Metropolitan State College of Denver, **Kenneth Hoover**, California State University, Stanislaus, **Helmut Knaust**, University of Texas, El Paso, and **Roger Zarnowski**, Angelo State University (1056-S1-1479)

3:20PM ► (846) *Fourier Series and the Discrete Wavelet Transformation.* Preliminary report. **Patrick J Van Fleet**, University of St. Thomas (1056-S1-1535)

3:40PM ► (847) *Wavelet Packets and Image Compression.* Preliminary report. **Cristen M Bonz** and **Elizabeth A Motz***, University of St Thomas (1056-S1-1691)

4:00PM ► (848) *A Sufficient Condition for the Optimality of Huffman Encoding.* Preliminary report. **William David Hall***, California State University, Stanislaus, and **Jonathan Brown**, California State University, Stanislaus (1056-S1-1784)

General Contributed Papers, VI

1:00 PM – 4:10 PM

Organizers: **Eric S. Marland**, Appalachian State University
Daniel J. Curtin, Northern Kentucky University

1:00PM (849) *Mathematics and the Internet: The Impact of New Media on a Discipline.* Preliminary report. **Samuel M Hansen**, University of Nevada Las Vegas (1056-Z1-1205)

1:15PM ► (850) *Utilizing Web-based Statistical Resources in Teaching Nontraditional Undergraduate Students in Online Learning Environments.* **Michael D. Miner**, American Public University System (1056-Z1-1898)

1:30PM ► (851) *What can your students do with an iPhone or iPod Touch in Math Class?* **Erick B Hofacker**, University of Wisconsin - River Falls (1056-Z1-1976)

1:45PM (852) *Using Wikis to Enhance Mathematical Communication and Develop Students' Investment in Mathematical Community.* Preliminary report. **Donna LaLonde** and **Jennifer D. Wagner***, Washburn University (1056-Z1-707)

2:00PM (853) *The Use of Spreadsheets to Illustrate Statistical and Mathematical Concepts.* **Morteza Shafii-Mousavi*** and **Kochanowski Paul**, Indiana University South Bend (1056-Z1-86)

2:15PM ► (854) *Impact of Technology on Mathematics Teaching.* **Mohammad Khadivi**, Jackson State University (1056-Z1-967)

2:30PM ► (855) *Fun and Motivational Activities for Exam Review Day.* **Min-Lin Lo**, California State University San Bernardino (1056-Z1-676)

2:45PM ► (856) *Euler-Cauchy Using Undetermined Coefficients.* **Doreen De Leon**, California State University, Fresno (1056-Z1-542)

3:00PM ► (857) *Visualization Projects in Multivariable Calculus.*
Jason J Molitierno, Sacred Heart University (1056-Z1-541)

3:15PM (858) *Using an Opening Quiz to set the Tone for a College Algebra Course.*
Gerald Agbegha* and **Nailong Guo**, Johnson C. Smith University (1056-Z1-1876)

3:30PM (859) *Strategies of Designing College Algebra with Modular Approach.* Preliminary report.
A. Serpil Saydam*, **A. Dale Magoun** and **Charlotte H. Owens**, University of Louisiana at Monroe (1056-Z1-834)

3:45PM (860) *Issues and Obstacles in Preparing Mathematics Graduate Students for Teaching.*
Mary Beisiegel, Western Oregon University (1056-Z1-1768)

4:00PM ► (861) *fUNcO!—A Mathematical Card Game.*
Mairead K Greene* and **Paula Shorter**, Rockhurst University (1056-Z1-2034)

SIAM Minisymposium on Mathematics and a Smart Planet

1:00 PM – 4:06 PM

Organizer: **Brenda Dietrich**, IBM T. J. Watson Research
Chair: **Lior Horesh**, IBM TJ Watson Research Center

1:00PM ► (862) *Managing the Earth: Modeling Data into Decisions under Geological and Engineering Uncertainty.*
Jef Caers, Stanford University (1056-60-804)

1:39PM (863) *Design in inverse problems.*
Eldad Haber*, UBC, **Lior Horesh**, IBM, and **Luis Tenorio**, Colorado School of Mines (1056-49-2102)

2:18PM (864) *Inversion—Taking one step backwards.*
Lior Horesh*, IBM TJ Watson Research Center, **Eldad Haber**, University of British Colombia, and **Luis Tenorio**, Colorado School of Mines (1056-49-2148)

2:57PM (865) *On the probabilistic validation of models for interacting agents.*
Roger Ghanem*, Civil and Environmental Engineering, University of Southern California, and **Sonjoy Das**, Department of Aerospace and Mechanical Engineering, University of Southern California

3:36PM (866) *Global optimization with response surfaces for computationally expensive functions with environmental applications.*
Rommel Regis, St. Joseph's University, **Christine Shoemaker***, School of Operations Research and Information Engineering, Cornell University, and **Yilun Wang**, Cornell University

Joint Committee on Women in the Mathematical Sciences Panel Discussion

1:00 PM – 2:30 PM

Hard problems, approximate solutions: Finding balance between math and family demands.
Organizer: **Kathleen M. O'Hara**, Mathematical Sciences Research Institute
Panelists: **Mary Ann Mason**, University of California, Berkeley
Marc Goulden, University of California, Berkeley
Carol Hollenshead, University of Michigan
Maura B. Mast, University of Massachusetts, Boston
Judy L. Walker, University of Nebraska

MAA Committee on Graduate Students-YMN Panel Discussion

1:00 PM – 2:20 PM

Finding a research topic and thesis advisor.
Organizers: **David C. Manderscheid**, University of Nebraska-Lincoln
Aaron Luttman, Clarkson University
Panelists: **Raegan J. Higgins**, Texas Tech University
Franziska Hinckelmann, Virginia Polytechnic Institute and State University
Steven G. Krantz, Washington University
Jennifer McNulty, University of Montana

SIGMAA on Statistics Education Panel Discussion

1:00 PM – 2:20 PM

Statistics ≠ mathematics: What a first- (or second-) time teacher of statistics should know.
Organizer: **Michael A. Posner**, Villanova University
Panelists: **Robin Lock**, St. Lawrence University
Elaine Newman, Sonoma State University
Leigh Lunsford, Longwood University
Ken Torre, Cotati-Rohnert Park Unified School District

SIGMAA on Math Circles for Students and Teachers, Part I

1:00 PM – 4:15 PM

Fostering, supporting, and propogating Math Circles (Part II is Saturday at 1:00 p.m.).
Organizers: **James S. Tanton**, St. Mark's Institute of Mathematics
Tatiana Shubin, San Jose State University

Summer Program for Women in Mathematics (SPWM) Reunion

1:00 PM – 4:00 PM

AMS Special Session on Arithmetic of Function Fields, II

1:30 PM – 4:20 PM

Organizers: **Allison Pacelli**, Williams College
Michael Rosen, Brown University

1:30PM (867) *A Gross-Zagier formula for quaternion algebras over totally real fields.* Preliminary report.
Kristin E. Lauter*, Microsoft Research, and **Eyal Z. Goren**, McGill University (1056-11-1669)

2:00PM (868) *An N-point version of the Mason-Stothers abc Theorem.*
Robert L. Benedetto, Amherst College (1056-11-659)

2:30PM (869) *The Reflection Theorem for class groups of global function fields and its applications.*
Yoonjin Lee, Ewha Womans University (1056-11-377)

3:00PM (870) *Prime polynomials.*
Paul Pollack, University of Illinois at Urbana-Champaign (1056-11-1082)

3:30PM ► (871) *Function Fields with Class Number Indivisible by a Prime ℓ.*
Michael W Daub*, University of California, Berkeley, **Allison Pacelli**, Williams College, **Michael Rosen**, Brown University, **Jaclyn Lang**, Bryn Mawr College, **Mona Merling**, Bard College, and **Natee Pitiwan**, Williams College (1056-11-1110)

4:00PM (872) *Class numbers of function fields.* Preliminary report.
Jing Long Hoelscher, University of Arizona (1056-11-994)

MAA Poster Session on Projects Supported by the NSF Division of Undergraduate Education

2:00 PM – 4:00 PM

Organizer: **Jon W. Scott**, Montgomery Community College

2:00PM (873) *Lurch: Software for Teaching Mathematical Proof.*
Nathan Carter*, Bentley University, and **Kenneth G. Monks**, University of Scranton

2:00PM (874) *DIYModeling—Do It Yourself Modeling and Simulation for STEM Learning.*
Frank Wattenberg*, U.S. Military Academy, **William C Bauldry**, Appalachian State University, **Joe Yanik**, Emporia State University, **Keith Erickson**, Georgia Gwinnett College, and **Marion Smith**, Texas Southern University

2:00PM (875) *MAA's Online Calculus Text.*
Lawrence Moore* and **David Smith**, Duke University

2:00PM (876) *MAA's Mathematical Sciences Digital Library (MathDL).*
Lawrence Moore*, Duke University, and **Tom Leathrum**, Jacksonville State University

2:00PM (877) *Maplets for Calculus.*
Philip B. Yasskin, Texas A&M University, and **Douglas B. Meade***, University of South Carolina

2:00PM (878) *The design of a research-based curriculum for real analysis.*
Kyeong Hah Roh, Arizona State University

2:00PM (879) *Research-Based Video for Teaching Undergraduate Proof.*
James Sandefur*, Georgetown University, **Connie Campbell**, Millsaps College, **Kay Somers**, Moravian College, and **Geoffrey Birky**, Georgetown University

2:00PM (880) *WeBWork, a Web-based Interactive Homework System.*
Arnold Pizer*, **Vicki Roth** and **Michael Gage**, University of Rochester

2:00PM (881) *Change Agents for Teaching and Learning Statistics (CATALST).*
Joan Garfield*, **Bob delMas**, **Andy Zieffler**, University of Minnesota, **Allan Rossman**, **Beth Chance**, California Polytechnic State University, San Luis Obispo, **George Cobb**, Mount Holyoke College, and **John Holcomb**, Cleveland State University

2:00PM (882) *Multidisciplinary Sustainability Modules: Integrating STEM Courses.*
Thomas J. Pfaff*, **Ali S. Erkan**, **Jason G. Hamilton** and **Michael Rogers**, Ithaca College

2:00PM (883) *CCLI2: Colorado Momentum.*
Mary Nelson*, **Harvey Segur**, **Anne Dougherty** and **James Curry**, University of Colorado, Boulder

2:00PM (884) *Investigating the Mathematical Biology of Metabolic Scaling using Manduca InSTaRs (Interdisciplinary Science Training and Research).*
Jennifer Garbett, **Judy Holdener***, **Chris Gillen**, **Brad Hartlaub**, **Harry Itagaki** and **Drew Kerkhoff**, Kenyon College

2:00PM (885) *STEM Real World Application Modules.*
Darren Narayan*, **William Basener**, **Matthew Coppenbarger**, **Paul Tymann** and **Moises Sudit**, Rochester Institute of Technology

2:00PM (886) *Paradigms in Physics: Multiple Entry Points.*
Tevian Dray*, **Corinne A Manogue**, **Barbara Edwards**, **David McIntyre** and **Emily van Zee**, Oregon State University

2:00PM (887) *Quantitative Reasoning in the Contemporary World (QRCW).*
Bernard L. Madison, University of Arkansas, **Stuart Boersma**, Central Washington University, **Caren L. Diefenderfer***, Hollins University, and **Shannon W. Dingman**, University of Arkansas

2:00PM (888) *College Ready in Mathematics and Physics Partnership.*
Gay Stewart, **Bernard L. Madison***, **Shannon W. Dingman**, University of Arkansas, **Pete Joenks**, Springdale High School, and **John Jones**, University of Arkansas, Fort Smith

2:00PM (889) *Undergraduate Biology and Mathematics Training Program at NJIT: The effect of neuronal morphology on passive properties of neurons.*
Farzan Nadim*, **Krutanjali Shah**, **Yamin Noor** and **A. Farzad Sheibanie**, New Jersey Institute of Technology

2:00PM (890) *Authentic Discovery Projects for Introductory Statistics.*
Robb Sinn*, **Dianna Spence** and **Brad Bailey**, North Georgia College

2:00PM (891) *Empowering Student Learning in Mathematical Analysis.*
Barbara Shipman* and **James Epperson**, The University of Texas at Arlington

2:00PM (892) *Modern Biology, Modern Mathematics, and Modern Solutions: Moving Biomathematics Education Beyond Calculus.*
Raina Robeva*, **Robin Davies**, Sweet Briar College, **Terrell Hodge** and **Alexander Enyedi**, Western Michigan University

2:00PM (893) *Quantitative Literacy Across the Curriculum in a Liberal Arts Setting.*
Semra Kilic-Bahi*, **Ben Steele** and **Peter White**, Colby-Sawyer College

2:00PM (894) *HBCU Retreat and Follow-On Program.*
Don Small*, United States Military Academy, and **Laurette Foster**, Prairie View A&M University

2:00PM (895) *Explorations in Complex Variables with Accompanying Applets: Undergraduate Research.*
Michael Dorff*, Brigham Young University, **Jim Rolf**, U.S. Air Force Academy, **Rich Stankewitz**, Ball State University, **Mike Brilleslyper**, **Beth Schaubroeck**, U.S. Air Force Academy, **Jane McDougall**, Colorado College, and **Ken Stephenson**, University of Tennessee

2:00PM (896) *Mathematical Biology Projects at UNCG.*
Jan Rychtar*, **Maya Chhetri**, **Mary Crowe**, **David Remington** and **Olav Rueppell**, The University of North Carolina at Greensboro

2:00PM (897) *Development and Dissemination of Computational Science Educational Materials and Curricula at the Undergraduate Level.*
Paula Federico*, **Terry Lahm**, **Andrea Karkowski**, Capital University, **Sheryl Hemkin**, Kenyon College, **Gerald Mueller**, Columbus State Community College, and **Ignatios Vakalis**, California State Polytechnic Institute

2:00PM (898) *Learning Discrete Mathematics and Computer Science via Primary Historical Sources.*
Jerry Lodder*, **David Pengelley** and **Guram Bezhanishvili**, New Mexico State University

2:00PM (899) *MBUR (Mathematical Biology & Undergraduate Research): Modeling Growth and Biochemical Pathways in Selenite Resistant Bacteria.*
George Yates*, **Jon Caguiat**, **Carl Sims**, **Jozsi Jalics** and **Mark Womble**, Youngstown State University

2:00PM (900) *SyBR-U: Synthetic Biology Research for Undergraduates.*
Laurie J. Heyer*, **A. Malcolm Campbell**, Davidson College, **Jeffrey L. Poet** and **Todd T. Eckdahl**, Missouri Western State University

2:00PM (901) *The Center for Women in Mathematics at Smith College.*
Ruth Haas* and **James Henle**, Smith College

2:00PM (902) *Studying Cell Response to Input Signals as the Basis for Interdisciplinary Training for Undergraduates in Biological and Mathematical Sciences.*
Ovidiu Lipan, **Kathy Hoke**, **Lester Caudill, Jr**, **Laura Runyen-Janecky** and **Garrett Graham***, University of Richmond

2:00PM (903) *Research and Education Program in Mathematical and Biological Sciences.*
Semen Koksal*, **Rob van Woesik**, **Dave Carroll**, **Richard Sinden**, **Eugene Dshalalow** and **Kristie Llera**, Florida Institute of Technology

2:00PM (904) *Quantitative Skills in Biology through Scientific Inquiry at James Madison University.*
D. Brian Walton*, **Anthony Tongen**, **Nusrat Jahan** and **Reid Harris**, James Madison University

2:00PM (905) *Research and Education in Computational Mathematics for Undergraduates in the Mathematical Sciences at NJIT.*
Zoi-Heleni Michalopoulou*, **Roy Goodman**, **David Horntrop**, **Jonathan Luke**, **Michael Siegel** and **Yuan-Nan Young**, New Jersey Institute of Technology

2:00PM (906) *Interactive Online Modules and Take-Home Assignments for Inquiry-Learning to Provide First-Hand Experience in Matrix Algebra Course.*
Hamide Dogan-Dunlap* and **Piotr Wojciechowski**, University of Texas at El Paso

2:00PM (907) *Experimental Mathematics.*
Marc Chamberland, Grinnell College

2:00PM (908) *Undergraduate Training in Bioinformatics.*
Ming-Ying Leung*, **Steve Aley**, **Vladik Kreinovich** and **Elizabeth Walsh**, The University of Texas at El Paso

2:00PM (909) *PREP: MAA's Professional Enhancement Program.*
J. Michael Pearson, Mathematical Association of America, **Nancy Baxter Hastings**, Dickinson College, **Nathaniel Dean**, Texas State University, San Marcos, **Virginia Buchanan**, Hiram College, and **Jon Scott***, Montgomery College

AMS Invited Address

2:15 PM – 3:05 PM

(910) *Laplacians on vector bundles on graphs.*
Richard W. Kenyon, Brown University (1056-60-14)

MAA-Project NExT Panel Discussion

2:30 PM – 3:45 PM

Mathematics and social justice.
Organizers: **Lily S. Khadjavi**, Loyola Marymount University
David T. Kung, St. Mary's College of Maryland
Panelists: **Shandy Hauk**, University of Northern Colorado
Eric Hsu, San Francisco State University
Lisa Marano, West Chester University

MAA CRAFTY Panel Discussion

2:35 PM – 3:50 PM

More voices from the partner disciplines: The second round of curriculum foundations workshops.
Organizer: **Sheldon P. Gordon**, Farmingdale State College
Panelists: **Andrew G. Bennett**, Kansas State University
Susan L. Ganter, Clemson University
Sheldon P. Gordon
William E. Haver, Virginia Commonwealth University
William Marion, Valparaiso University

SIGMAA on Statistics Education and SIGMAA on Research in Undergraduate Mathematics Education Panel Discussion

2:35 PM – 3:50 PM

Excuse me; where is the department of statistics education?
Organizer: **Michael A. Posner**, Villanova University
Panelists: **Dennis Pearl**, Ohio State University
Mike Shaugnessy, Portland State University
Bob DelMas, University of Minnesota
Andrew Zieffler, University of Minnesota

AMS Committee on the Profession Panel Discussion

2:45 PM – 4:15 PM

What I wish I had known when applying for a job.
Moderator: **Christopher K. McCord**, Northern Illinois University
Panelists: **Elizabeth T. Beazley**, University of Michigan and Williams College
Julie Bergner, University of California, Riverside
Karl Kempf, Intel and Arizona State University
Bryna Kra, Northwestern University
Ken Ono, University of Wisconsin-Madison

Tony DeRose, Pixar Animation Studios

AMS Retiring Presidential Address

3:20 PM – 4:10 PM

(911) *Reflections and perspectives.*
James G. Glimm, Stony Brook University

Joint Prize Session

4:25 PM – 5:25 PM

SIGMAA on Environmental Mathematics Guest Lecture

5:30 PM – 6:30 PM

Speaker and title to be announced.

Joint Prize Session Reception

5:30 PM – 6:30 PM

SIGMAA on Business, Industry, and Government Guest Lecture

5:45 PM – 6:45 PM

5:45PM (912) *From Netflix to Gerrymanders: A Sample of BIG Applications of Mathematics.*
Barry A Cipra, Northfield, MN (1056-A0-1541)

SIGMAA on Statistics Education Business Meeting and Reception

5:45 PM – 7:15 PM

SIGMAA on Mathematics Instruction Using the Web Reception and Business Meeting

5:45 PM – 6:30 PM

Presenter: **Bruce W. Yoshiwara**, Pierce College

MAA Two-Year College Reception

5:45 PM – 7:30 PM

MAA Special Presentation for Students

6:00 PM – 7:00 PM

6:00PM ► (913) *Low dimensional topology for fun and profit, or, how to extract money from the R4 space.*
Cliff Stoll, Acme Klein Bottle Company

SIGMAA on Research in Undergraduate Mathematics Education Business Meeting

6:00 PM – 7:30 PM

SIGMAA on Environmental Mathematics Business Meeting

6:30 PM – 7:00 PM

SIGMAA on Mathematics Instruction Using the Web Presentation and Discussion

6:30 PM – 7:30 PM

Life after Wolfram Alpha.
Presenter: **Bruce W. Yoshiwara**, Pierce College

SIGMAA on Mathematics and the Arts Special Presentation

7:00 PM – 9:00 PM

Open mike mathematical poetry reading.
Organizer: **Douglas Norton**, Villanova University

SIGMAA on Business, Industry, and Government Reception

7:15 PM – 8:00 PM

Young Mathematicians' Network Open Forum

7:30 PM – 8:30 PM

Friday, January 15

Joint Meetings Registration

7:30 AM – 4:00 PM

AMS Special Session on Mathematics and Physical Experiment, I

7:30 AM – 10:50 AM

Organizers: **Roger Thelwell**, James Madison University
Anthony Tongen, James Madison University
Paul Warne, James Madison University

7:30AM ► (914) *Shock Wave Formation on Turbulent Coanda Surfaces.*
Thomas Dowd, James Madison University (1056-76-1537)

8:00AM ► (915) *The Applied Mathematics Laboratory: translating what you see into what you do.*
Michael Tabor, University of Arizona (1056-97-1045)

8:30AM ► (916) *GPS Tracking of a Roller Coaster.* Preliminary report.
Michael C. Sostarecz, Monmouth College (1056-00-1096)

9:00AM ► (917) *Experiments from a Capstone Laboratory at New Jersey Institute of Technology.*
Michael Booty, New Jersey Institute of Technology (1056-00-1733)

9:30AM ► (918) *Notes from the MEC Lab at the University of Delaware.*
John A Pelesko, University of Delaware (1056-74-699)

10:00AM (919) *Experiments in the Classroom.*
Jon Jacobsen, Harvey Mudd College (1056-37-1030)

10:30AM (920) *Reinventing the Wheel!*
Roger Thelwell, James Madison University (1056-35-1634)

AMS-MAA-SIAM Special Session on Research in Mathematics by Undergraduates, I

8:00 AM – 10:50 AM

Organizers: **Darren Narayan**, Rochester Institute of Technology
Bernard Brooks, Rochester Institute of Technology

Jacqueline Jensen, Sam Houston State University

Carl V. Lutzer, Rochester Institute of Technology

Vadim Ponomarenko, San Diego State University

Tamas Wiandt, Rochester Institute of Technology

8:00AM (921) *Configurations of extremal type II lattices and codes.*
Scott Kominers, Harvard University (1056-06-2154)

8:30AM (922) *Modular forms arising from Q(n) and Dyson's rank.*
Maria Monks, Massachusetts Institute of Technology (1056-11-2153)

9:00AM ► (923) *Efficient simulation of fluid flow.* Preliminary report.
David Alexander Hannasch* and **Monika Neda**, University of Nevada, Las Vegas (1056-65-165)

9:30AM ► (924) *Image Denoising Via Feature-Based Sparse and Redundant Dictionaries.* Preliminary report.
Josh Koslosky* and **Stacey Levine**, Duquesne University (1056-49-173)

10:00AM ► (925) *Analytic Properties of Unitary Equivalence to Constant Diagonal Matrices.* Preliminary report.
Daniel E Poore, Pomona College (1056-15-185)

10:30AM ► (926) *Complete Growth and Graph Products of Groups.*
Daniel Allen, University of Maine at Farmington, **Meghan Cream**, Wake Forest University, **Kate Finlay**, Lafayette College, and **Ranjan Rohatgi***, Northwestern University (1056-20-274)

AMS-AWM Special Session on Spectral Problems on Compact Riemannian Manifolds, I

8:00 AM – 10:50 AM

Organizers: **Carolyn Gordon**, Dartmouth College

Ruth Gornet, University of Texas at Arlington

Craig Sutton, Dartmouth College

8:00AM (927) *Spectral bounds on 2-orbifold diffeomorphism type.*
Emily Proctor, Middlebury College, and **Elizabeth Stanhope***, Lewis & Clark College (1056-53-1590)

8:30AM (928) *Spectral and geometric bounds on orbifold homotopy type.* Preliminary report.
Emily Proctor*, Middlebury College, and **Elizabeth Stanhope**, Lewis & Clark College (1056-58-919)

9:00AM (929) *Some applications of the trace formula on orbifolds to the inverse spectral problem.* Preliminary report.
Alejandro Uribe, University of Michigan, Ann Arbor (1056-58-1289)

9:30AM (930) *On the singularities of the exponential map.*
Benjamin Schmidt*, Michigan State University, and **Keith Burns**, Northwestern University (1056-51-1041)

10:00AM (931) *Quantum ergodic restriction theorems.*
Steve Zelditch, Johns Hopkins Univ and Northwestern Univ (1056-35-748)

10:30AM (932) *Spectral rigidity of analytic plane domains with one mirror symmetry.*
Hamid Hezari*, MIT, and **Steve Zelditch**, Johns Hopkins University (1056-35-1012)

AMS Special Session on Nonlinear Hyperbolic Equations and Control Systems in Physics and Engineering, II

8:00 AM – 10:50 AM

Organizers: **Petronela Radu**, University of Nebraska-Lincoln

Daniel Toundykov, University of Nebraska-Lincoln

8:00AM (933) *Uniform stabilization of the system of dynamic elasticity by non-linear boundary dissipation.*
Roberto Triggiani, University of Virginia (1056-35-532)

8:30AM (934) *Concerning the Qualitative of a Coupled Fluid-Structure Semigroup.*
George Avalos, University of Nebraska-Lincoln (1056-35-569)

9:00AM (935) *Optimal control of a thermoelastic structural acoustic model.*
Catherine Lebiedzik, Wayne State University (1056-35-2037)

9:30AM (936) *Analysis and Simulation of a One-dimensional Plasma Model.*
Stephen Pankavich, University of Texas at Arlington (1056-35-560)

10:00AM (937) *Existence of time periodic solutions of non-linear wave equations.*
Jintae Kim, Tuskegee University (1056-35-1631)

10:30AM (938) *Bridging the asymptotic behavior of solutions to hyperbolic equations with parabolic equations.*
Petronela Radu*, University of Nebraska-Lincoln, **Grozdena Todorova** and **Borislav Yordanov**, University of Tennessee-Knoxville (1056-35-1074)

AMS Special Session on Biomathematics: Modeling in Biology, Ecology, and Epidemiology, I

8:00 AM – 10:50 AM

Organizers: **Olcay Akman**, Ilinois State University

Linda Allen, Texas Tech University

Timothy D. Comar, Benedictine University

Sophia Jang, Texas Tech University

Lih-Ing Roeger, Texas Tech University

8:00AM (939) *The fundamental bifurcation theorem for Darwinian matrix models.* Preliminary report.
Jim M. Cushing, University of Arizona (1056-92-603)

8:30AM (940) *Bifurcation analysis of a model for hormonal regulation of the menstrual cycle.*
James F. Selgrade, North Carolina State University (1056-92-786)

9:00AM (941) *Darwinian Dynamics of Avian Populations with Reproductive Synchrony.* Preliminary report.
Shandelle M. Henson*, Andrews University, **J. M. Cushing**, University of Arizona, and **James L Hayward**, Department of Biology, Andrews University (1056-92-1807)

9:30AM (942) *Competitive Exclusion in a Juvenile-Adult Model with Continuous and Seasonal Reproduction.*
Azmy S. Ackleh* and **Ross A. Chiquet**, University of Louisiana at Lafayette (1056-92-1016)

10:00AM (943) *Modeling the Movements of a Thermoregulating Timber Rattlesnake.* Preliminary report.
John G. Alford*, Sam Houston State University, and **Bill Lutterschmidt**, Department of Biological Sciences and Texas Research Institute for Environmental Studies/Sam Houston State University (1056-92-114)

10:30AM (944) *Discrete host-parasitoid models with Allee effects and age structure in the host.*
Sophia R-J Jang, Texas Tech University (1056-92-740)

AMS Special Session on Enumerative Combinatorics, I

8:00 AM – 10:50 AM

Organizers: **Brian Miceli**, Trinity University
Jeff Remmel, University of California San Diego

8:00AM ► (945) *SL_k-Tilings of Lattices.* Preliminary report.
Francois Bergeron, Universite du Quebec a Montreal (1056-05-704)

8:30AM (946) *A basis for the coinvariant space for quasisymmetric polynomials.* Preliminary report.
Sarah K Mason*, UCSD/Wake Forest University, and **Aaron Lauve**, Texas A&M (1056-05-1361)

9:00AM (947) *Experimental Investigations into the Zeros of Rook Polynomials and Analytic Functions.* Preliminary report.
Jim Haglund, University of Pennsylvania (1056-05-1586)

9:30AM (948) *A Pieri rule for skew Schur functiond.*
Sami H Assaf*, MIT, and **Peter R. W. McNamara**, Bucknell University (1056-05-1578)

10:00AM (949) *Some enumerative and order theoretic aspects of the rook monoid.*
Mahir Bilen Can, Tulane University (1056-05-1371)

10:30AM (950) *Partitions, Orthogonal Polynomials and q-Series.* Preliminary report.
George E. Andrews, The Pennsylvania State University (1056-05-475)

AMS Special Session on L-Functions and Analytic Number Theory, I

8:00 AM – 10:50 AM

Organizers: **Alina Bucur**, Institute for Advanced Study
Chantal David, Concordia University
Matilde Lalin, University of Alberta

8:00AM (951) *Recent progress on QUE.*
Soundararajan Kannan, Stanford University (1056-11-1609)

8:30AM (952) *Ranks of Jacobians of modular curves.*
Kaneenika Sinha, PIMS/Alberta (1056-11-666)

9:00AM (953) *Schur polynomials, metaplectic Whittaker functions and the Yang-Baxter equation.*
Daniel W Bump, Stanford (1056-11-1403)

9:30AM (954) *Lennon's work on relations between traces of Frobenius and hypergeometric functions.* Preliminary report.
Ben Brubaker* and **Catherine Lennon**, MIT (1056-11-1463)

10:00AM (955) *Weyl Group Multiple Dirichlet Series.* Preliminary report.
Jennifer Beineke, Western New England College, **Ben Brubaker**, Massachusetts Institute of Technology, and **Sharon Frechette***, College of the Holy Cross (1056-11-802)

10:30AM (956) *Explicit Upper Bounds for L-functions on the critical line.*
Vorrapan Chandee, Stanford University (1056-11-376)

AMS Special Session on Representation Theory and Nonassociative Algebras, II

8:00 AM – 10:50 AM

Organizer: **Andrew Douglas**, City University of New York

8:00AM (957) *On coverings of the smallest Paige loop.*
Stephen M Gagola III, University of Arizona (1056-20-130)

8:30AM (958) *Associative Geometry.*
Michael Kinyon*, University of Denver, and **Wolfgang Bertram**, Institut Élie Cartan Nancy (1056-20-1766)

9:00AM (959) *Enveloping algebras of Malcev algebras.*
Marina Tvalavadze, University of Saskatchewan (1056-17-718)

9:30AM (960) *Equivariant map algebras.*
Erhard Neher, **Alistair Savage***, University of Ottawa, and **Prasad Senesi**, Catholic University of America (1056-17-415)

10:00AM ► (961) *E8 Theory.* Preliminary report.
A Garrett Lisi, Makawao, HI (1056-83-1051)

10:30AM (962) *The Structure of E_6.*
Tevian Dray*, Oregon State University, and **Aaron Wangberg**, Winona State University (1056-17-1224)

AMS Special Session on Arithmetic and Nonarchimedean Dynamics, III

8:00 AM – 9:50 AM

Organizers: **Joseph Silverman**, Brown University
Michelle Manes, University of Hawaii
Raphael Jones, College of the Holy Cross

8:00AM (963) *Dynamics of f(x) = x+1/x via Elliptic Curves.*
Jang-Woo Park* and **Shuhong Gao**, Clemson University (1056-11-1794)

8:30AM (964) *Some fractals associated to $K3$ surfaces.*
Arthur Baragar, University of Nevada Las Vegas (1056-11-1751)

9:00AM (965) *Dynamical Mordell-Lang results via Euclidean uniformizations.*
Thomas Scanlon, University of Californa, Berkeley (1056-12-841)

9:30AM (966) *Galois theory of quadratic rational functions with a non-trivial automorphism.* Preliminary report.
Michelle Manes*, University of Hawaii at Manoa, and **Rafe Jones**, College of the Holy Cross (1056-11-831)

MAA-AMS-MER Invited Paper Session on Mathematics and Education Reform, II: Climate, Sustainability, and the Curriculum

8:00 AM – 10:50 AM

Organizers: **William H. Barker**, Bowdoin College
William G. McCallum, University of Arizona
Bonnie S. Saunders, University of Illinois at Chicago
Mary Lou Zeeman, Bowdoin College

Deborah Hughes Hallett, University of Arizona

8:00AM ► (967) *Climate and Sustainability in the Mathematics Curriculum.* Preliminary report.
Mary Lou Zeeman, Bowdoin College (1056-BC-1444)

8:30AM ► (968) *Climate Change: Impact and Opportunities.*
Deborah Hughes Hallett, University of Arizona, Harvard Kennedy School (1056-BC-1753)

9:00AM (969) *Mathematics Concepts Needed in the Global Systems Science Course.*
Alan D Gould, University of California Berkeley – Lawrence Hall of Science (1056-BC-1266)

9:30AM ► (970) *Introducing Students and Teachers to the Connections Between Science and Mathematics using NASA Space Science Discoveries as a Vehicle for Mathematics Education.*
Sten F Odenwald, Catholic University of America/ADNET/NASA (1056-BC-1251)

10:00AM ► (971) *How Calculus can Participate in Multidisciplinary Sustainability Modules.* Preliminary report.
Thomas J Pfaff*, **Ali S Erkan**, **Jason G Hamilton** and **Michael Rogers**, Ithaca College (1056-BC-1314)

10:30AM Audience discussion about the ideas generated in this session on Climate and Sustainability in the Curriculum.

MAA Invited Paper Session on The Mathematics of Origami

8:00 AM – 10:55 AM

Organizers: **Tamara Veenstra**, University of Redlands
Thomas C. Hull, Western New England College

8:00AM (972) *Paper Folding, Orders of Elements, and Binary Representations of Fractions.*
Tamara B Veenstra, University of Redlands (1056-BF-1225)

8:30AM ► (973) *Combinatorial Methods in Flat Origami.*
Thomas C. Hull, Western New England College (1056-BF-1057)

9:00AM (974) *Mathematical Methods in Origami Design.*
Robert J. Lang, Langorigami.com (1056-BF-1497)

9:30AM ► (975) *Bisections, Trisections and Quintisections by Origami.* Preliminary report.
Roger C. Alperin, San Jose State University (1056-BF-1242)

10:00AM ► (976) *Rigid origami.*
Ileana Streinu, Smith College (1056-BF-1996)

10:30AM (977) *Computational Origami from Science to Sculpture.*
Erik D. Demaine* and **Martin L. Demaine**, Computer Science and Artificial Intelligence Laboratory, Massachusetts Institute of Technology (1056-BF-1946)

AMS Session on Differential and Difference Equations, III

8:00 AM – 10:55 AM

8:00AM (978) *Computation of Green's functions via successive image theory.*
D. Palaniappan, Texas A&M University (1056-35-1783)

8:15AM (979) *Homogenization of The Laplace Equation with Oscillating Stationary Ergodic Free Boundary.* Preliminary report.
Betul Orcan, University of Texas at Austin (1056-35-1793)

8:30AM (980) *Micromirror Method For Catadioptric Sensor Design.*
Emek Kose Can*, Loyola Marymount University, and **Ronald Perline**, Drexel University (1056-35-1828)

8:45AM (981) *Analysis of nonlinear Darcy-Forchheimer flows in porous media.*
Adem Cakmak, Ohio University, Lancaster (1056-35-1845)

9:00AM (982) *Uniqueness of solutions to linear wave equations.* Preliminary report.
Phillip D Whitman, Princeton University (1056-35-1972)

9:15AM ► (983) *Approximating Convection Dominated Diffusion PDEs Using an Adaptively Weighted Least Squares Finite Element Approach.* Preliminary report.
Myles D Baker*, Baylor University and Wabash College, and **Sarah R Farell**, Bard College and Wabash College (1056-35-241)

9:30AM ► (984) *An inverse Sturm-Liouville problem using three spectra.* Preliminary report.
Mihaela Cristina Drignei, Allegheny College (1056-34-330)

9:45AM (985) *On the existence of a double S-shaped bifurcation curve.*
Jerome Goddard II*, Mississippi State University, **EunKyoung Lee**, Pusan National University, and **Ratnasingham Shivaji**, Mississippi State University (1056-34-350)

10:00AM ► (986) *Particular Solution to the Euler-Cauchy Equation: A Novel Approach.* Preliminary report.
Adnan H Sabuwala, California State University, Fresno (1056-34-388)

10:15AM (987) *Analysis of a Truly Nonlinear Oscillator.*
Dorian Wilkerson, Clark Atlanta University (1056-34-420)

10:30AM (988) *First Integrals for Systems via Complex Partial Lagrangians.*
Imran Naeem*, LUMS, Lahore, Pakistan, **Fazal Mahomed**, University of the Witwatersrand, and **R Naz**, IIU, Islamabad (1056-34-425)

10:45AM (989) *Nonautonomous fractional integrodifferential equations with nonlocal initial conditions.*
Haewon Lee* and **Peter Frempong-Mireku**, Dillard University (1056-35-2032)

AMS Session on Biomathematics, III

8:00 AM – 10:55 AM

8:00AM ► (990) *Modeling Stochastic Cardiac Caveolae: a potential source of arrhythmogenic persistent sodium current in cardiomyocytes.*
Ian M. Besse*, **Colleen C. Mitchell**, University of Iowa, **Erwin F. Shibata**, Molecular Physiology and Biophysics, University of Iowa, and **Thomas Hund**, Cardiovascular Medicine, University of Iowa (1056-92-1833)

8:15AM (991) *A Mathematical Model for the MAPK Pathway in Starfish Oocytes.* Preliminary report.
Semen Koksal*, **Ioana Policeanu** and **David Carroll**, Florida Institute of Technology (1056-92-1844)

8:30AM ► (992) *A piecewise-defined two-variable model for cardiac tissue.*
Lisa Driskell, Purdue University (1056-92-1859)

8:45AM (993) *Effect of the Diffusion Coefficient on Noise Sensitivity in the Stochastic Chemostat.*
Suzanne Galayda* and **Ernest Barany**, New Mexico State University (1056-92-1869)

9:00AM (994) *Identifying Effective Age-Based Mammogram Screening Schedules Using a Stochastic Population Model of Breast Cancer.*
Sarah Geneser*, Stanford University, **Stephanie L. Rutledge**, San Diego State University Research Foundation, and **Sylvia K. Plevritis**, Stanford University (1056-92-1899)

9:15AM Break

9:30AM ► (995) *Poisson Approximations for Palindrome Distributions in DNA Viral Genomes.*
Ming-Ying Leung, University of Texas at El Paso (1056-92-1902)

9:45AM (996) *On the Expectation and Variance of the Reversal Distance.*
Yiting Yang*, University of South Carolina, and **Laszlo Szekely**, University of South Carolina (1056-92-2146)

10:00AM (997) *Predicting Flexibility and Motions of Proteins Using Rigidity.*
Adnan Sljoka and **Walter Whiteley***, York University (1056-52-51)

10:15AM (998) *Fibonacci Hexagon and Genetic Tableau.*
Okan Gurel*, IBM, and **Demet Gurel**, Touro College (1056-54-109)

10:30AM (999) *2-D Biharmonic Equation for the Displacement of an Isotropic Kelvin-Voigt Viscoelastic Plate.* Preliminary report.
Robert J Ronkese, United States Military Academy at West Point (1056-74-650)

10:45AM (1000) *Optimal vaccine distribution in a spatiotemporal epidemic model with an application to rabies and raccoons.*
Rachael Miller Neilan*, Louisiana State University, and **Suzanne Lenhart**, NIMBioS, University of Tennessee (1056-93-407)

AMS Session on Difference Equations and Time Scales

8:00 AM – 10:25 AM

8:00AM ► (1001) *Qualitative Behaviour of Dynamic Equations on Time Scales.* Preliminary report.
Allan Peterson* and **Lynn Erbe**, University of Nebraska-Lincoln (1056-39-372)

8:15AM (1002) *Positive solutions of even order periodic boundary value problems.*
Qingkai Kong and **Min Wang***, Northern Illinois University (1056-39-390)

8:30AM (1003) *Modeling of Groundwater Level of a Specified Cut Slope.*
Adam B Baharum, **AlQahtani Hessah***, **Zalila B Ali**, **Habibah B Latih** and **Swee Peng Koay**, Universiti Sains Malaysia (1056-39-398)

8:45AM (1004) *Oscillation and nonoscillation for nonlinear dynamic equations.*
Lynn H. Erbe*, **Allan C. Peterson**, University of Nebraska, Lincoln, and **Baoguo Jia**, Zhongshan University, Guangzhou, China (1056-39-439)

9:00AM (1005) *Some Properties of the Generalized Laplace Transform on Time Scales.*
Chris Ahrendt, University of Nebraska-Lincoln (1056-39-505)

9:15AM Break

9:30AM (1006) *Differential-difference Equations in Entire Functions.*
Vadim Tkachenko, Ben-Gurion University of the Negev, Israel (1056-39-771)

9:45AM (1007) *A model of an SIR disease on time scales.* Preliminary report.
Raegan Higgins, Texas Tech University (1056-39-1322)

10:00AM (1008) *Unitary Operators Associated to Hyperbolic Reflection Groups.* Preliminary report.
Mihai Stoiciu*, Williams College, and **Norbert Peyerimhoff**, Durham University, UK (1056-39-1470)

10:15AM (1009) *Strong Approximation for Markov Modulated Random Sequences with Two-Time Scales.*
Son Luu Nguyen* and **George Gang Yin**, Wayne State University (1056-60-1123)

AMS Session on Approximations

8:00 AM – 10:55 AM

8:00AM (1010) *Linear Dependence of Translates.* Preliminary report.
Ashley N Moses, Saint Louis University (1056-00-318)

8:15AM (1011) *Greedy Approximation with regard to Non-greedy Bases.*
Vladimir Temlyakov, **Mingrui Yang***, University of South Carolina, and **Peixin Ye**, Nankai University (1056-41-331)

8:30AM (1012) *Ratio Boundary Extension for Empirical Mode Decomposition.*
Qin Wu* and **Sherman Riemenschneider**, West Virginia University (1056-41-426)

8:45AM Break

9:00AM (1013) *Extensions of Bernstein's Inequality to Rational Functions.*
Mohammed A. Qazi*, Tuskegee University, and **Q. I. Rahman**, Université de Montréal (1056-41-729)

9:15AM (1014) *Cesáro Summability of Expansions in Orthogonal Polynomials on a Cylinder.*
Jeremy Wade, Pittsburg State University (1056-41-812)

9:30AM Break

9:45AM (1015) *Optimal Learning of Bandlimited Functions from Localized Sampling.*
Charles Micchelli, State University of New York, The University at Albany, **Yuesheng Xu**, Syracuse University, and **Haizhang Zhang***, University of Michigan (1056-41-926)

10:00AM ► (1016) *The second derivatives of the Chebyshev polynomials as M-matrices.* Preliminary report.
Joseph Kolibal, The University of Southern Mississippi (1056-41-962)

10:15AM (1017) *Local Lipschitz Constant for Vector Valued Approximation.* Preliminary report.
Mohammad A AlQudah* and **James R Angelos**, Central Michigan University (1056-41-1310)

10:30AM (1018) *On Even and Odd Variation-Diminishing Convolution Transforms.*
Terence G Hanchin, Kent State University (1056-41-1903)

10:45AM (1019) *Approximation by Bivariate Linear Splines on Triangulations.*
Edmond J. Nadler, Eastern Michigan University (1056-41-2050)

AMS Session on Functional Analysis and Operator Theory, I

8:00 AM – 10:55 AM

8:00AM (1020) *Weak compactness in the space of Operator Valued Measures $M_{ba}(\Sigma, \mathcal{L}(X, Y))$ with an Application.* Preliminary report.
NasirUddin Ahmed, University of Ottawa (1056-46-21)

8:15AM (1021) *A Generalized Ston-Wierstrass theorem for Cz-vector lattices and Cz-algebras.* Preliminary report.
Hueytzen J Wu*, Texas A&M University - Kingsville, and **Wan-Hong Wu**, UT Health Science Center - San Antonio (1056-46-258)

8:30AM (1022) *Path-connectedness of the space of norm-attaining functionals on certain Banach spaces.*
Antonia E Cardwell, Millersville University of Pennsylvania (1056-46-726)

8:45AM (1023) *Dominated Ergodic Theorem for isometries of non-commutative L_p-spaces, $1<p<\infty$.* Preliminary report.
Shukhrat M Usmanov, Ashford University (1056-46-924)

► 9:00AM (1024) *Aperiodicity in Topological k-Graphs.* Preliminary report.
Sarah E. Wright, Dartmouth College (1056-47-217)

9:15AM (1025) *On real, Jordan and Lie structures in locally W*-algebras.*
Alexander A. Katz, St. John's University, NY, **Roman Kushnir** and **Mark Ustayev***, University of South Africa, Pretoria, South Africa (1056-46-1032)

9:30AM (1026) *Crossed product C*-algebras by finite group actions with the projection free tracial Rokhlin property.*
Dawn Archey, Ben Gurion University (1056-46-1211)

9:45AM (1027) *Continuous Dependence Results for Ill-posed Evolution Problems in a Banach Space.*
Matthew A. Fury, Bryn Mawr College (1056-46-1261)

10:00AM (1028) *Operator spaces with an ideal structure.*
Sonia Sharma, University of Houston (1056-46-1291)

10:15AM (1029) *Exponential integrability: a unified approach.*
Carlo Morpurgo*, University of Missouri, Columbia, and **Luigi Fontana**, Universita' di Milano - Bicocca, Italy (1056-46-1302)

10:30AM (1030) *On a reduction method for nonassociative L_p-spaces.*
Genady Ya. Grabarnik, York College, CUNY, **Alexander A. Katz***, St. John's University, and **Laura Shwartz**, IBM T. J. Watson Research Center, Hawthorne, NY (1056-46-1552)

10:45AM (1031) *Traces of operator derivatives.* Preliminary report.
Anna Skripka, Texas A&M University (1056-47-110)

AMS Session on Algebraic Geometry

8:00 AM – 10:40 AM

8:00AM (1032) *The Converse of Abel's theorem ('polynomial' and 'rational').* Preliminary report.
Veniamin Kisunko, University of Toronto (1056-14-57)

8:15AM (1033) *The geometry of multipartite quantum systems.*
Carl A. Miller* and **Eric Chitambar**, University of Michigan, Ann Arbor (1056-14-153)

8:30AM (1034) *Rational Fibrations of $\overline{M}_{g,1}$.*
David Jensen, University of Texas (1056-14-447)

8:45AM (1035) *Space Curve Singularities and the Semple Tower.* Preliminary report.
Alex L Castro*, **Richard Montgomery**, UCSC, and **Michail Zhitomirskii**, Technion - Haifa - IL (1056-14-624)

9:00AM (1036) *GIT Compactification of the Quintic Threefolds.*
Chirag M Lakhani, North Carolina State University (1056-14-971)

9:15AM Break

9:30AM (1037) *The Laplace transform of the cut-and-join equation and the Bouchard-Marino conjecture on Hurwitz numbers.*
Bertrand Eynard, Service de Physique Theorique de Saclay, **Motohico Mulase**, University of California, Davis, and **Brad Safnuk***, Central Michigan University (1056-14-1317)

9:45AM (1038) *Tensor Product of Picard Stacks.*
Ahmet Emin Tatar, Florida State University (1056-14-1473)

10:00AM (1039) *Algebraic cycles and degenerations for a class of surfaces of general type.*
Christopher Lyons, California Institute of Technology (1056-14-1933)

10:15AM ► (1040) *Representations of polynomials non-negative on non-compact subsets of $\mathbb{R}^2$.*
Ha N Nguyen* and **Victoria Powers**, Emory University (1056-12-688)

10:30AM (1041) *Fan Cohomology and Equivariant Chow Rings of Toric Varieties.*
Mu-wan Huang, Southwest Minnesota State University (1056-19-1689)

MAA Session on Undergraduate Mathematical Biology, I

8:00 AM – 10:55 AM

Organizers: **Timothy D. Comar**, Benedictine University
Raina S. Robeva, Sweet Briar College

8:00AM (1042) *Interdisciplinary curricular innovations at the University of the Virgin Islands.*
Robert C Stolz and **Camille A. McKayle***, University of the Virgin Islands (1056-Q5-1676)

8:20AM (1043) *Developing Computational Skills in Biocalculus Courses.* Preliminary report.
Timothy Comar, Benedictine University (1056-Q5-459)

8:40AM ► (1044) *The Growth of Interdisciplinary Math-Biology Courses at James Madison University.* Preliminary report.
D. Brian Walton*, **Anthony Tongen**, **Nusrat Jahan** and **Reid Harris**, James Madison University (1056-Q5-1755)

9:00AM ► (1045) *Introductory Mathematical Biology through Finite Dynamical Systems.*
Raina S Robeva*, Sweet Briar College, and **Terrell Hodge**, Western Michigan University (1056-Q5-1402)

9:20AM ► (1046) *Research in Mathematical Biology at UNCG.*
Jan Rychtar, The University of North Carolina at Greensboro (1056-Q5-1777)

9:40AM ► (1047) *UBM Research and Training Activities in BioMath.* Preliminary report.
Semen Koksal, Florida Institute of Technology (1056-Q5-1969)

10:00AM ► (1048) *Bio-Surveillance in Undergraduate Mathematics Classroom.* Preliminary report.
Urmi Ghosh-Dastidar, New York City College of Technology, CUNY (1056-Q5-2023)

10:20AM ► (1049) *Mathematical Biology and Undergraduate Research (MBUR) at Youngstown State University.*
George T Yates, Youngstown State University (1056-Q5-1882)

10:40AM ► (1050) *Viscoelastic Effects in Biological Soft Tissues.*
S. Minerva Venuti* and **Padmanabhan Seshaiyer**, George Mason University (1056-Q5-1530)

MAA Session on General Contributed Papers, VII

8:00 AM – 10:55 AM

Organizers: **Eric S. Marland**, Appalachian State University
Daniel J. Curtin, Northern Kentucky University

8:00AM ► (1051) *The Role of Permutatation Matrices in Magic Squares.* Preliminary report.
Peter Staab* and **Michael Andrade**, Fitchburg State College (1056-Z1-874)

8:15AM ► (1052) *Rolling Archimedean Dice.*
Dylan W Helliwell*, Seattle University, and **Peter Littig**, University of Washington, Bothell (1056-Z1-2039)

8:30AM ► (1053) *Chess, Church, and Knots: Statistics Through Service and Research.*
Neil Nicholson, William Jewell College (1056-Z1-102)

8:45AM ► (1054) *Making Sense of Sampling Distributions: Activities for an Introductory Statistics Course.* Preliminary report.
Kate G McGivney, Shippensburg University (1056-Z1-1697)

9:00AM ► (1055) *Some Results, Problems and Conjectures On Generalized Markoff Numbers.*
Shanzhen Gao, Florida Atlantic University (1056-Z1-689)

9:15AM (1056) *Effect of noise in Canonical Correlation Analysis with application to Ozone Pollution.*
Katerina G. Tsakiri* and **Igor G. Zurbenko**, State University of New York at Albany (1056-Z1-683)

9:30AM ► (1057) *Set Difference and Jump Sequences.*
Chelsea Cerini*, **Sommer Sprowls** and **Roman Wong**, Washington & Jefferson College (1056-Z1-484)

9:45AM ► (1058) *The Mystery of the M&m Sequences.*
Sommer L Sprowls*, **Chelsea Cerini** and **Roman Wong**, Washington & Jefferson College (1056-Z1-483)

10:00AM ► (1059) *What a higher q-skew τ-derivation can do for you.*
Heidi A. Haynal, Walla Walla University (1056-Z1-294)

10:15AM (1060) *Likelihood Inference for Nonlinear Regression Models.*
Harshini Fernando, Purdue University North Central (1056-Z1-791)

10:30AM (1061) *Trilinable Points of Curves.*
Michael S McClendon* and **Charles L Cooper**, University of Central Oklahoma (1056-Z1-2088)

10:45AM ► (1062) *Level curves of the angle function of a positive definite symmetric matrix.*
Neeraj Bajracharya, University of North Texas (1056-Z1-609)

MAA Session on Mathematics, Equity, Diversity, and Social Justice, II

8:00 AM – 10:50 AM

Organizers: **Patricia Hale**, California State Polytechnic University Pomona
Shandy Hauk, University of Northern Colorado
Dave Kung, St. Mary's College, Maryland

8:00AM (1063) *The history, impact, and current efforts of Emerging Scholars Programs.*
Natasha M Speer, University of Maine (1056-H7-1930)

8:30AM ► (1064) *Challenging Eurocentric Mathematics History to Encourage Understanding of Cultural Diversity in Mathematics Classrooms.*
Elizabeth C Rogers, Piedmont College (1056-H7-2127)

9:00AM ► (1065) *Increasing the Participation of Girls in Mathematics and other STEM Fields in Higher Education.*
Tina Alves Mancuso* and **Deborah Lawrence**, The Sage Colleges (1056-H7-1608)

9:30AM ► (1066) *From research to mathematics curriculum development: Social Justice for African Americans in Chester Heights.*
Julius Davis, University of Maryland, College Park (1056-H7-1518)

10:00AM ► (1067) *Algebra Project Curricula – Mathematics meaning through experience and dialogue.* Preliminary report.
David W. Henderson*, Cornell University, and **Kelly Gaddis**, Bard College (1056-H7-1908)

10:30AM ► (1068) *The Algebra Project: Building Math Literacy.*
Marcus Hung, San Francisco Unified School District (1056-H7-406)

MAA Session on Mathematics Courses for the Liberal Arts Students, III

8:00 AM – 10:55 AM

Organizer: **Reva Kasman**, Salem State College

8:00AM ► (1069) *Mathematics and General Education: Exposing Students to Mathematics and its Tools in the 21st Century.* Preliminary report.
Manuel J. Sanders, University of South Carolina Beaufort (1056-J1-1668)

8:20AM (1070) *Designing a "Math for Liberal Studies" Course.*
James E. Hamblin, Shippensburg University (1056-J1-870)

8:40AM ► (1071) *Including Presentations as a Component in a Liberal Arts Math History Course.*
Sean D Simpson, Westchester Community College (1056-J1-747)

9:00AM ► (1072) *Great Ideas of Modern Mathematics: An Approach to a Rigorous Mathematics Course for the Liberal Arts Student.* Preliminary report.
Robert A. Blumenthal, Georgia College & State University (1056-J1-95)

9:20AM ► (1073) *Teaching the Nature of Applied Mathematics.* Preliminary report.
G. Edgar Parker, James Madison University (1056-J1-458)

9:40AM ► (1074) *Evolution of the Mathematical Sampler.*
Jeffery Thomas McLean, University of St. Thomas (1056-J1-855)

10:00AM (1075) *Teaching Quantitative Reasoning with the News.* Preliminary report. **Stuart Boersma***, Central Washington University, **Caren L Diefenderfer**, Hollins University, **Shannon W Dingman** and **Bernard L Madison**, University of Arkansas (1056-J1-508)

10:20AM (1076) *Projects & Portfolios Motivate Most.* **Rich West**, Francis Marion University (1056-J1-1769)

10:40AM (1077) *Reaching the Unreachable: Pulling Students Kicking and Screaming into a Mathematical Vortex Where They Transform to Develop Mathematical Eyes through Innovative Approaches and Activities.* **Deborah L. Gochenaur**, Shippensburg University (1056-J1-1974)

MAA Session on Quantitative Reasoning and the Environment

8:00 AM – 10:55 AM

Organizers: **Maura B. Mast**, University of Massachusetts Boston
Karen D. Bolinger, Clarion University
Cinnamon Hillyard, University of Washington Bothell

8:00AM (1078) *An Across-the-Curriculum Approach to Quantitative Literacy in Environmental Studies.* **Ben Steele***, **Semra Kilic-Bahi**, **Nick Baer**, **Leon Malan**, **Laura Alexander** and **Harvey Pine**, Colby-Sawyer College (1056-P1-1639)

8:20AM (1079) *Water, Water, Everywhere—Even in Statistics.* **John C. Nardo*** and **Judith Lynn Gieger**, Oglethorpe University (1056-P1-1948)

8:40AM (1080) *Raising Awareness of Environmental Issues in Statistics Course.* Preliminary report. **Thomas J Pfaff**, Ithaca College (1056-P1-1610)

9:00AM (1081) *Sustainability as a Focus for an Introductory Calculus Course.* **Michael Olinick**, Middlebury College (1056-P1-1093)

9:20AM (1082) *Could i-Tree Software Have Helped the Lorax?* **Jan O. Case*** and **Scott W. Beckett**, Jacksonville State University (1056-P1-1312)

9:40AM (1083) *The Environment, Mathematics and Our Community Role.* **Ben Fusaro**, Florida State University (1056-P1-1997)

10:00AM (1084) *Using QL Modules to Analyze and Present Large Data Sets in a Winter Ecology Course.* Preliminary report. **Judith Moran**, Trinity College (1056-P1-1276)

10:20AM (1085) *Modeling Radon in Pennsylvania.* Preliminary report. **Michael Huber**, Muhlenberg College (1056-P1-276)

10:40AM (1086) *Necessary Environmental Numeracy for a Successful Society.* Preliminary report. **Martin E. Walter**, University of Colorado, Boulder (1056-P1-847)

SIAM Minisymposium on Graph Theory, I

8:00 AM – 10:55 AM

Organizers: **Andre Kundgen**, California State University San Marcos
Hal Kierstead, Arizona State University

8:00AM (1087) *The thickness and chromatic number of r-inflated graphs.* **Michael Albertson**, Smith College, **Debra Boutin***, Hamilton College, and **Ellen Gethner**, University of Colorado Denver (1056-05-1063)

8:30AM (1088) *The Canonical Coloring Graph.* **Ruth Haas**, Smith College (1056-05-963)

9:00AM (1089) *Distinguishing with Mike Albertson.* **Karen L. Collins**, Wesleyan University (1056-05-1245)

9:30AM (1090) *Looking for a new proof of the Four Color Theorem.* Preliminary report. **Walter Stromquist**, Swarthmore College (1056-05-1551)

10:00AM (1091) *Finding minors in graphs with a given path structure.* **Radhika Ramamurthi***, **Andre Kundgen**, California State University San Marcos, and **Michael Pelsmajer**, Illinois Institute of Technology (1056-05-2048)

10:30AM (1092) *Maximum Induced Forests in Graphs of Bounded Treewidth.* **Glenn G Chappell**, Department of Computer Science, University of Alaska Fairbanks, and **Michael J. Pelsmajer***, Illinois Institute of Technology (1056-05-1715)

PME Council Meeting

8:00 AM – 11:00 AM

Employment Center

8:00 AM – 7:00 PM

AMS Session on History of Mathematics

8:15 AM – 10:55 AM

8:15AM (1093) *Ancient Numeral System And The Great Pyramid.* Preliminary report. **Ricie Dimatatac Bulanhagui**, Alalum, San Pascual, Batangas (1056-01-399)

8:30AM (1094) *French and English Influences On Early American Mathematics.* **Andrew B Perry**, Springfield College (1056-01-692)

8:45AM (1095) *Nasir-aldin Tusi: A True Scholar in Many Disciplines.* Preliminary report. **Mohammad Moazzam**, Salisbury University (1056-01-937)

9:00AM (1096) *Benjamin Gompertz: Pioneer of Actuarial Science.* Preliminary report. **Charlotte K. Simmons*** and **Jesse W. Byrne**, University of Central Oklahoma (1056-01-1027)

9:15AM Break

9:30AM (1097) *Max Dehn.* **David Peifer**, UNC Asheville (1056-01-1042)

9:45AM (1098) *Teaching Mathematics at the 19th century Virginia Military Institute.* Preliminary report. **Maryam Vulis**, USMA Prep School (1056-01-1734)

10:00AM (1099) *On Avicenna's Arithmetic.* **Mahmoud H Annaby**, Qatar University (1056-01-1860)

10:15AM (1100) *Euler's work on the prime divisors of numbers of the form* $mx^2 + ny^2$. **Paul R Bialek***, Trinity International University, and **Dominic W Klyve**, Carthage College (1056-11-1819)

10:30AM (1101) *Origin and Extensions of the Secant Method and Characterizations of the BFGS Secant Method.* Preliminary report. **Joanna M. Papakonstantinou**, Rice University (1056-49-673)

10:45AM ► (1102) *Algebraic cryptology from an historical viewpoint.* Preliminary report.
Chris Christensen, Northern Kentucky University (1056-01-1790)

AMS Session on Discrete Mathematics, IV

8:15 AM – 10:40 AM

8:15AM ► (1103) *Ramsey Core Numbers.* Preliminary report.
Allan Edward Bickle, Western Michigan University (1056-05-1273)

8:30AM ► (1104) *On the enumeration of the cyclically fully commutative elements in Coxeter groups.*
Tom Boothby, University of Washington, **Jeffrey Burkert***, Harvey Mudd College, **Morgan Eichwald**, University of Montana, **Dana C. Ernst**, Plymouth State University, **Richard M. Green**, University of Colorado at Boulder, and **Matthew Macauley**, Clemson University (1056-05-1861)

8:45AM (1105) *On the cyclically fully commutative elements of Coxeter groups.*
Tom Boothby, University of Washington, **Jeffrey Burkert**, Harvey Mudd, **Morgan Eichwald**, University of Montana, **Dana C. Ernst***, Plymouth State University, **Richard M. Green**, University of Colorado at Boulder, and **Matthew Macauley**, Clemson University (1056-05-1831)

9:00AM ► (1106) *An explicit derivation of the Möbius function for Bruhat order.*
Brant C. Jones, University of California, Davis (1056-05-914)

9:15AM Break

9:30AM ► (1107) *Projections of Ocneanu traces are Kazhdan-Lusztig R-polynomials.*
W. Andrew Pruett, Baylor University (1056-05-476)

9:45AM (1108) *Symmetric Permutations with No Long Decreasing Subsequences.*
Eric S Egge, Carleton College (1056-05-249)

10:00AM ► (1109) *Fragility in Matroids.* Preliminary report.
Carolyn B. Chun*, **Dillon Mayhew**, Victoria University, **Stefan van Zwam**, University of Waterloo, and **Geoff Whittle**, Victoria University (1056-05-1494)

10:15AM ► (1110) *Edge Coverings of Bipartite Graphs and the Geometry of the Hausdorff Metric.*
Steven Schlicker*, Grand Valley State University, and **Katrina Honigs**, University of California, Berkeley (1056-51-116)

10:30AM (1111) *Hypergraphic subspace arrangements.*
Matthew S. Miller*, Bucknell University, and **Max Wakefield**, United States Naval Academy (1056-55-289)

AMS Special Session on Interactions of Inverse Problems, Signal Processing, and Imaging, II

8:30 AM – 10:50 AM

Organizer: **M. Zuhair Nashed**, University of Central Florida

8:30AM ► (1112) *A Perturbed Whittaker-Kotel'nikov-Shannon Sampling theorem.*
Mahmoud H Annaby*, Qatar University, **Hassan A Hassan**, Cairo University, and **Omar H El-Haddad**, Beni Suef University (1056-94-1840)

9:00AM (1113) *Convergence and Rate of Approximation for Generalized Sampling-type Operators in Orlicz Spaces.*
Laura Angeloni, Università degli Studi di Perugia (1056-41-1726)

9:30AM (1114) *Non-uniform sampling expansions and local reconstruction on subspaces of $L_2(R)$.*
Nikolaos Dimitrios Atreas, Aristotle University of Thessaloniki, Polytechnic School (1056-94-1137)

10:00AM (1115) *Color Image Restoration Using Nonlocal Mumford-Shah Regularizers.*
Miyoun Jung, **Xavier Bresson**, UCLA, **Tony F Chan**, NSF and UCLA, and **Luminita A. Vese***, UCLA (1056-35-1136)

10:30AM (1116) *Approximation Theory in Signal and Image Processing. Applications to Endovascular Surgery.*
Gianluca Vinti, University of Perugia (1056-94-1602)

AMS-MAA Graduate Student Fair

8:30 AM – 10:30 AM

Undergrads! Take this opportunity to meet representatives from mathematical sciences graduate programs.

MAA Session on Online Homework—Innovation and Assessment, II

8:40 AM – 10:55 AM

Organizers: **Michael E. Gage**, University of Rochester
Arnold K. Pizer, University of Rochester
Vicki Roth, University of Rochester

8:40AM (1117) *Assessing the Impact on Student Learning and Behavior in a First Applied Statistics Course by Innovative Use of Three Delivery Types Including Online Homework: Experimental Design and Implementation.*
William H Rybolt* and **John D McKenzie**, Babson College (1056-M1-975)

9:00AM (1118) *Assessing the Impact on Student Learning and Behavior in a First Applied Statistics Course by Innovative Use of Three Delivery Types Including Online Homework: Initial Results.*
John D McKenzie* and **William H Rybolt**, Babson College (1056-M1-976)

9:20AM ► (1119) *Using Multiple Technologies to Engage Students in Math Learning.* Preliminary report.
Gerald Agbegha* and **Nailong Guo**, Johnson C. Smith University (1056-M1-1843)

9:40AM ► (1120) *Online Assessment of Homework in College Algebra and Math Concepts For Teachers Courses.*
A. S. Elkhader, Northern State University (1056-M1-1571)

10:00AM (1121) *Using WebAssign for Uniform Assessment in Precalculus, 1300 Students at a Time.*
Lisa Townsley* and **Edward Azoff**, University of Georgia (1056-M1-1066)

10:20AM ► (1122) *MathNerds and Webwork: a free, supervised tutoring system for online homework.* Preliminary report.
W. Ted Mahavier*, Lamar University & MathNerds, **Valerio De Angelis**, Xavier University of Louisiana & MathNerds, and **Kyehong Kang**, Lamar University (1056-M1-1141)

10:40AM ► (1123) *Using Public Domain Software for Online Homework and Tutorials at the University of Puerto Rico.*
Daniel L McGee* and **J Maider Marin**, University of Puerto Rico - Mayaguez (1056-M1-1542)

MAA Invited Address

9:00 AM – 9:50 AM

► (1124) *Motion Planning and Graph Layout: at the Crossroads of Geometry, Discrete Mathematics, and Algorithm Design.* Preliminary report.
Sue Whitesides, University of Victoria (1056-A0-11)

ASL Invited Address

9:00 AM – 9:50 AM

(1125) *Expansions of o-minimal structures by trajectories of definable vector fields.*
Chris Miller, Ohio State University (1056-03-72)

MAA Minicourse #13: Part B

9:00 AM – 11:00 AM

Taking symbols seriously: Teaching form and function in college algebra.
Organizers: **William G. McCallum**, University of Arizona
Deborah Hughes Hallett, University of Arizona and Harvard University
Pat Shure, University of Michigan

MAA Minicourse #4: Part B

9:00 AM – 11:00 AM

Using video-case studies in teaching a proof-based gateway course to the mathematics major.
Organizers: **James T. Sandefur**, Georgetown University
Connie M. Campbell, Millsaps College
Kay B. Somers, Moravian College

MAA Minicourse #7: Part B

9:00 AM – 11:00 AM

Teaching with clickers in the classroom.
Organizers: **Derek Bruff**, Vanderbilt University
Adam Lucas, Saint Mary's College of California

Student Hospitality Center

9:00 AM – 5:00 PM

MAA-Young Mathematicians' Network Panel Discussion

9:00 AM – 10:20 AM

Promotion and tenure: You know you want it.
Organizers: **Barry A. Balof**, Whitman College
Joshua D. Laison, Willamette College
Panelists: **Jason D. Rosenhouse**, James Madison University
Francis E. Su, Harvey Mudd College
Matthew P. Richey, St. Olaf College
Jacqueline A. Jensen, Sam Houston State University

AMS Special Presentation

9:30 AM – 11:00 AM

A conversation on nonacademic employment.
Moderator: **James G. Glimm**, SUNY at Stony Brook

Exhibits and Book Sales

9:30 AM – 5:00 PM

ASL Invited Address

10:00 AM – 10:50 AM

(1126) *Ramsey theory for finite structures.*
Slawomir J. Solecki, University of Illinois at Urbana-Champaign (1056-03-74)

AMS Special Session on Use of Technology in Modern Complex Analysis Research, II

10:00 AM – 10:50 AM

Organizers: **Beth Schaubroeck**, U.S. Air Force Academy
Michael Dorff, Brigham Young University
James Rolf, U.S. Air Force Academy

10:00AM ► (1127) *An Introduction to Metacalibration and its Application to Multiple Bubble Problems.*
Donald C. Sampson, **Rebecca Dorff*** and **James P Dilts**, Brigham Young University (1056-49-468)

10:30AM ► (1128) *Convex Combinations of Harmonic Mappings to Regular Polygons.*
Jessica A Spicer*, University of Arkansas, and **Samuel J Ferguson**, University of North Carolina (1056-43-1347)

AMS Invited Address

10:05 AM – 10:55 AM

(1129) *Zonotopal algebra, analysis, and combinatorics.*
Olga Holtz*, University of California-Berkeley, Technische Universitaet Berlin, Institute for Advanced Study, and **Amos Ron**, University of Wisconsin-Madison (1056-13-6)

AMS-MAA Invited Address

11:10 AM – NOON

(1130) *Evolving curves and surfaces.*
Brian White, Stanford University (1056-51-42)

MAA Poster Session on Research by Undergraduate Students

NOON – 1:00 PM

Students must set up their posters during this hour.

AMS Colloquium Lectures: Lecture III

1:00 PM – 2:00 PM

(1131) *Reduced decompositions.*
Richard P. Stanley, M.I.T. (1056-05-18)

MAA Lecture for Students

1:00 PM – 1:50 PM

► (1132) *How math made modern music ~~mad~~ Irrational!*
David T. Kung, Saint Mary's College of Maryland (1056-A0-15)

AMS Current Events Bulletin

1:00 PM – 4:45 PM

1:00PM (1133) *Approximate groups and their applications: work of Bourgain, Gamburd, Helfgott and Sarnak.*
Ben J Green, University of Cambridge, UK (1056-11-1569)

2:00PM (1134) *Multivariate stable polynomials: theory and applications.*
David G. Wagner, University of Waterloo (1056-32-2100)

3:00PM (1135) *The conformal geometry of billiards.*
Laura DeMarco, University of Illinois at Chicago (1056-37-1737)

4:00PM (1136) *On the Kervaire Invariant Problem.*
Michael Hopkins, Harvard University (1056-55-1879)

AMS-MAA-SIAM Special Session on Research in Mathematics by Undergraduates, II

1:00 PM – 5:20 PM

Organizers: **Darren Narayan**, Rochester Institute of Technology
Bernard Brooks, Rochester Institute of Technology
Jacqueline Jensen, Sam Houston State University
Carl V. Lutzer, Rochester Institute of Technology
Vadim Ponomarenko, San Diego State University
Tamas Wiandt, Rochester Institute of Technology

1:00PM ► (1137) *Analyzing Hyperspectral Images.*
Brian Allen*, Messiah College, and **Kristen Bretney**, Loyola Marymount University (1056-94-145)

1:30PM ► (1138) *Coexistence of Stable ECM Solutions in the Lang-Kobayashi System.*
Ericka Mochan*, Western New England College, and **C. Davis Buenger**, Rice University (1056-34-144)

2:00PM ► (1139) *Greedy Algorithms for Generalized k-rankings of graphs.*
Sandra James*, Concordia University - St. Paul, and **Andrew Zemke**, Rochester Institute of Technology (1056-05-142)

2:30PM ► (1140) *Finding Ramsey Numbers.*
Kevin Black*, Harvey Mudd College, and **Daniel Leven**, Rutgers Unviersity (1056-05-143)

3:00PM (1141) *Mathematics Models of Mancala.*
Reginald Ford*, **M. Vergara**, **J. C. Ortega**, **D. Melendez** and **Z. Pena**, James Madison University (1056-91-2094)

3:30PM ► (1142) *Comparison of Homogenous cyclic expressions.*
B. Sriram, Indian Institute of Technology, Kanpur (1056-08-26)

4:00PM ► (1143) *The Strong Symmetric Genus of Small D-type Generalized Symmetric Groups.* Preliminary report.
Michelle Bowser*, **Trevor Partridge** and **Kirsten Rodgers**, Grove City College (1056-20-77)

4:30PM (1144) *The Energy of Graphs and Matrices.*
Duy D Nguyen*, Texas Christian University, **Katelyn L McCall**, University of Rochester, **Laura J Buggy**, College of St. Benedict, **Amalia V Culiuc**, Mount Holyoke College, and **Sivaram K Narayan**, Central Michigan University (1056-15-78)

5:00PM ► (1145) *Subgraph Summability Number.* Preliminary report.
Kassandra A Johnston*, University of New Mexico, **Philip R Zerull**, **Sivaram K Narayan** and **Jordan D Webster**, Central Michigan University (1056-05-79)

AMS-MAA Special Session on History of Mathematics, I

1:00 PM – 6:20 PM

Organizers: **Craig Fraser**, University of Toronto
Deborah Kent, Hillsdale College
Sloan Despeaux, Western Carolina University

1:00PM ► (1146) *The Mathematics of the Antikythera Mechanism.*
James Evans, University of Puget Sound (1056-01-929)

1:30PM ► (1147) *The various "Indian rules" in medieval and early modern Western mathematics.* Preliminary report.
Kim Plofker, Union College (1056-01-1189)

2:00PM (1148) *Descartes, Van Schooten, and algebraic extensions of fields.*
Michel Pierre Serfati, Université Paris VII/ Denis Diderot (1056-01-56)

2:30PM (1149) *Curvature and symmetry in Newton's early computations of orbital dynamics.*
Michael Nauenberg, UCSC (1056-01-1560)

3:00PM ► (1150) *Johann Bernoulli's lost lecture on differential calculus and its sequels.*
Ruediger Thiele, Hall, Germany (1056-01-1572)

3:30PM ► (1151) *From cascades to calculus: episodes in the history of Rolle's theorem.*
June Barrow-Green, The Open University, Milton Keynes, UK (1056-01-273)

4:00PM (1152) *D company: the rise and fall of differential operator theory in Britain, 1810s-1870s.*
Ivor O. Grattan-Guinness, Middlesex University, UK (1056-01-1877)

4:30PM ► (1153) *Pasch and Klein on intuition and proofs.*
Dirk Schlimm, McGill University (1056-01-1156)

5:00PM ► (1154) *Why was Wantzel Overlooked for a Century? The Changing Importance of an Impossibility Result.*
Jesper Lützen, University of Copenhagen (1056-01-808)

5:30PM (1155) *From idea to mathematical object: Herman Minkowski's introduction of general convex sets.*
Tinne Hoff Kjeldsen, IMFUFA, Roskilde University (1056-01-304)

6:00PM (1156) *Building a Nation: The Evolution of a Mathematical Research Community from the Italian States to the Kingdom of Italy.*
Laura Martini, Siena, Italy (1056-01-1331)

AMS-AWM Special Session on Spectral Problems on Compact Riemannian Manifolds, II

1:00 PM – 5:50 PM

Organizers: **Carolyn Gordon**, Dartmouth College
Ruth Gornet, University of Texas at Arlington
Craig Sutton, Dartmouth College

1:00PM (1157) *Inverse scattering results for manifolds hyperbolic at infinity.*
David Borthwick, Emory University, and **Peter A. Perry***, University of Kentucky (1056-58-1112)

1:30PM (1158) *The genus spectrum of a hyperbolic 3-manifold.*
D. B. McReynolds*, University of Chicago, and **Alan W. Reid**, University of Texas in Austin (1056-53-1227)

2:00PM (1159) *Length-spectral rigidity for flat metrics.*
Moon Duchin*, University of Michigan, **Christopher J Leininger**, University of Illinois, and **Kasra Rafi**, University of Oklahoma (1056-51-1425)

2:30PM (1160) *The Cut-off Covering Spectrum.*
Christina Sormani, CUNY Graduate Center and Lehman College, and **Guofang Wei***, UC Santa Barbara (1056-53-529)

3:00PM (1161) *Spectral problems for polygons.*
Julie Rowlett, Hausdorff Center for Mathematics (1056-58-869)

3:30PM Break

4:00PM (1162) *Eigenvalues and Isoperimetric Inequalities.*
Jesse Ratzkin, University College Cork (1056-35-283)

4:30PM (1163) *Hearing Delzant polygons from the equivariant spectrum.*
Emily B. Dryden*, Bucknell University, **Victor Guillemin**, Massachusetts Institute of Technology, and **Rosa Sena-Dias**, Instituto Superior Técnico, Lisbon (1056-58-1299)

5:00PM (1164) *The fundamental domain of Random Riemann surfaces.*
Eran Makover* and **Jeff McGowan**, Central Connecticut State University (1056-58-527)

5:30PM (1165) *The fundamental domain of Random Riemann surfaces.*
Jeffrey McGowan* and **Eran Makover**, Central Connecticut State University (1056-58-525)

AMS Special Session on Commutative Algebra, II

1:00 PM – 5:50 PM

Organizers: **Susan Cooper**, University of Nebraska-Lincoln
Graham Leuschke, Syracuse University
Sean M. Sather-Wagstaff, North Dakota State University

1:00PM (1166) *Ascent and descent modulo exact zero divisors.* Preliminary report.
Luchezar L. Avramov, **Inês Bonacho dos Anjos Henriques***, University of Nebraska-Lincoln, and **Liana M. Sega**, University of Missouri, Kansas City (1056-13-1604)

1:30PM (1167) *Vanishing of Tor over complete intersections.*
Olgur Celikbas, University of Nebraska, Lincoln (1056-13-901)

2:00PM (1168) *Infinite Cohen-Macaulay posets and non-Noetherian Stanley-Reisner rings.*
Erin Chamberlain, Brigham Young University (1056-13-813)

2:30PM (1169) *The rank of a hypergeometric system.*
Christine Berkesch, Purdue University (1056-14-944)

3:00PM (1170) *Asymptotic behavior of value semi-groups.*
S. D. Cutkosky, **K. Dalili***, University of Missouri - Columbia, and **O. Kashcheyeva**, University of Illinois at Chicago (1056-13-2019)

3:30PM (1171) *A New Elementwise Criterion for Weak Subintegrality.*
Marie A Vitulli, University of Oregon (1056-13-1581)

4:00PM Discussion

4:30PM (1172) *Modules over one-dimensional local rings of infinite Cohen-Macaulay type.* Preliminary report.
Silvia Saccon, University of Nebraska-Lincoln (1056-13-621)

5:00PM (1173) *Local rings and high syzygies.* Preliminary report.
Hamid Rahmati*, Texas Tech university, and **Janet Striuli**, Fairfield University (1056-13-2028)

5:30PM (1174) *Constructing Algebras from Witt vectors.*
Paul C Roberts, University of Utah (1056-13-800)

AMS Special Session on Enumerative Combinatorics, II

1:00 PM – 5:50 PM

Organizers: **Brian Miceli**, Trinity University
Jeff Remmel, University of California San Diego

1:00PM (1175) *Major Index for 01-Fillings of Moon Polyominoes.*
William Chen, Center for Combinatorics, Nankai University, **Svetlana Poznanović***, **Catherine Yan**, Texas A&M University, and **Arthur Yang**, Center for Combinatorics, Nankai University (1056-05-1212)

1:30PM ► (1176) *Matrix Bijections.*
Anthony A. Mendes, California Polytechnic State University, San Luis Obispo (1056-05-166)

2:00PM ► (1177) *Probabilistic proofs of hook length formulas involving trees.*
Bruce E Sagan, Michigan State U. and NSF (1056-05-519)

2:30PM (1178) *Invariants, Kronecker products and combinatorics of some remarkable diophantine systems.*
Adriano Garsia, UC, San Diego (1056-05-1881)

3:00PM (1179) *Enumerating (2+2)-free posets by the number of minimal elements and other statistics.*
Sergey Kitaev, Reykjavik University (1056-05-473)

3:30PM ► (1180) *The distributions of k-drops and k-excedences in permutations.*
Jeffrey E Liese, California Polytechnic State University, San Luis Obispo (1056-05-949)

4:00PM (1181) *Wilf equivalence for generalized factor order modulo k.*
Thomas Langley*, Rose-Hulman Institute of Technology, **Jeffrey Liese**, California Polytechnic State University, San Luis Obispo, and **Jeffrey Remmel**, University of California, San Diego (1056-05-1275)

4:30PM (1182) *A hierarchy of generalized pattern avoidance and $\beta(0,1)$-trees.*
Einar Steingrimsson, Reykjavik University (1056-05-1886)

5:00PM ► (1183) *Avoiding Colored Partitions.* Preliminary report.
Adam Goyt, Minnesota State University, and **Lara Pudwell***, Valparaiso University (1056-05-1359)

5:30PM ► (1184) *A Continuum of Partition Statistics.*
Nicholas A. Loehr*, Virginia Tech, and **Gregory S. Warrington**, University of Vermont (1056-05-487)

AMS Special Session on Differential Galois Theory and Group Representations: A Tribute to Andy Magid, I

1:00 PM – 6:20 PM

Organizers: **James Carrell**, University of British Columbia

Lourdes Juan, Texas Tech University
Alex Lubotzky, Hebrew University
Brian Parshall, University of Virginia
Marius van der Put, University of Groningen

1:00PM (1185) *Differential 'Galois' extensions with new constants.* **Lourdes Juan***, Texas Tech University, and **Andy R. Magid**, University of Oklahoma (1056-20-1991)

1:30PM (1186) *Differential Groups and Factorization of Partial Differential Operators.* **Phyllis J Cassidy**, The City College of New York, and **Michael F Singer***, North Carolina State University (1056-12-605)

2:00PM (1187) *Infinitesimal differential Galois groups from jet spaces.* **Thomas Scanlon**, University of California, Berkeley (1056-13-839)

2:30PM (1188) *The Galois group of monodromy evolving deformations.* **Claude Mitschi***, Université de Strasbourg, France, and **Michael F. Singer**, North Carolina State University, Raleigh (1056-34-1144)

3:00PM (1189) *Spin groups as differential Galois groups.* **Arne Ledet*** and **Lourdes Juan**, Texas Tech University (1056-12-1040)

3:30PM (1190) *Geometry of differential Tannakian categories.* **Henri Gillet**, University of Illinois at Chicago, **Sergey Gorchinskiy**, Steklov Mathematical Institute, and **Alexey Ovchinnikov***, City University of New York (1056-14-1407)

4:00PM (1191) *Symmetries of Standard Equations.* **Camilo Sanabria**, The CUNY Graduate Center (1056-34-433)

4:30PM ► (1192) *Differential Galois Theory and Darboux Transformations.* Preliminary report. **Primitivo B. Acosta-Humánez**, Universidad Sergio Arboleda (1056-34-638)

5:00PM (1193) *What can Mathematicians Contribute to Research in Education?* **Hyman Bass*** and **Deborah Loewenberg Ball**, University of Michigan (1056-97-1520)

6:00PM (1194) *Galois theory of difference equations with difference parameters.* **Benjamin Antieau***, University of Illinois at Chicago, and **Alexey Ovchinnikov**, City University of New York (1056-13-1328)

AMS Special Session on L-Functions and Analytic Number Theory, II

1:00 PM – 5:50 PM

Organizers: **Alina Bucur**, Institute for Advanced Study
Chantal David, Concordia University
Matilde Lalin, University of Alberta

1:00PM (1195) *Real quadratic analogues of traces of singular moduli.* **W Duke***, UCLA, **O Imamoglu**, ETH, and **A Toth**, Eotvos Lorand University (1056-11-1067)

1:30PM (1196) *Periods and L-functions.* **Brooke Feigon**, University of Toronto (1056-11-1086)

2:00PM (1197) *Periods and central values of quadratic base change L-functions.* **David Whitehouse**, Massachusetts Institute of Technology (1056-11-522)

2:30PM (1198) *The relative trace formula and average values of L-functions.* **Andrew H. Knightly***, University of Maine, and **Charles Li**, Chinese University of Hong Kong (1056-11-641)

3:00PM (1199) *Average Frobenius distribution for elliptic curves defined over number fields.* **Ethan C. Smith***, Michigan Technological University, and **Kevin James**, Clemson University (1056-11-789)

3:30PM (1200) *Nonvanishing of canonical Hecke L-functions for CM number fields.* **Riad Masri*** and **Tonghai Yang**, University of Wisconsin at Madison (1056-11-1363)

4:00PM (1201) *Higher weight Heegner points.* **Kimberly Hopkins**, University of Texas at Austin (1056-11-824)

4:30PM (1202) *Euclidean Prime Degree Galois Number Fields.* Preliminary report. **Kevin J McGown**, University of California, San Diego (1056-11-308)

5:00PM (1203) *Divisibility properties of values of partial zeta functions at non-positive integers.* Preliminary report. **Barry R. Smith**, University of California, Irvine (1056-11-751)

5:30PM (1204) *Critical zeros of Dirichlet L-functions.* Preliminary report. **J. Brian Conrey**, American Institute of Mathematics (1056-11-677)

AMS Special Session on Recent Advances in Evolution Equations and Applications

1:00 PM – 6:50 PM

Organizers: **Guoping Zhang**, Morgan State University
Gaston N'Guerekata, Morgan State University
Yi Li, University of Iowa
Wen-Xiu Ma, University of South Florida

1:00PM (1205) *Circular spectrum and bounded solutions of periodic evolution equations in Banach spaces.* **Gaston M. N'guerekata**, Morgan State University (1056-34-995)

1:30PM (1206) *Existence and uniqueness of mild solutions to impulsive fractional differential equations.* **Gisèle Mophou**, Université des Antilles et de la Guyane (1056-35-984)

2:00PM ► (1207) *Existence of pseudo almost automorphic solutions to some classes of nonautonomous partial evolution equations.* Preliminary report. **Toka Diagana**, Howard University (1056-34-1149)

2:30PM (1208) *Analytical approaches for solving nonlinear equations.* **Wen-Xiu Ma**, University of South Florida (1056-35-1397)

3:00PM (1209) *Standing wave solutions of the discrete nonlinear Schrödinger equations with site-dependent nonlinearity.* Preliminary report. **Guoping Zhang**, Morgan State University (1056-35-1341)

3:30PM (1210) *On Solvability of Initial-Boundary Value Problems for Multi-Weighted Parabolic Systems.* Preliminary report. **Alexander Kozhevnikov**, Univ. of Haifa, Israel (1056-35-24)

4:00PM (1211) *Front Behavior for Traveling Wave Solutions of a Modified Fisher PDE.*
Ronald E Mickens, Clark Atlanta University (1056-35-400)

4:30PM (1212) *Blow-up phenomena due to concentrated nonlinear sources in* $\mathbb{R}^N$.
Patcharin Tragoonsirisak, Fort Valley State University (1056-35-312)

5:00PM (1213) *Well-posedness and regularity of one phase Hele-Shaw bubble problem.* Preliminary report.
Xuming Xie, Morgan State University (1056-35-85)

5:30PM (1214) *Multiple Solutions to an Elliptic Problem Related to Vortex Pairs.*
Yi Li*, University of Iowa, Xian Jiaotong University, and **Shuangjie Peng**, Central China Normal University (1056-35-1977)

6:00PM (1215) *Lp Convergence with Rates of Smooth Poisson-Cauchy Type Singular Operators.*
George A. Anastassiou* and **Razvan A Mezei**, University of Memphis (1056-41-37)

6:30PM (1216) *Operator Valued Measures as Feedback Control for Stochastic Systems on Hilbert Space.*
Nasiruddin U Ahmed, University of Ottawa (1056-49-44)

AMS Special Session on The Mathematics of Information and Knowledge, II

1:00 PM – 5:40 PM

Organizers: **Naoki Saito**, University of California Davis
Ronald R. Coifman, Yale University
James G. Glimm, SUNY at Stony Brook
Peter W. Jones, Yale University
Mauro Maggioni, Duke University
Jared Tanner, University of Edinburgh

1:00PM (1217) *The Power of Convex Relaxation: Near-optimal Matrix Completion.*
Emmanuel Candes*, Stanford University, and **Terence Tao**, University of California, Los Angeles (1056-90-1503)

► 2:00PM (1218) *Challenges in Computational Medicine and Biology.*
Donald Geman, Johns Hopkins University (1056-92-993)

3:00PM (1219) *A Geometric Perspective on Learning Theory and Algorithms.*
Partha Niyogi, The University of Chicago (1056-68-1536)

4:00PM (1220) *A multiscale approach to characterize macromolecular dynamics and functions.*
Cecilia Clementi, Department of Chemistry, Rice University (1056-92-1980)

► 5:00PM (1221) *Virtual Surgery: Scientific Computing in Real Time.*
Joseph M Teran, University of California, Los Angeles (1056-65-1802)

MAA-AMS-MER Invited Paper Session on Mathematics and Education Reform, III: Refocusing Algebra: From Middle School to College

1:00 PM – 5:50 PM

Organizers: **William H. Barker**, Bowdoin College
William G. McCallum, University of Arizona
Bonnie S. Saunders, University of Illinois at Chicago
William Haver, Virginia Commonwealth University
Donald B. Small, U.S.M.A.

1:00PM (1222) *The Chicago Algebra Initiative: A Multi-University Collaboration with the Chicago Public Schools.*
Lynn Narasimhan*, DePaul University, and **Paul Sally**, University of Chicago (1056-BC-1346)

1:30PM (1223) *The Chicago Algebra Initiative: Data and Results.*
David C Jabon*, DePaul University, and **Paul J. Sally, Jr.**, University of Chicago (1056-BC-1357)

2:00PM (1224) *Making the Transition from High School Algebra to College Algebra.*
Erick B Hofacker, University of Wisconsin - River Falls (1056-BC-2053)

► 2:30PM (1225) *MAA/CRAFTY College Algebra Guidelines.*
Don Small, United States Military Academy (1056-BC-1183)

► 3:00PM (1226) *Modeling Based College Algebra at Virginia Commonwealth University.*
Bill Haver* and **Aimee Ellington**, Virginia Commonwealth University (1056-BC-868)

► 3:30PM (1227) *Traversing Bumps Along the Road to a Contemporary College Algebra Curriculum.* Preliminary report.
Irene M Haskins, Husson University, Bangor, Maine (1056-BC-1772)

4:00PM (1228) *Refocusing and reMODELING College Algebra - A Team Activity.*
Erick B Hofacker, University of Wisconsin - River Falls (1056-BC-2052)

4:30PM (1229) *Retention Benefits of Refocused College Algebra.*
Bernadette F. Turner* and **Donna Stallings**, Lincoln University, Jefferson City, MO (1056-BC-1761)

► 5:00PM (1230) *Studio College Algebra at Kansas State University.*
Andrew G Bennett*, **Rachel B Manspeaker**, **Rekha Natarajan** and **Jennifer Paulhus**, Kansas State University (1056-BC-815)

5:30PM (1231) *Revitalizing Algebra for First-Year College Students: An Attempt to Change Students' Beliefs and Attitudes.*
Barbara E. Edwards, Oregon State University (1056-BC-1501)

AMS Session on Differential and Difference Equations, IV

1:00 PM – 6:10 PM

1:00PM (1232) *On Stability of Solutions of Fractional Order SEIR Epidemic Model with Vertical Transmission.* Preliminary report.
Elif Demirci* and **Nuri Ozalp**, Ankara University (1056-34-448)

1:15PM (1233) *Oscillation of Impulsive Partial Difference Equations with Continuous Variables.*
Ravi P. Agarwal, Florida Institute of Technology, and **Fatma Karakoc***, Ankara University, Turkey (1056-34-492)

1:30PM (1234) *Analysis and Numerical Solution of a Non-local ODE Motivated by Flutter.*
John V. Matthews* and **Boris P. Belinskiy**, University of Tennessee at Chattanooga (1056-34-496)

► 1:45PM (1235) *Bounded Error Parameter Identification and the Design of Experiments for Models Described by Ordinary Differential Equations.* Preliminary report.
Adam Fletcher Childers, Roanoke College (1056-34-777)

2:00PM (1236) *Integral inequalities for certain nonlinear systems on time scales.*
Mehmet Unal, Bahcesehir University (1056-34-851)

2:15PM ► (1237) *Cyclic Central Configurations in the Four-Body Problem.* Preliminary report.
Josep Cors, Universitat Politècnica de Catalunya, **Glen R. Hall**, Boston University, and **Gareth E. Roberts***, College of the Holy Cross (1056-70-972)

2:30PM (1238) *Asymptotically Autonomous Differential Inclusions.* Preliminary report.
Zhivko S. Athanassov, Bulgarian Academy of Sciences (1056-34-862)

2:45PM (1239) *Dynamics of a segmentation clock model with discrete and distributed delays.*
Peng Feng, Florida Gulf Coast University (1056-34-873)

3:00PM (1240) *Modeling of Electrostatic-Elastic Membrane Systems Motivated by MEMS Devices.*
J. Regan Beckham, University of Texas at Tyler (1056-34-1174)

3:15PM (1241) *Oscillation criteria for some types of second order nonlinear dynamic equations.*
Billur Kaymakcalan*, Georgia Southern University, **Ravi P. Agarwal**, Florida Institute of Technology, **Said R. Grace**, Cairo University, and **Wichuta Sae-jie**, Mahidol University, Bangkok (1056-34-1221)

3:30PM ► (1242) *Solutions of the Nonlinear Schrödinger Equation with Prescribed Asymptotics at Infinity.* Preliminary report.
John Bernard Gonzalez, Northeastern University (1056-35-1987)

3:45PM (1243) *Dirichlet forms on Laakso Spaces.*
Benjamin Steinhurst, University of Connecticut (1056-34-1368)

4:00PM (1244) *Existence of solutions for impulsive integral boundary value problems of fractional order.*
Seenith Sivasundaram, ERAU (1056-34-1434)

4:15PM (1245) *Models of two-patch predator-prey community dynamics.*
Faina Berezovskaya, Howard University (1056-34-1665)

4:30PM ► (1246) *Oscillation criteria for second order dynamic inclusions.*
Elvan Akin-Bohner, Missouri University of Science and Technology (1056-34-1838)

4:45PM Break.

5:00PM ► (1247) *Mathematical analysis of synchronization of pacemaker cells in mammals.*
Menaka B Navaratna*, Florida Gulf Coast University, and **Channa N Navaratna**, Indiana University of Pennsylvania (1056-34-1229)

5:15PM (1248) *Analysis of radial stagnation flow toward a stretching cylinder.*
Antonio Mastroberardino* and **Joseph E Paullet**, Penn State Erie, The Behrend College (1056-34-1852)

5:30PM ► (1249) *Parameter Dependency on the Period of the Solutions for the Duffing Equation with Double-well Potential.* Preliminary report.
Ben T Nohara* and **A Arimoto**, Tokyo City University (1056-34-2043)

5:45PM (1250) *Conditions for the Existence of a Steady State Solution for a Competition System of Plankton Population.*
Chihchien Yu, University of Arkansas - Fort Smith (1056-37-261)

6:00PM (1251) *The Change in Electric Potential due to Lightning.*
Beyza Aslan*, University of North Florida, and **William Hager**, University of Florida (1056-35-381)

AMS Session on Mathematics Education

1:00 PM – 3:55 PM

1:00PM ► (1252) *Why should humanities majors have all the fun?*
Jane W Hartsfield, American University (1056-00-160)

1:15PM ► (1253) *What are they thinking? Examining the mathematical disposition of preservice elementary teachers.*
Charles Adam Feldhaus, Ohio University (1056-97-13)

1:30PM (1254) *Why do children in public and rural primary schools perform worse in mathematics: unresolved questions on equitable access to early childhood education?*
A. N. Meremikwu, University of Calabar Nigeria (1056-97-209)

1:45PM ► (1255) *Local Research Experience for Undergraduates YSU in the summer of 2008.* Preliminary report.
Jacek Fabrykowski, Youngstown State University (1056-97-305)

2:00PM ► (1256) *Examples of a Mathematical Habit of the Mind and its effect on Students.*
Richard Millman, Georgia Institute of Technology (1056-97-465)

2:15PM ► (1257) *Undergraduate Research and Service Learning Projects Developed from Institutional Research Questions.*
Maria Zack* and **Greg Crow**, Point Loma Nazarene University (1056-97-846)

2:30PM ► (1258) *Use of ConcepTests and Voting in Upper Division Math Courses.*
David O Lomen, University of Arizona (1056-97-1889)

2:45PM ► (1259) *Social Network Surveys in Math and Science Education.*
Carole Basile, **Steve Culpepper**, **Steven Di Lisio***, **Adam Ruff** and **Diana White**, University of Colorado at Denver (1056-97-1914)

3:00PM (1260) *Mathematics majors' belief about mathematics after taking a methods of proof class and professors' belief about the effectiveness of such a class.*
Elsa Medina, Cal Poly San Luis Obispo (1056-97-2070)

3:15PM (1261) *Trends in Statistics PhD Graduates.*
Pam Arroway* and **Ashley Swandby**, Department of Statistics, North Carolina State University (1056-00-1595)

3:30PM ► (1262) *Unshackling Linear Algebra from Linear Notation.*
Elisha Peterson, United States Military Academy (1056-15-1231)

3:45PM ► (1263) *Disruption of Symmetry Creates New Symmetries.* Preliminary report.
Robert M. Sulman, Central Methodist University (1056-00-1232)

AMS Session on Dynamical Systems

1:00 PM – 5:25 PM

1:00PM ► (1264) *Computation of Heteroclinic Arcs for Diffeomorphisms of $\mathbb{R}^3$.*
J. D. Mireles-James*, University of Texas, at Austin, and **Hector Lomeli**, ITAM, Mexico City, Mexico (1056-37-45)

1:15PM (1265) *Scattering of solitary waves in the Fermi-Pasta-Ulam lattice.* Preliminary report. **Aaron Hoffman**, Boston University (1056-37-103)

1:30PM ► (1266) *Semigroups of matrices with dense orbits.* Preliminary report. **Mohammad Javaheri**, Trinity College (1056-37-137)

1:45PM (1267) *Mathematical Analysis of Dengue Treatment Model with Variable Viral Load.* **Salisu Mohammed Garba**, University of Manitoba (1056-37-293)

2:00PM (1268) *Model of The Drosophila Circadian Clock: Loop Regulation and Transcriptional Integration.* **Hassan M Fathallah-Shaykh***, University of Alabama at Birmingham, and **Jerry L Bona**, University of Illinois at Chicago (1056-37-693)

2:15PM Break

2:30PM ► (1269) *Dynamics of semigroups of Moebius transformations.* Preliminary report. **Sebastian M Marotta***, University of the Pacific, **David Fried**, Boston University, and **Rich Stankewitz**, Ball State University (1056-37-793)

2:45PM ► (1270) *Towards billiards of the Koch snowflake.* Preliminary report. **Robert G. Niemeyer*** and **Michel L. Lapidus**, UC Riverside (1056-37-820)

3:00PM (1271) *Asymptotics of Grow-Up Solutions and Global Attractors for Slowly Non-Dissipative PDEs.* Preliminary report. **Nitsan Ben-Gal**, Brown University (1056-37-1073)

3:15PM (1272) *One-parameter interval exchange actions.* **Christopher F Novak**, University of Michigan-Dearborn (1056-37-1187)

3:30PM (1273) *Extreme value theory for some dynamical systems.* Preliminary report. **Chinmaya Gupta***, University of Houston, **Mark Holland**, University of Exeter, and **Matthew Nicol**, University of Houston (1056-37-1243)

3:45PM (1274) *Evolving a Smooth Curve of Initial Conditions Under a Time-Dependent Two-Dimensional ODE.* **Paul von Dohlen***, William Paterson University, and **Patrick Miller**, Stevens Institute of Technology (1056-37-1460)

4:00PM (1275) *Newton diagram methods for analysis of the replicator equation.* **Faina Berezovskaya***, Howard University, **Artem Novozhilov** and **Georgy Karev**, National Institutes of Health, Bethesda, MD (1056-37-1686)

4:15PM (1276) *Speedups of Ergodic Group Extensions.* **Andrey Babichev***, California State University, Fresno, and **Adam Fieldsteel**, Wesleyan University (1056-37-1847)

4:30PM (1277) *Combinatorial Classification of Cubic Polynomials with a fixed Siegel Disk.* Preliminary report. **Ross M Ptacek*** and **John C Mayer**, University of Alabama at Birmingham (1056-37-1942)

4:45PM (1278) *The Maximal Inequality and the Ergodic Theorem for Discrete Hausdorff Means.* Preliminary report. **Constantine Georgakis**, DePaul University (1056-37-1994)

5:00PM (1279) *Renormalization and lower-dimensional Brjuno invariant tori of Hamiltonian systems.* **Sasa Kocic***, University of Toronto, and **Hans Koch**, University of Texas at Austin (1056-37-2021)

5:15PM (1280) *Symbolic Dynamics for Nonhyperbolic Systems.* **David Richeson***, Dickinson College, and **Jim Wiseman**, Agnes Scott College (1056-58-1811)

AMS Session on Computational Mathematics, II

1:00 PM – 5:40 PM

1:00PM (1281) *Reconstructing physical parameters in systems of reaction-diffusion equations in electrocardiology.* **Yuan He*** and **David E Keyes**, Department of Applied Physics and Applied Mathematics, Columbia University (1056-65-1058)

1:15PM ► (1282) *Truncated Incomplete Hessian Newton Minimization with Application to Biomolecular Potential Energy Function.* **Mazen George Zarrouk*** and **Dexuan Xie**, University of Wisconsin - Milwaukee (1056-65-1125)

1:30PM ► (1283) *Fast Solvers for Models of Steady Fluid Flow.* **P. A. Lott***, National Institute of Standards & Technology, and **H. C. Elman**, University of Maryland, College Park (1056-65-1182)

1:45PM ► (1284) *Fighting Gibbs' phenomenon through quotienting.* Preliminary report. **Jean-Paul Berrut**, University of Fribourg, Switzerland (1056-65-1185)

2:00PM ► (1285) *Numerical solutions of fourth order boundary value problems using Bernoulli polynomials.* Preliminary report. **Md Shafiqul Islam**, University of Dhaka (1056-65-1223)

2:15PM ► (1286) *Solving two-dimensional linear and nonlinear Volterra integral equations by the differential transform method.* **Jang Bongsoo**, Ulsan National Institute of Science and Technology (UNIST) (1056-45-1025)

2:30PM (1287) *Signal Fraction Analysis with Constraints and Extensions.* **Fatemeh Emdad***, The University of Texas Medical Branch, and **Michael Kirby**, Colorado State University (1056-00-1188)

2:45PM (1288) *Reduced Basis Element Method for 2D Maxwell's Problem.* **Yanlai Chen***, **Jan S. Hesthaven**, Brown University, and **Yvon Maday**, Brown University and Paris 6 (1056-65-1298)

3:00PM ► (1289) *Model and Optimization of Organic Photovoltaic Cells.* **Amelia McNamara***, Macalester College, **Jordan Seering**, University of Minnesota-Twin Cities, and **Yi Zeng**, University of Illinois at Urbana-Champaign (1056-65-1301)

3:15PM (1290) *Higher order Strang split integral deferred correction methods for Vlasov equations.* Preliminary report. **Andrew Christlieb**, **Maureen Morton***, Michigan State University, and **Jing-Mei Qiu**, Colorado School of Mines (1056-65-1345)

3:30PM (1291) *Computing Laser Ablation by a Finite-Volume Method.* **Sean Cohen***, **Alina Chertock**, North Carolina State University, **V. A. Trofimov** and **I. A. Shirokov**, Moscow State University (1056-65-1418)

3:45PM Break

4:00PM (1292) *A Discontinuous Galerkin Solver for Full-Band Boltzmann-Poisson Models.* **Yingda Cheng***, **Irene M Gamba**, University of Texas at Austin, **Armando Majorana**, Universit'a di Catania, and **Chi-Wang Shu**, Brown University (1056-65-1490)

4:15PM (1293) *Reconstruction of thin tubular inclusions in three-dimensional domains using electrical impedance tomography.*
Roland Griesmaier, University of Delaware (1056-65-1548)

4:30PM (1294) *Delaunay refinement methods for FSI systems undergoing changes in topological properties.* Preliminary report.
Edward W. Swim, United States Military Academy (1056-65-1713)

4:45PM (1295) *Resilient Modulus Modeling with information theory approach.*
Ali S. Shaqlaih*, **Luther White** and **Musharraf Zaman**, University of Oklahoma (1056-65-1780)

5:00PM ► (1296) *Numerical Study of a Quantum Memory Model.* Preliminary report.
Charles N. Cook*, Alma College, and **Maria Emelianenko**, George Mason University (1056-65-1781)

5:15PM ► (1297) *Domain decomposition method for solving three-dimensional parabolic partial differential equations.*
Younbae Jun, University of West Alabama (1056-65-1873)

5:30PM (1298) *The Rapid Advance and Slow Retreat of a Mushy Zone.* Preliminary report.
Nicholas Gewecke* and **Tim Schulze**, University of Tennessee, Knoxville (1056-86-269)

AMS Session on Functional Analysis and Operator Theory, II

1:00 PM – 5:40 PM

1:00PM (1299) *Weighted Composition Operators from H^∞ to the Bloch Space of a Bounded Homogeneous Domain.* Preliminary report.
Robert F. Allen*, University of Wisconsin – La Crosse, and **Flavia Colonna**, George Mason University (1056-47-309)

1:15PM (1300) *Eigenvalues for Perturbations of Densely Defined Linear Maximal Monotone Operators.* Preliminary report.
Dhruba R Adhikari*, Mississippi University for Women, and **Athanassios G Kartsatos**, University of South Florida (1056-47-577)

1:30PM (1301) *An induced diffusion distance.* Preliminary report.
Maxim J. Goldberg, Ramapo College of NJ, and **Seonja Kim***, SUNY Rockland Community College (1056-47-1005)

1:45PM (1302) *The Generalized Degree for Multifunctions Perturbations of Maximal Monotone Operators and Applications.*
Boubakari Ibrahimou, Murray State University (1056-47-1008)

2:00PM ► (1303) *Spectral Analysis of Conjugate Self-Adjoint Operators.* Preliminary report.
Zhong Wang*, Zhaoqing University, and **Hongyou Wu**, NIU (1056-47-1099)

2:15PM Break.

2:30PM (1304) *Kinds of pseudomonotonocitiy in study of variational inequalities.*
Dan D. Pascali, Courant Institute, New York University (1056-47-1142)

2:45PM (1305) *Fixed Point Composition C^*-algebras.*
Katie Spurrier Quertermous, University of Virginia (1056-47-1165)

3:00PM (1306) *Function theory on a quantum domain.*
Meghna Mittal, University of Houston (1056-47-1375)

3:15PM (1307) *Topology of invariant subspace lattice of shift operators in higher dimensions.*
Shonia Giorgi, Ohio University Lancaster (1056-47-1399)

3:30PM (1308) *Quantum analog of Donoho-Stark Uncertainty Principle.*
Genady Grabarnik, York College, CUNY, NY (1056-47-1451)

3:45PM (1309) *Convex and Nonsmooth Analysis of Minimal Time Functions in Banach Spaces.*
Mau Nam Nguyen, University of Texas-Pan American (1056-49-421)

4:00PM (1310) *Crossed Products by Automorphisms with the Tracial Quasi-Rokhlin Property.*
Julian Michael Buck, University of Oregon (1056-47-1754)

4:15PM (1311) *n-symmetric Linear Transformations and von Neumann algebras.* Preliminary report.
Mark Stankus, California Polytechnic State University Of San Luis Obispo (1056-47-1853)

4:30PM (1312) *Computing the C*-algebra of an inverse semigroup with the Munn representation.*
David Milan, University of Texas at Tyler (1056-47-2107)

4:45PM (1313) *Recursive Decomposition of a C^* -subalgebra of $C^*(R, X)$.* Preliminary report.
Hutian Liang, University of Oregon (1056-47-2124)

5:00PM (1314) *On the Nonpositive Solution of the Nonlinear Inverse Autoconvolution Problem.*
Z Dai*, Alma College, and **P K Lamm**, Michigan State University (1056-45-1010)

5:15PM ► (1315) *Good Lambda Inequality and Riesz potentials for Non Doubling Measures in $\mathbb{R}^n$.* Preliminary report.
Mukta B. Bhandari, Kansas State University (1056-42-709)

5:30PM (1316) *Generalized Convolution Systems: Axioms and Properties.*
Adam W Parr, University of the Virgin Islands (1056-43-1816)

MAA Session on Arts and Mathematics, I

1:00 PM – 5:55 PM

Organizer: **Douglas E. Norton**, Villanova University

1:00PM ► (1317) *A Brief Study of Modularity in Mosaic Designs.*
Reza Sarhangi, Towson University (1056-C1-301)

1:20PM ► (1318) *Conformal Models of Hyperbolic Geometry.* Preliminary report.
Vladimir L. Bulatov, Corvallis, OR (1056-C1-950)

1:40PM ► (1319) *Exploring Chaotic Patterns in Chinese Landscape Paintings by Structural Cloning Method.* Preliminary report.
Mingjang Chen, Center for General Education, National Chiao-Tung University (1056-C1-177)

2:00PM ► (1320) *The Joy of the Curve.*
Susan A. McBurney, Western Springs, Illinois (1056-C1-299)

2:20PM ► (1321) *Empirical Origin of the Design Concepts and the Euclidean Geometry.*
Fatma Mete*, Department of Fiber Science and Apparel Design, Cornell University, and **Osman Yurekli**, Ithaca College (1056-C1-1580)

2:40PM ► (1322) *Projective Geometry and The Art of The Renaissance.*
Meighan I. Dillon, Southern Polytechnic State University (1056-C1-461)

3:00PM ► (1323) *Modular Perspective in The Music Lesson by Vermeer.* Preliminary report.
Helmer Aslaksen, National University of Singapore (1056-C1-591)

3:20PM (1324) *Digital roots, Vedic multiplication and Fibonacci numbers.*
Fatma Mete, Cornell University, and **Yurekli Osman***, Ithaca College (1056-C1-1457)

3:40PM ► (1325) *Dancing in Mathematical Circles.*
Karl H. Schaffer, De Anza College, Dr. Schaffer and Mr. Stern Dance Ensemble (1056-C1-2010)

4:00PM ► (1326) *Dancing and Groups: An Active Activity.* Preliminary report.
Melanie Anne Pivarski, Roosevelt University (1056-C1-749)

4:20PM (1327) *The Great Calculus II Art Contest.*
Pedro Teixeira, Knox College (1056-C1-2011)

4:40PM ► (1328) *Measuring Complexity of d-Note Pitch Collections Within a c-Note Chromatic Universe.*
Joshua P. Case, University of Maine at Farmington (1056-C1-1246)

5:00PM ► (1329) *A Mathematical Tour of Baltimore.*
Robert Edward Lewand, Goucher College (1056-C1-157)

5:20PM (1330) *The topology of Jorge Luis Borges'* Library of Babel.
William Goldbloom Bloch, Wheaton College (1056-C1-872)

5:40PM ► (1331) *Once upon a time there was ... A epistemological "fable" of music and mathematics.*
Rosanna Iembo*, International Institute of Informatics and Systems, Orlando, Florida, USA; University of Calabria, Italy, and **Irene Iaccarino**, Crotone, Italy (1056-C1-1020)

MAA Session on Undergraduate Mathematical Biology, II

1:00 PM – 1:35 PM

Organizers: **Timothy D. Comar**, Benedictine University
Raina S. Robeva, Sweet Briar College

1:00PM ► (1332) *Predictive Modeling in Quantitative Biology.*
Jeff R Knisley, East Tennessee State University (1056-Q5-1531)

1:20PM ► (1333) *Modeling the Spread of Disease in Undergraduate Microbiology.*
Angela B. Shiflet* and **George W Shiflet**, Wofford College (1056-Q5-1988)

MAA Session on General Contributed Papers, VIII

1:00 PM – 5:55 PM

Organizers: **Eric S. Marland**, Appalachian State University
Daniel J. Curtin, Northern Kentucky University

1:00PM ► (1334) *SIGMAA-QL 2009 Quantitative Literacy Survey: Preliminary Results.* Preliminary report.
Milo Schield, Augsburg College (1056-Z1-1088)

1:15PM (1335) *Teaching a Senior Seminar in Humanistic Mathematics.*
Sarah J Greenwald* and **Eric Marland**, Appalachian State University (1056-Z1-182)

1:30PM ► (1336) *Reflection Papers on the Big Ideas.*
Jeremy Case, Taylor University (1056-Z1-1448)

1:45PM (1337) *Can Instructors Award Partial Credit on Multiple Choice Questions?*
Janet L. Braunstein* and **Edward W. Swim**, United States Military Academy at West Point (1056-Z1-1992)

2:00PM ► (1338) *Refocused College Algebra at Harris-Stowe State University.* Preliminary report.
Ann Podleski, Harris-Stowe State University (1056-Z1-2042)

2:15PM (1339) *The Impact of Additional Mathematics Support on Student Performance.*
Ciarán Mac an Bhaird* and **Ann O'Shea**, National University of Ireland Maynooth (1056-Z1-2119)

2:30PM ► (1340) *History of The Return of Applications in Undergraduate Mathematics in the United States.*
Walter Meyer, Adelphi University (1056-Z1-357)

2:45PM ► (1341) *50 years of College Math. Have I learned anything?* Preliminary report.
Bryan V. Hearsey, Lebanon Valley College (1056-Z1-368)

3:00PM (1342) *One of the first mathematical texts of the Jewish Bookcase.*
Greisy Winicki Landman, Cal Poly Pomona (1056-Z1-288)

3:15PM ► (1343) *New Materials on History of Mathematics.*
Satish C. Bhatnagar, University of Nevada Las Vegas (1056-Z1-1712)

3:30PM ► (1344) *Mathematicians Card and Poster.* Preliminary report.
Sang-Gu Lee and **Kyung-Won Kim***, Sungkyunkwan University (1056-Z1-1517)

3:45PM ► (1345) *The Elements of Euclid.*
Meighan I. Dillon, Southern Polytechnic State University (1056-Z1-456)

4:00PM ► (1346) *British Royal Society: A Fraternity of Experimentalists.*
Donna M Pierce, Whitworth University (1056-Z1-354)

4:15PM (1347) *History as a meaning-making tool: Illuminating prospective mathematics teachers' knowledge of algebra.*
Kathleen M Clark, Florida State University (1056-Z1-1440)

4:30PM ► (1348) *Winifred Edgerton Merrill—She Opened Doors.*
Susan E. Kelly*, University of Wisconsin- La Crosse, and **Sarah Rozner**, University of Northern Colorado (1056-Z1-1817)

4:45PM ► (1349) *Mihailo Petrovic and his interval mathematics.* Preliminary report.
Radoslav M. Dimitric, Pittsburgh (1056-Z1-127)

5:00PM (1350) *The Orthogonal Tower for Σ^∞ Emb($\coprod_m D^n, V$).* Preliminary report.
Nicholas Hamblet, University of Virginia (1056-Z1-1597)

5:15PM ► (1351) *Well Behaved Rotation About Planar Non-linear Curves: An analysis of the volume and uniqueness of a solid swept out by rotation about a non-linear axis.* Preliminary report.
Adam V Lewicki* and **Robert Whitton**, Davidson College (1056-Z1-1543)

5:30PM ► (1352) *Three Simple Questions about Tetrahedra.* Preliminary report.
Charles Waiveris, Central Connecticut State University (1056-Z1-1081)

5:45PM ► (1353) *Why Automobile Sunshades Fold Oddly: An Intruiging Application of Topology.*
Curtis Feist*, Southern Oregon University, and **Ramin Naimi**, Occidental College (1056-Z1-1355)

MAA Session on Philosophy of Mathematics for Working Mathematicians

1:00 PM – 4:45 PM

Organizers: **Bonnie Gold**, Monmouth University
Carl Behrens, Alexandria, Virginia

1:00PM (1354) *What Is the Character of Mathematical Law?* **James R Henderson**, University of Pittsburgh at Titusville (1056-M5-259)

1:30PM (1355) *John Stuart Mill's "Pebble Arithmetic" and the Nature of Mathematical Objects.* **Carl E. Behrens**, Alexandria, VA (1056-M5-596)

2:00PM (1356) *Dummett Down: Intuitionism and Mathematical Existence.* Preliminary report. **Thomas Drucker**, University of Wisconsin–Whitewater (1056-M5-1635)

2:30PM (1357) *The Articulation of Mathematics—A Pragmatic/Constructive Approach to The Philosophy of Mathematics.* Preliminary report. **Martin E Flashman**, Humboldt State University (1056-M5-1771)

3:00PM (1358) *Molyneux's Problem.* Preliminary report. **Lawrence A. D'Antonio**, Ramapo College of New Jersey (1056-M5-445)

3:30PM (1359) *Mathematical practice and the philosophy of mathematics.* Preliminary report. **Jeff Buechner**, Dept. Philosophy; Rutgers University-Newark and The Saul Kripke Center, CUNY, The Graduate Center (1056-M5-1015)

4:00PM (1360) *Being a Realist Without Being a Platonist.* Preliminary report. **Daniel C. Sloughter**, Furman University (1056-M5-444)

4:30PM (1361) *An analysis of the notion of natural number.* **Ruggero Ferro**, University of Verona, Italy (1056-M5-1918)

MAA Session on Publishing Mathematics on the Web

1:00 PM – 5:15 PM

Organizers: **Thomas E. Leathrum**, Jacksonville State University
William F. Hammond, The University at Albany
Kyle T. Siegrist, University of Alabama in Huntsville

1:00PM (1362) *A multimedia document workflow using docutils.* Preliminary report. **Matthew Leingang**, New York University (1056-N5-630)

1:20PM (1363) *Displaying Mathematics with Plain HTML.* **Claus Schubert**, SUNY Cortland (1056-N5-341)

1:40PM (1364) *The Importance of Good Source Markup.* **William F. Hammond**, University at Albany (SUNY) (1056-N5-712)

2:00PM (1365) *Customizing and Extending Content MathML.* Preliminary report. **Kyle T Siegrist**, University of Alabama in Huntsville (1056-N5-1662)

2:20PM (1366) *Math Authoring for the Web Made Easier.* **Thomas E Leathrum**, Jacksonville State University (1056-N5-547)

2:40PM (1367) *An RIA Approach to Web Mathematics.* **Donald W. DeLand**, Integre Technical Publishing (1056-N5-1809)

3:00PM (1368) *Textbooks as Sage Notebooks.* **Robert A Beezer**, University of Puget Sound (1056-N5-1050)

3:20PM (1369) *MathJax: a JavaScript-based engine for including TeX and MathML in HTML.* **Davide P Cervone**, Union College (1056-N5-1947)

3:40PM (1370) *WebKit + MathML.* **R. Alexander Milowski**, San Francisco, CA (1056-N5-1505)

4:00PM (1371) *MathType, Math Markup, and the Goal of Cut and Paste.* **Robert R Miner**, Design Science, Inc. (1056-N5-1504)

4:20PM (1372) *MathML 3.0.* **Patrick D. F. Ion**, Mathematical Reviews / AMS (1056-N5-1271)

4:40PM (1373) *Revising the MSC (Mathematics Subject Classification).* **Patrick D. F. Ion**, Mathematical Reviews / AMS (1056-N5-1278)

5:00PM (1374) *Tiddly Geometry.* Preliminary report. **Patrick D. F. Ion**, Mathematical Reviews / AMS (1056-N5-1262)

MAA Session on Research on the Teaching and Learning of Undergraduate Mathematics, I

1:00 PM – 4:55 PM

Organizers: **Keith Weber**, Rutgers University
Stacy Brown, Pitzer College
Natasha A. Speer, University of Maine
Karen A. Marrongelle, Portland State University

1:00PM (1375) *Appropriating New Definitions: The Case of Lipschitz Functions.* **Jessica L Knapp**, Pima Community College (1056-P5-1952)

1:40PM (1376) *Undergraduate students' assessment of the persuasiveness of mathematical arguments: Beyond private and public senses of conviction.* **Juan Pablo Mejia Ramos***, Rutgers University, and **Matthew Inglis**, Loughborough University (1056-P5-1350)

2:20PM (1377) *A design of instructional interventions for the resolution of cognitive dissonance in an advanced calculus class.* **Kyeong Hah Roh**, Arizona State University (1056-P5-2068)

2:40PM (1378) *Between construction and communication: What goes into revising a proof?* Preliminary report. **Yvonne Lai***, University of Michigan, and **Keith H Weber**, Rutgers University (1056-P5-1343)

3:00PM (1379) *Examples, Uncertainty, & Skepticism: An Examination of the Underpinnings of An Intellectual Need for Proof.* **Stacy A. Brown**, Pitzer College (1056-P5-1488)

3:20PM (1380) *Understanding mathematical proofs: What does it mean and how can it be assessed?* Preliminary report. **Evan Fuller***, Montclair State University, **Keith Weber**, **Pablo Mejia-Ramos**, **Kathryn Rhoads**, Rutgers, **Robert Search**, Centenary College, and **Aron Samkoff**, Rutgers (1056-P5-753)

3:40PM (1381) *Clarifying the Stages of Mathematical Defining: Gestation and Presentation.* **Paul Christian Dawkins**, University of Texas at Arlington (1056-P5-1151)

4:00PM ► (1382) *Examining Undergraduate Students' Reading and Use of Mathematics Textbooks.*
Angie Hodge* and **Ryan Hiltner**, North Dakota State University (1056-P5-2022)

4:20PM ► (1383) *An Example of a Non-traditional Pedagogy in an Abstract Algebra Class: What is the effect on student motivation?*
Tim Fukawa-Connelly, University of New Hampshire (1056-P5-184)

4:40PM ► (1384) *The role of e-assessment in student learning in mathematics.* Preliminary report.
Douglas Quinney, University of Keele, UK (1056-P5-32)

SIAM Minisymposium on Graph Theory, II

1:00 PM – 5:55 PM

Organizers: **Andre Kundgen**, California State University San Marcos
Hal Kierstead, Arizona State University

1:00PM (1385) *Equitable list coloring of graphs with low maximum degree.* Preliminary report.
H. A. Kierstead, Arizona State University, and **A. V. Kostochka***, University of Illinois at Urbana-Champaign (1056-05-723)

1:30PM (1386) *Hamiltonian Square Cycle in Ore-type Graphs.*
Phong Q Chau, Arizona State University (1056-05-1511)

2:00PM (1387) *Tiling in Multipartite Graphs.*
Ryan Martin, Iowa State University (1056-05-333)

2:30PM ► (1388) *Decompositions of graphs and hypergraphs.*
Sebastian M Cioabă, University of Delaware (1056-05-1146)

3:00PM (1389) *Distributed algorithms and graph theory.*
Andrzej Czygrinow, Arizona State University (1056-68-908)

3:30PM (1390) *Adjacency Posets of Planar Graphs.*
Stefan Felsner, **Chingman Li**, Institut für Mathematik, Technische Universität Berlin, and **William T. Trotter***, Georgia Institute of Technology (1056-05-1582)

4:00PM (1391) *On extremal problems in a Boolean lattice.* Preliminary report.
Maria Axenovich*, **Jacob Manske** and **Ryan Martin**, Iowa State University (1056-05-1254)

4:30PM (1392) *Maker-Breaker Games: Building a Big Chain in a Poset.*
Daniel Cranston*, Virginia Commonwealth University, **Bill Kinnersley**, **Kevin Milans**, **Greg Puleo** and **Douglas West**, University of Illinois, Urbana-Champaign (1056-05-441)

5:00PM ► (1393) *Degree Ramsey Numbers of Graphs.* Preliminary report.
Tao Jiang, Miami University, Ohio, **Bill Kinnersley**, **Kevin G. Milans*** and **Douglas B. West**, University of Illinois at Urbana-Champaign (1056-05-558)

5:30PM (1394) *Spanning cycles through specified edges in bipartite graphs.*
Reza Zamani and **Douglas B. West***, University of Illinois (1056-05-955)

NAM Granville-Brown-Hayes Session of Presentations by Recent Doctoral Recipients in the Mathematical Sciences

1:00 PM – 3:25 PM

Organizer: **Dawn Lott**, Delaware State University

1:00PM (1395) *Liquidation of a large block of stock with regime switching.*
Moustapha N. Pemy*, Towson University, **Q Zhang**, University of Georgia, and **G Yin**, Wayne State University (1056-49-469)

1:30PM ► (1396) *Third Graders' Strategies and Preferences for Solving Arithmetic Problems: A Gender Difference Study.*
Nicola D. Edwards-Omolewa, Delaware State University (1056-97-702)

2:00PM (1397) *Parametric Copula Models for Markovian Processes, for African-American Male Career Heuristics.*
Kobi A. Abayomi*, Georgia Institute of Technology, School of Industrial Engineering - Statistics Group, **Lee Hawkins**, Wall Street Journal/CNBC, and **Kenneth Land**, Duke University (1056-62-1026)

2:30PM ► (1398) *Calculating target Cataract Surgical Rates for Africa.*
Talithia D Williams, Harvey Mudd College (1056-62-1374)

3:00PM (1399) *Brownian motion indexed by a time scale and its applications.*
Suman Sanyal, Marshall University (1056-60-1340)

AMS-MAA Committee on Teaching Assistants and Part-Time Instructors Panel Discussion

1:00 PM – 3:00 PM

Becoming a teacher of college mathematics: Video cases for novice college mathematics instructor professional development.

Organizers: **John D. Eggers**, University of California San Diego
Shandy Hauk, University of Northern Colorado
Mark K. Davis, University of Northern Colorado
Eric Hsu, San Francisco State University
Natasha M. Speer, University of Maine

Panelists: **Eric Hsu**
David E. Meel, Bowling Green State University
Natasha M. Speer

AMS Session on Algebras, I

1:15 PM – 5:55 PM

1:15PM (1400) *Idempotents and Annihilators in Endomorphism Rings of Modules.* Preliminary report.
Gangyong Lee*, The Ohio State University, **S. Tariq Rizvi** and **Cosmin S. Roman**, The Ohio State University at Lima (1056-16-112)

1:30PM (1401) *On dualizing the notion of slenderness.* Preliminary report.
Radoslav M. Dimitric, Pittsburgh (1056-16-129)

1:45PM (1402) *Rings and Covered Groups.* Preliminary report.
G. Alan Cannon, Southeastern Louisiana University, **C. J. Maxson**, Texas A&M University, and **Kent M. Neuerburg***, Southeastern Louisiana University (1056-16-412)

2:00PM ► (1403) *Indecomposable division algebras over function fields of smooth p-adic curves.*
Feng Chen, Emory University (1056-16-998)

2:15PM Break

2:30PM (1404) *On skew power series rings.* Preliminary report.
Linhong Wang, Southeastern Louisiana University (1056-16-1353)

2:45PM (1405) *A decomposition of the Dynkin idempotent in the Hopf algebra of graphs.* Preliminary report.
Forest Fisher* and **William Schmitt**, The George Washington University (1056-16-1369)

3:00PM (1406) *Unit-regular Skew Group Rings.*
Kathi Crow, American University in Cairo (1056-16-1563)

3:15PM ► (1407) *A combinatorial approach to the description of endomorphism rings.* Preliminary report.
Jose A. Velez-Marulanda, University of Iowa (1056-16-1656)

3:30PM (1408) *Action of the symmetry group of the n-dimensional hypercube on the algebra associated to the Hasse graph of the n-cube.* Preliminary report.
Colleen Duffy, University of Wisconsin - Eau Claire (1056-16-1814)

3:45PM Break

4:00PM (1409) *Periodicity of quadratic differential equations in nonassociative algebras and dimensions of subalgebras.*
Nora C. Hopkins, Indiana State University (1056-17-120)

4:15PM (1410) *On Demazure Crystals of $U_q(\widehat{sl}(n))$.*
Julie C Beier, Mercer University (1056-17-183)

4:30PM (1411) *Nilpotent Orbit Theory and Infinitesimal Blocks of Parabolic Category $\mathcal{O}$.* Preliminary report.
Kenyon J Platt*, Brigham Young University, and **Bobbe J Cooper**, University of Minnesota (1056-17-245)

4:45PM (1412) *Properties of the Frattini Subalgebra in a Lie algebra.* Preliminary report.
Kristen Stagg, North Carolina State University (1056-17-363)

5:00PM (1413) *Multipliers of Lie Algebras of Maximal Class.* Preliminary report.
Lindsey R Bosko, North Carolina State University (1056-17-364)

5:15PM (1414) *Blocked and Group-Graded Matrix Constructions from Directed Graphs.* Preliminary report.
Kenneth L Price* and **Stephen Szydlik**, University of Wisconsin Oshkosh (1056-17-801)

5:30PM (1415) *Multipliers for the Nilpotent Series of Strictly Upper Triangular Matrices.* Preliminary report.
Louis A. Levy, Millersville University (1056-17-1729)

5:45PM (1416) *Tiling spaces and the Baum Connes Conjecture.* Preliminary report.
Semail Ulgen Yildirim, Northwestern University (1056-19-559)

ASL Invited Address

2:00 PM – 2:50 PM

(1417) *Randomness and computational strength.*
Joseph S. Miller, University of Wisconsin-Madison (1056-03-71)

MAA Session on Online Homework—Innovation and Assessment, III

2:00 PM – 4:55 PM

Organizers: **Michael E. Gage**, University of Rochester
Arnold K. Pizer, University of Rochester
Vicki Roth, University of Rochester

2:00PM ► (1418) *What I Learned about Using Online Homeworks from Student Feedback.*
Laura A. McSweeney, Fairfield University (1056-M1-1170)

2:20PM ► (1419) *Increasing Student Success Using Online Homework.* Preliminary report.
Tina Alves Mancuso, The Sage Colleges (1056-M1-1611)

2:40PM (1420) *Using WeBWorK in Linear Algebra.*
Thomas R Hagedorn* and **Karen Clark**, The College of New Jersey (1056-M1-1706)

3:00PM ► (1421) *Using Online Homework and Data Mining to Assess Student Learning in Mathematics Courses.* Preliminary report.
Michael B Scott, California State University, Monterey Bay (1056-M1-2044)

3:20PM ► (1422) *Online Homework—Does It Work?* Preliminary report.
Ronnie P Crane, Hawaii Pacific University (1056-M1-2071)

3:40PM ► (1423) *The Utilization of Discussion Boards for Homework in an Interactive Delivery Course: Linear Algebra and Differential Equations.*
Stephanie A. Swainston* and **Brynja R. Kohler**, Utah State University (1056-M1-1862)

4:00PM (1424) *Implementing Online Homework and Quizzes in a Pre-Calculus Course: Challenges and Rewards.* Preliminary report.
Ann E Moskol, Rhode Island College (1056-M1-2029)

4:20PM ► (1425) *Common Innovative Uses of Online Homework Systems Webassign, MyMathLab, and WebWork.* Preliminary report.
Semail Ulgen Yildirim, Northwestern University (1056-M1-1841)

4:40PM ► (1426) *The "Third Wave" of WeBWorK Assessment.* Preliminary report.
Vicki J Roth*, University of Rochester, and **Flora McMartin**, Broad-Based Knowledge, LLC (1056-M1-1163)

MAA Minicourse #11: Part B

2:15 PM – 4:15 PM

The mathematics of Islam and its use in the teaching of mathematics.

Organizer: **Victor J. Katz**, University of the District of Columbia

MAA Minicourse #12: Part B

2:15 PM – 4:15 PM

Learning discrete mathematics via historical projects.

Organizers: **Jerry M. Lodder**, New Mexico State University
Guram Bezhanishvili, New Mexico State University
David Pengelley, New Mexico State University

MAA Minicourse #6: Part B

2:15 PM – 4:15 PM

Developing departmental self-studies.

Organizers: **Donna L. Beers**, Simmons College
Nancy Baxter Hastings, Dickinson College

Rocky Mountain Mathematics Consortium Board of Directors Meeting

2:15 PM – 4:10 PM

MAA Presentations by Teaching Award Recipients

2:30 PM – 4:00 PM

Organizers: **Martha J. Siegel**, Towson University
David M. Bressoud, Macalester College

2:30PM ► (1427) *What we are doing at BYU to increase the number of students taking mathematics courses and becoming math majors.*
Michael Dorff, Brigham Young University (1056-A0-623)

2:30PM ► (1428) *Ask Good Questions.*
Allan J. Rossman, California Polytechnic State University - San Luis Obispo (1056-A0-767)

2:30PM ► (1429) *Lessons learned in the teaching and learning of mathematics.*
Curtis D. Bennett, Loyola Marymount University (1056-A0-1339)

AMS Committee on Science Policy Panel Discussion

2:30 PM – 4:00 PM

Evaluation of the NSF's VIGRE program.

MAA Poster Session on Research by Undergraduate Students

2:30 PM – 4:00 PM

Judging of all posters will take place during this time.

ASL Invited Address

3:00 PM – 3:50 PM

(1430) *Bar-recursive interpretations of classical analysis.*
Fernando J. Ferreira, Universidade de Lisboa (1056-03-69)

MAA Session on Mathematics and Sports, I

3:20 PM – 3:55 PM

Organizer: **Howard L. Penn**, U.S. Naval Academy

3:20PM ► (1431) *How Game Players Get Ranked—The Mathematics of Elo Ratings.* Preliminary report.
Maryam Vulis, USMA Prep School (1056-H5-996)

3:40PM Discussion

AMS Session on Discrete Mathematics, V

3:45 PM – 6:25 PM

3:45PM (1432) *Lower bounds in minimum rank problems.*
Lon H Mitchell*, Virginia Commonwealth University, **Sivaram K Narayan**, Central Michigan University, and **Andy Zimmer**, University of Illinois (1056-05-903)

4:00PM (1433) *C-sets in an uncountable semigroup.* Preliminary report.
John H. Johnson, Howard University (1056-05-905)

4:15PM (1434) *The Rees Product with a Poset or its Dual Poset.*
Tricia Muldoon Brown*, Armstrong Atlantic State University, and **Margaret Readdy**, University of Kentucky (1056-05-910)

4:30PM (1435) *Permutations with Ascending and Descending Blocks.*
Jacob N Steinhardt, Massachusetts Institute of Technology (1056-05-979)

4:45PM (1436) *Generalized Oval Derivation.*
Timothy L Vis, University of Colorado Denver (1056-05-997)

5:00PM ► (1437) *Potential-Based Strategies for Breaker for Maker-Breaker Tic-Tac-Toe on the Integer Lattice with Numerous Directions.*
Klay Kruczek*, Western Oregon University, and **Eric Sundberg**, Occidental College (1056-91-1917)

5:15PM (1438) *A winning strategy for Maker in the Maker-Breaker version of Tic-Tac-Toe on the integer lattice with numerous winning line directions.*
Eric Sundberg*, Occidental College, and **Klay Kruczek**, Western Oregon University (1056-05-1951)

5:30PM (1439) *Extremal functions of excluded block permutation matrices.*
Adam C Hesterberg, Princeton University (1056-05-1113)

5:45PM (1440) *The* $(1,2)$*-step competition graph of a tournament.*
Sarah K. Merz*, University of the Pacific, and **Kim A. S. Factor**, Marquette University (1056-05-795)

6:00PM ► (1441) *Elements in unavoidable minors of* 3*-connected binary matroids.* Preliminary report.
Deborah A Chun, Louisiana State University (1056-05-1277)

6:15PM ► (1442) *A degree condition for spanning cycles in bipartite graphs.*
Louis DeBiasio*, **Andrzej Czygrinow** and **H. A. Kierstead**, Arizona State University (1056-05-1097)

MAA Poster Session on Research by Undergraduate Students

4:00 PM – 5:30 PM

All participants are invited to view the posters and speak with the presenters.

Organizer: **Diana M. Thomas**, Montclair State University

ASL Session for Contributed Papers

4:10 PM – 5:45 PM

4:10PM (1443) *"Universal" Schnorr tests.*
Nicholas Rupprecht, University of Michigan

4:35PM (1444) *The computability of conditional probability distributions.*
Nathanael L Ackerman, University of California, Berkeley, **Cameron E Freer*** and **Daniel M Roy**, Massachusetts Institute of Technology

5:00PM (1445) *Probabilistic computation and stochastic processes.*
Wesley Calvert, Murray State University

5:25PM (1446) *Computable dimension of Heyting algebras.*
Amy Turlington, University of Connecticut

AMS Congressional Fellowship Session

4:30 PM – 6:30 PM

Organizer: **Samuel M. Rankin, III**, AMS

MAA Panel Discussion

5:00 PM – 7:00 PM

Current issues in actuarial science education.

Organizers: **Robert E. Buck**, Slippery Rock University
Bettye Anne Case, Florida State University
Kevin E. Charlwood, Washburn University
Steve Paris, Florida State University

Moderator: **Robert E. Buck**

Panelists: **James W. Daniel**, University of Texas Austin
Bryan V. Hearsey, Lebanon Valley College

SIGMAA on Quantitative Literacy Business Meeting

5:00 PM – 6:00 PM

SIGMAA on the Philosophy of Mathematics Business Meeting, Reception, and Guest Lecture

5:15 PM – 7:15 PM

► 6:15PM (1447) *What is Philosophy of Mathematics? A Case Study of Fictionalism.*
Charles Chihara, University of California, Berkeley (1056-A0-1220)

SIGMAA on Mathematical and Computational Biology Business Meeting and Guest Lecture

6:00 PM – 8:00 PM

7:00PM (1448) *Using mathematical approaches to understand and manage spatially distributed populations: From invasive species to fisheries.*
Alan Hastings, University of California Davis

MAA Special Theatrical Presentation

6:00 PM – 7:00 PM

The theater of the mathematically absurd.

Presenter: **Colin Adams**, and the Mobiusbandaid Players

AMS Mathematical Reviews Reception

6:00 PM – 7:00 PM

SIGMAA on Mathematics and the Arts Business Meeting

7:00 PM – 8:00 PM

NAM Cox-Talbot Address

7:30 PM – 8:15 PM

► (1449) *The Number Zero: Its Origin and Use.*
Abdulalim Abdullah Shabazz, Grambling University (1056-01-307)

SIGMAA on Mathematics and the Arts Special Presentation

8:00 PM – 9:00 PM

Bruce Beasley *will discuss his sculptures which consist of intersecting forms that are developed using a computer program.*

MAA-Project NExT Reception

8:30 PM – 10:30 PM

All Project NExT Fellows, consultants, and other friends of Project NExT are invited.

Organizers: **Judith Covington**, Louisiana State University Shreveport
Joseph A. Gallian, University of Minnesota-Duluth
Aparna W. Higgins, University of Dayton
Gavin LaRose, University of Michigan

Saturday, January 16

MAA Minority Chairs Breakfast Meeting

7:00 AM – 8:45 AM

Joint Meetings Registration

7:30 AM – 2:00 PM

AMS Special Session on Biomathematics: Modeling in Biology, Ecology, and Epidemiology, II

7:30 AM – 10:50 AM

Organizers: **Olcay Akman**, Ilinois State University
Linda Allen, Texas Tech University
Timothy D. Comar, Benedictine University
Sophia Jang, Texas Tech University
Lih-Ing Roeger, Texas Tech University

► 7:30AM (1450) *Integrin Dynamics in Motile Cells: A Stochastic Approach.* Preliminary report.
Hannah L Callender*, University of Portland, and **Hans G Othmer**, University of Minnesota (1056-92-614)

► 8:00AM (1451) *Organism-Associated and Mat-Forming Metagenome Statistical Analysis using Random Forests Algorithms.* Preliminary report.
Mayra Hernandez*, San Diego State University, **Isaacs Kate**, San Jose State University, **Naneh Apkarian**, Pomona College, **Michelle Creek**, Chapman University, **Eric Guan**, Torrey Pines High School, **Chris Peterson**, Pomona College, and **Todd Regh**, Southern Oregon University (1056-92-1958)

8:30AM (1452) *Optimal Seasonal Plant Reproduction.* Preliminary report.
Anthony DeLegge* and **Steven Dunbar**, University of Nebraska-Lincoln (1056-92-54)

9:00AM (1453) *Super-spreading events in infectious diseases.* Preliminary report.
Anna Mummert* and **Sydney Mkhatshwa**, Marshall University (1056-92-466)

9:30AM (1454) *The Dynamics of One-Predator Two-Prey Systems for Integrated Pest Management.* Preliminary report.
Timothy D Comar* and **Pinal Shah**, Benedictine University (1056-92-460)

10:00AM (1455) *Seeking Optimal Treatment Strategies for Malaria Infection.* Preliminary report.
Jeremy J Thibodeaux, University of Central Oklahoma (1056-92-385)

10:30AM (1456) *Qualitative Analysis of Models for Anaerobic Digestion including Syntrophic Interactions.* Preliminary report.
Marion Weedermann, Dominican University (1056-34-125)

AMS Special Session on Mathematics and Physical Experiment, II

7:30 AM – 10:50 AM

Organizers: **Roger Thelwell**, James Madison University
Anthony Tongen, James Madison University
Paul Warne, James Madison University

7:30AM ► (1457) *Spreading Surfactant on a Thin Liquid Layer.*
Ellen Peterson* and **Michael Shearer**, North Carolina State University (1056-76-472)

8:00AM ► (1458) *Particle size segregation in granular flow.*
Michael Shearer*, North Carolina State University, **Laura Golick**, Emory University, Georgia, **Lindsay H May**, Baltimore, MD, and **Karen E Daniels**, North Carolina State University (1056-76-1284)

8:30AM ► (1459) *Simulation and validation of 3-dimensional fatigue cracks.*
David L Chopp, Northwestern University (1056-74-2101)

9:00AM ► (1460) *Mathematical theory of particle laden flow.*
Andrea Bertozzi, UCLA (1056-76-178)

9:30AM (1461) *Dynamics of Free Surface Perturbations Along an Annular Viscous Film Flowing Down a Vertical Fiber.*
Linda B. Smolka*, **Dennis Fillebrown**, Bucknell University, **Bree Guerra**, University of Texas at Austin, and **Justin North**, Ohio State University (1056-76-1561)

10:00AM ► (1462) *Symmetry and locomotion in theory and experiment.*
Stephen Childress, New York University, Courant Institute of Mathematical Sciences (1056-76-737)

10:30AM ► (1463) *Inverse boundary value problems arising in the diagnosis and treatment of heart disease and breast cancer.*
David Isaacson*, Rensselaer Polytechnic Institute, **J. C. Newell** and **G. C. Saulnier**, RPI (1056-92-310)

AMS Session on Probability and Statistics, IV

7:45 AM – 8:55 AM

7:45AM ► (1464) *The minimum measure of concordance in a multivariate version of Spearman's rank correlation.* Preliminary report.
Raymond E. Molzon, Michigan Technological University (1056-62-2020)

8:00AM ► (1465) *The Mid-Pleistocene Transition: From Forcing to Pacing of Glaciers.* Preliminary report.
Eric R Ruggieri* and **C. Lawrence**, Brown University (1056-62-2095)

8:15AM (1466) *Characterization and Dispersive Ordering of the Cauchy, Gauss and Logistic Laws.*
Broderick Oluyede, Georgia Southern University (1056-62-1351)

8:30AM ► (1467) *Compound Covariate Predictor (CCP) Classification Technique Applied on More Than Two Groups Gene Expression data.* Preliminary report.
Akram M. Almohalwas, Central Michigan University (1056-62-1426)

8:45AM (1468) *Schroedinger-Type Eigenmaps for the Analysis and Classification of Multispectral Data in Bio-Medical Imaging.*
Martin Ehler*, Norbert Wiener Center, University of Maryland, and **Wojciech Czaja**, University of Maryland (1056-58-2036)

AMS-MAA-SIAM Special Session on Research in Mathematics by Undergraduates, III

8:00 AM – 10:50 AM

Organizers: **Darren Narayan**, Rochester Institute of Technology
Bernard Brooks, Rochester Institute of Technology
Jacqueline Jensen, Sam Houston State University
Carl V. Lutzer, Rochester Institute of Technology
Vadim Ponomarenko, San Diego State University
Tamas Wiandt, Rochester Institute of Technology

8:00AM (1469) *Knots, Sticks, and Indicatrix.* Preliminary report.
Bena Tshishiku*, Washington and Lee University, **Dan Collins**, Cornell University, **Charmaine Sia**, MIT, **Rob Silversmith**, **Katherine Hawkins** and **Colin Adams**, Williams College (1056-57-966)

8:30AM ► (1470) *Planar and Spherical Stick Indices of Torus Knots.*
Colin Adams, Williams College, **Dan Collins**, Cornell University, **Katherine Hawkins**, Williams College, **Charmaine Sia**, Massachusetts Institute of Technology, **Rob Silversmith***, Williams College, and **Bena Tshishiku**, Washington and Lee University (1056-57-422)

9:00AM ► (1471) *Symplectic Volumes and Ribbon Graphs.*
Julia C Bennett*, Bard College, **David V Cochran**, Virginia Commonwealth University, and **Kaitlin Woskoff**, Hartwick College (1056-53-82)

9:30AM ► (1472) *Modulation Frames and Infinite Symmetric Matrices.*
Robert G. Fraser*, Case Western Reserve University, **Andrew Dugowson**, Pomona College, and **Yeonhyang Kim**, Central Michigan University (1056-46-88)

10:00AM ► (1473) *Continuous Frames on Manifolds.* Preliminary report.
Daniel Freeman, Texas A&M University, **Daniel Poore**, Pomona College, **A. Rebecca Wei***, Case Western Reserve University, and **Madeline Wyse**, Pomona College (1056-58-92)

10:30AM ► (1474) *The Isoperimetric Problem in Sectors with Disk Density.*
Alexander Diaz*, Universidad de Puerto Rico Mayaguez Campus, **Nate Harman**, University of Massachusetts, Amherst, **Sean Howe**, University of Arizona, Tucson, and **David Thompson**, Williams College (1056-53-99)

AMS-MAA Special Session on History of Mathematics, II

8:00 AM – 10:50 AM

Organizers: **Craig Fraser**, University of Toronto

Deborah Kent, Hillsdale College
Sloan Despeaux, Western Carolina University

8:00AM ► (1475) *"Ad Calculum Sinuum": Thomas Harriot's Sine Table Interpolation Formulas.*
Janet L Beery, University of Redlands (1056-01-1116)

8:30AM ► (1476) *Newton's Proof of Heron's Formula.*
William Dunham, Muhlenberg College (1056-01-335)

9:00AM ► (1477) *Mathematics as imperialism? The role of mathematicians in the political expansion of British mathematical practices.*
Josipa G Petrunic, University College London (1056-01-1249)

9:30AM ► (1478) *A comparison of Edwin Abbott Abbott and Lewis Carroll.* Preliminary report.
William F. Lindgren*, Slippery Rock University, and **Thomas F. Banchoff**, Brown University (1056-01-1184)

10:00AM ► (1479) *The Early Years of G. H. Hardy's career.*
Brenda Davison, Simon Fraser University (1056-01-482)

10:30AM ► (1480) *Joel E. Hendricks and the Analyst.* Preliminary report.
James J Tattersall, Providence College (1056-01-494)

AMS-SIAM Special Session on Applications of Algebraic Geometry, I

8:00 AM – 10:50 AM

Organizers: **Frank Sottile**, Texas A&M University
Luis Garcia-Puente, Sam Houston State University

8:00AM (1481) *Algebraic aspects of persistence.*
Gunnar Erik Carlsson, Stanford University (1056-55-1638)

8:30AM (1482) *From Isomap to Persistence: nonlinear dimensionality reduction with circular coordinates.*
Vin de Silva, Pomona College (1056-68-2149)

9:00AM ► (1483) *Topological data analysis and the nudged elastic band method.* Preliminary report.
Henry Adams*, **Gunnar Carlsson**, Stanford University, and **Atanas Atanasov**, Columbia University (1056-55-2063)

9:30AM (1484) *Recovering exact results from numerical computation in algebraic geometry.*
Daniel J. Bates*, Colorado State University, **Jonathan D. Hauenstein**, Fields Institute/Texas A&M, **Tim McCoy**, University of Notre Dame, **Chris Peterson**, Colorado State University, and **Andrew J. Sommese**, University of Notre Dame (1056-14-1120)

10:00AM ► (1485) *Computing Hilbert functions using dual bases.* Preliminary report.
Jonathan D Hauenstein, Fields Institute/Texas A&M (1056-14-1178)

10:30AM (1486) *Zebra Fish, Tumor Growth, and Algebraic Geometry.*
Andrew Sommese, University of Notre Dame (1056-14-2079)

AMS Special Session on Categorical and Algebraic Methods in Representation Theory, I

8:00 AM – 10:50 AM

Organizers: **Jon Brundan**, University of Oregon
Julia Pevtsova, University of Washington
Eric Friedlander, University of Southern California

8:00AM (1487) *Morita Equivalence Revisited.*
Paul Frank Baum, Pennsylvania State University (1056-16-520)

8:30AM (1488) *A combinatorial approach to Specht module cohomology.*
David J Hemmer, University at Buffalo, State University of New York (1056-20-860)

9:00AM (1489) *Vanishing ranges for the cohomology of finite groups of Lie type.*
Christopher P. Bendel*, University of Wisconsin-Stout, **Daniel K. Nakano**, University of Georgia, and **Cornelius Pillen**, University of South Alabama (1056-20-434)

9:30AM (1490) *Low Degree Cohomology for Finite Simple Groups.*
Robert M Guralnick*, University of Southern California, and **Pham Huu Tiep**, University of Arizona (1056-20-450)

10:00AM (1491) *Support varieties and representation type.*
Joerg Feldvoss, University of South Alabama, and **Sarah Witherspoon***, Texas A&M University (1056-16-598)

10:30AM (1492) *Bundles and submodule functors.* Preliminary report.
Jon F Carlson*, University of Georgia, **Eric M Friedlander**, University of Southern California, and **Julia Pevtsova**, University of Washington (1056-20-867)

AMS Special Session on Harmonic Analysis and Representations of Reductive p-adic Groups, I

8:00 AM – 10:40 AM

Organizers: **Robert Doran**, Texas Christian University
Paul Sally, University of Chicago
Loren Spice, Texas Christian University

8:00AM (1493) *Characters Tell All: The Plancherel Formula Done Right.* Preliminary report.
Paul J Sally*, University of Chicago, and **Loren Spice**, Texas Christian University (1056-22-825)

8:50AM (1494) *Invariant distributions supported on compact elements.*
Stephen M DeBacker, University of Michigan (1056-22-2035)

9:20AM (1495) *Parametrizing Nilpotent Orbits in Symmetric Spaces Using Bruhat-Tits Theory.*
Ricardo Portilla, University of Michigan-Ann Arbor (1056-20-1365)

9:50AM (1496) *Geometric Structure in the Representation Theory of Reductive p-adic Groups.*
Paul Frank Baum, Pennsylvania State University (1056-22-136)

10:20AM (1497) *On some local L-packets and character sheaves.*
Clifton Cunningham, University of Calgary (1056-11-1038)

AMS Special Session on Integrability of Dynamical Systems and Solitons Equations, I

8:00 AM – 10:50 AM

Organizers: **Zhijun Qiao**, University of Texas-Pan American

Taixi Xu, Southern Polytechnic State University

Wenxiu Ma, University of South Florida

8:00AM (1498) *On meromorphic solutions to the Korteweg-de Vries equation with non-decaying initial data supported on a left half line.*
Alexei Rybkin, University of Alaska Fairbanks (1056-35-1218)

8:30AM (1499) *Integrable systems and invariant geometric flows in similarity and projective geometries.*
Changzheng Qu, Northwest University, P. R. China (1056-35-2086)

9:00AM (1500) *On the Long-Time H2-Stability of the Implicit Euler Scheme for the 2D Magnetohydrodynamics Equations.*
Florentina Tone, University of West Florida (1056-35-913)

9:30AM (1501) *Stability of the Positive Steady States for a Nonhomogeneous Semilinear Parabolic Problem.*
Yi Li*, University of Iowa, Xian Jiaotong University, and **Baishun Lai**, Hunan Normal University and Henan University (1056-35-1982)

10:00AM (1502) *Quantizations of differential operator modules.*
Charles H Conley, University of North Texas (1056-17-665)

10:30AM (1503) *Component-trace identities and Hamiltonian structures of integrable couplings.*
Wen-Xiu Ma, University of South Florida (1056-37-1393)

AMS Special Session on Interactions of Inverse Problems, Signal Processing, and Imaging, III

8:00 AM – 10:50 AM

Organizer: **M. Zuhair Nashed**, University of Central Florida

8:00AM ► (1504) *An analysis of the singular values from the binary information with its preserver and patternization.*
Duk-Sun Kim* and **Sang-Gu Lee**, Sungkyunkwan University (1056-15-1162)

8:30AM (1505) *A novel kernel correlation model with correspondence estimation.*
Pengwen Chen, University of Connecticut (1056-49-644)

9:00AM (1506) *Multiscale Registration of Planning CT and Daily Cone Beam CT Images for Adaptive Radiation Therapy.*
Dana Paquin*, California Polytechnic State University, **Doron Levy**, Department of Mathematics and CSCAMM, University of Maryland, and **Lei Xing**, Stanford University (1056-92-432)

9:30AM (1507) *Regularization of Inverse Magnetoencephalography by a Spline Method.*
Michel Volker, Geomathematics Group, University of Siegen, Germany (1056-65-513)

10:00AM (1508) *Stack filter classifiers with an application to change detection in images.*
G. Beate Zimmer*, Texas A&M University-Corpus Christi, **Reid Porter** and **Don Hush**, Los Alamos National Laboratory (1056-68-121)

10:30AM (1509) *On Weakly Bounded Noise in Ill-Posed Problems.*
P. P. B. Eggermont*, **V. N. LaRiccia**, Food and Resource Economics, University of Delaware, and **M. Z. Nashed**, University of Central Florida (1056-47-1818)

AMS Special Session on Optimal Frames and Operator Algebras, I

8:00 AM – 10:50 AM

Organizers: **David Larson**, Texas A&M University

Deguang Han, University of Central Florida

Shidong Li, San Francisco State University

8:00AM (1510) *Sparse approximations and the minimum subspace approximation property.*
Akram Aldroubi*, Vanderbilt University, and **Romain Tessera**, CNRS, Ecole Normal Sup., Lyon (1056-47-322)

8:30AM (1511) *Filter bank fusion frames.*
Matthew Fickus*, Air Force Institute of Technology, **Amina Chebira**, Swiss Federal Institute of Technology Lausanne, and **Dustin G. Mixon**, Princeton University (1056-42-523)

9:00AM ► (1512) *Distance estimates and a flow converging to equal-norm Parseval frames.*
Bernhard G Bodmann*, University of Houston, and **Peter G Casazza**, University of Missouri (1056-46-535)

9:30AM (1513) *A frame theoretic construction for spectral imaging data.* Preliminary report.
John J. Benedetto, Norbert Wiener Center, University of Maryland (1056-42-564)

10:00AM (1514) *Spanning Properties of Frames.*
Peter G. Casazza*, University of Missouri, **Bernhard G. Bodmann**, **Vern I. Paulsen**, University of Houston, and **Darrin Speegle**, St. Louis University (1056-46-635)

10:30AM (1515) *Frames for L^2 of measures with scale self-similarity.* Preliminary report.
Palle E. T. Jorgensen, University of Iowa (1056-46-761)

AMS Special Session on Parabolic Geometries, Integrable Systems, and Twistor Theory, I

8:00 AM – 10:40 AM

Organizers: **Dana Mihai**, Carnegie Mellon University

Jonathan Holland, University of Pittsburgh

George Sparling, University of Pittsburgh

8:00AM (1516) *Weyl and the foundations (1918, 1929) of gauge theory.*
Alexander Afriat, Université de Bretagne Occidentale (PaHST & REHSEIS) (1056-83-1022)

8:30AM (1517) *Affine sphere equation, Hitchin system and Painleve III.*
Prim Plansangkate, Centre de recherches mathématiques (1056-51-634)

9:00AM (1518) *Invariants of projective structures on surfaces and some applications.*
Robert L Bryant, University of California at Berkeley and MSRI (1056-53-31)

10:00AM (1519) *Four-dimensional metrics conformal to Kahler.*
M. Dunajski, University of Cambridge (1056-53-562)

MAA-AMS Invited Paper Session on the Scholarship of Teaching and Learning in Mathematics

8:00 AM – 10:50 AM

Organizers: **Jacqueline M. Dewar**, Loyola Marymount University
Thomas F. Banchoff, Brown University
Pam Crawford, Jacksonville University

8:00AM ► (1520) *SoTL in the Mathematics Content Preparation of Teachers: Infusing K-12 Exemplars in the Undergraduate Mathematics Curriculum.* **Kathryn T Ernie**, University of Wisconsin - River Falls (1056-BE-1719)

8:30AM (1521) *Research Experiences for Pre-service and In-service Secondary Mathematics Teachers.* **Saad El-Zanati***, **David Barker** and **Wendy O'Hanlon**, Illinois State University (1056-BE-462)

9:00AM ► (1522) *Assessing Student Learning in an Introductory-Level Mathematics Course with a Sustainability Emphasis.* **Rikki B Wagstrom**, Metropolitan State University (1056-BE-1306)

9:30AM ► (1523) *Preliminary Thoughts on Quantitative Literacy.* Preliminary report. **Michael C Burke**, College of San Mateo (1056-BE-1510)

10:00AM ► (1524) *What is inquiry? What is evidence?* **Rose Asera**, Carnegie Foundation for the Advancement of Teaching (1056-BE-1832)

10:30AM ► (1525) *Differentiating Instruction in a Large Lecture Class.* Preliminary report. **Andrew G Bennett***, **Rachel Manspeaker**, **Danielle McNaney** and **Ala Alnaser**, Kansas State University (1056-BE-1454)

AMS Session on Computational Mathematics, III

8:00 AM – 10:55 AM

8:00AM (1526) *Mathematical Modeling of Tail Movement.* **Glenn Steven Young***, **Anthony L. Tongen**, James Madison University, **Nina Bence** and **Corey Cleland**, Department of Biology, James Madison University (1056-65-1916)

8:15AM (1527) *Analysis of 3D Potts Model Monte Carlo Simulation of Crystalline Grain Growth.* **Joshua D. Snyder**, George Mason University (1056-65-1962)

8:30AM (1528) *An optimization-based approach to discretizing the eikonal equation.* **Christopher M Kuster**, Carroll University (1056-65-1973)

8:45AM ► (1529) *HSS preconditioning techniques for the Navier-Stokes equations.* Preliminary report. **Jia Liu**, University of West Florida (1056-65-2069)

9:00AM (1530) *A Spectral Time-Domain Method for Computational Electrodynamics.* Preliminary report. **James V Lambers**, University of Southern Mississippi (1056-65-2073)

9:15AM (1531) *Interpolation error estimates for hexahedral finite elements: geometrical approach.* **Kanagaratnam Arunakirinathar**, University of Kwa-Zulu Natal (1056-65-2078)

9:30AM ► (1532) *Decomposition Method for Henry's Problem.* **Julia Petereit**, University of Nevada, Reno (1056-41-679)

9:45AM ► (1533) *Parallel Performance of Some SHA-3 Second Round Candidates.* Preliminary report. **Jason Worth Martin**, James Madison University (1056-12-2077)

10:00AM (1534) *Multistep Kinetic Monte Carlo.* Preliminary report. **Holly N. Clark*** and **Tim P. Schulze**, University of Tennessee, Knoxville (1056-76-285)

10:15AM (1535) *Application of the Riemann-Hilbert technique to a problem of a supercavitating wedge.* **Anna Zemlyanova*** and **Yuri Antipov**, Louisiana State University (1056-76-338)

10:30AM (1536) *Comparisons of Different Groove Structures in a Steady-Liquid Flow for Designing Efficient Micro Heat Pipes.* **Mulugeta Markos**, North Carolina Wesleyan College (1056-76-742)

10:45AM (1537) *Flow structure of a sphere or spheroid immersed in shear flows in the Stoke's regime.* **Longhua Zhao***, **Roberto Camassa** and **Richard M. McLaughlin**, University of North Carolina at Chapel Hill (1056-76-961)

AMS Session on Research by Undergraduates, I

8:00 AM – 10:55 AM

8:00AM ► (1538) *Efficient computation of failure probabilities in optical fiber communication systems.* **Zachary Marzec***, **Jonathan Schuster**, SUNY at Buffalo, **Lucas Bunt** and **Benjamin Kanouse**, Buffalo State College (1056-78-1698)

8:15AM ► (1539) *Computer Model of Gravitational Lensing Systems.* **Philip S Naudus**, George Mason University (1056-85-1646)

8:30AM ► (1540) *On Property P_1 and Spaces of Operators.* Preliminary report. **Junsheng Fang**, **David Larson**, Texas A&M University, and **Stephen Rowe***, Florida Atlantic University Harriet L. Wilkes Honors College (1056-15-394)

8:45AM ► (1541) *m-Refinably Extendable Functions.* Preliminary report. **John R Meuser**, Illinois Wesleyan University (1056-00-359)

9:00AM ► (1542) *What Moves You: Using Legs for Vehicular Transportation.* **Jonathan Graf***, Towson University, **Olga Stulov**, SUNY New Paltz, and **Jim Sochacki**, James Madison University (1056-34-334)

9:15AM (1543) *Modeling, Analysis and Computation of Fluid Structure Interaction Models for Biological Systems.* **S. Minerva Venuti*** and **Padmanabhan Seshaiyer**, George Mason University (1056-35-1523)

9:30AM ► (1544) *Nucleation and Spinodal Decomposition in Ternary-component Alloys.* Preliminary report. **Colleen T Ackermann***, Virginia Polytechnic Institute and State University, and **William D Hardesty**, University of Maryland Baltimore County (1056-35-321)

9:45AM ► (1545) *Modeling Phase Separation in Ternary Alloys.* **James O'Beirne**, George Mason University (1056-35-1186)

10:00AM ► (1546) *Parameter Estimation in a System of Differential Equations.* **Franz William Hamilton**, George Mason University (1056-35-1260)

10:15AM ► (1547) *Numerical Modeling and Analysis of Fluid Structure Interaction in Biological Systems.* Preliminary report. **Avis A Foster***, **Daniel M Anderson**, **S. Minerva Venuti** and **Padmanabhan Seshaiyer**, George Mason University (1056-35-1617)

10:30AM ► (1548) *Prolonging the effectiveness of transgenic insecticidal crops.*
John Bantle*, **Aaron Festinger**, **Hee-Joon Jo** and **Ryan Klafehn**, University at Buffalo (1056-92-1791)

10:45AM ► (1549) *Complex dynamics of a single nephron model with tubuloglomerular feedback and a myogenic mechanism.*
John Dambra*, University at Buffalo, and **Steven Leuthe**, Buffalo State College (1056-92-1799)

AMS Session on Number Theory, III

8:00 AM – 10:40 AM

8:00AM ► (1550) *Poincaré Series of Diagonal Polynomials.* Preliminary report.
Dibyajyoti Deb, University of Kentucky, USA (1056-11-1199)

8:15AM ► (1551) *Special Sierpiński Numbers.* Preliminary report.
Gregory P. Dresden, **Carrie E. Finch***, Washington & Lee University, **Josh Harrington**, University of South Carolina, **Lenny K. Jones**, Shippensburg University, and **Mark R. Kozek**, Whittier College (1056-11-1297)

8:30AM (1552) *Explicit bounds for the number of p-core partitions of n.*
Byungchan Kim and **Jeremy Rouse***, University of Illinois, Urbana-Champaign (1056-11-1235)

8:45AM (1553) *Sifting Limits for Selberg's $\Lambda^2\Lambda^-$ Sieve.* Preliminary report.
C S Franze, Central Michigan University (1056-11-1244)

9:00AM Break

9:15AM ► (1554) *On the sum of the reciprocals of the amicable numbers.* Preliminary report.
Jonathan W. Bayless*, Husson University, and **Dominic Klyve**, Carthage College (1056-11-790)

9:30AM (1555) *D. Stanton's conjecture on t-core partitions.*
Byungchan Kim*, University of Illinois at Urbana-Champaign, and **Jeremy Rouse**, University of Illinois at Urbana-Champain (1056-11-1336)

9:45AM ► (1556) *Generalizing a Theorem of Sierpiński Using Lucas Sequences.* Preliminary report.
Lenny Jones, Shippensburg University (1056-11-859)

10:00AM (1557) *Diophantine Questions and the Adeles.*
Thomas J Wright, Johns Hopkins University (1056-11-1383)

10:15AM ► (1558) *Diophantine Approximation for Alternate Forms of Continued Fractions.*
David E. Molnar, Ridgewood, NJ (1056-37-1508)

10:30AM (1559) *The Riemann Hypothesis and the Roots of the Riemann Zeta Function.*
Samuel W Gilbert, Vienna, VA (1056-11-48)

MAA Session on Innovative and Effective Ways to Teach Linear Algebra, I

8:00 AM – 10:55 AM

Organizers: **David M. Strong**, Pepperdine University
Gilbert Strang, Massachusetts Institute of Technology
David C. Lay, University of Maryland

8:00AM ► (1560) *Eigenvalues and eigenvectors—helping students see what they do.*
Melvin A Nyman*, Alma College, **John Berry**, University of Plymouth (England), **Douglas A Lapp** and **Dennis St. John**, Central Michigan University (1056-G1-1640)

8:20AM ► (1561) *Student-centered linear algebra activities.*
Gulden Karakok*, UMERC, Umea University, Sweden, and **Corinne A. Manogue**, Department of Physics, Oregon State University (1056-G1-1868)

8:40AM ► (1562) *Introducing Linear Algebra to Middle School Students.* Preliminary report.
Pamela G Coxson, University of California San Francisco (1056-G1-534)

9:00AM (1563) *Interesting projects while teaching Linear Algebra course.*
Yun Lu, Kutztown University of PA (1056-G1-822)

9:20AM (1564) *Learning the Language of Linear Algebra: Using Reading Assignments to Immerse Students in Terminology and Ideas.*
Matt Boelkins, Grand Valley State University (1056-G1-856)

9:40AM (1565) *Three tested ways to empower students to engage in linear algebra.*
Peg Howland* and **Brynja R. Kohler**, Utah State University (1056-G1-2000)

10:00AM ► (1566) *Matrices of Sequences: Recurrence and Computation.*
Mark Anderson Miller, Marietta College (1056-G1-198)

10:20AM ► (1567) *Transitioning to a Laguerre Basis.*
Elyn Rykken*, Muhlenberg College, and **Maureen Carroll**, University of Scranton (1056-G1-2002)

10:40AM ► (1568) *Using Quaternions and Rotations Matrices for Rotations in R3.*
Paul Raymond Bouthellier, University of Pittsburgh-Titusville (1056-G1-237)

MAA Session on General Contributed Papers, IX

8:00 AM – 10:55 AM

Organizers: **Eric S. Marland**, Appalachian State University
Daniel J. Curtin, Northern Kentucky University

8:00AM (1569) *A Summer of Knots.*
Alan Alewine, McKendree University (1056-Z1-543)

8:15AM (1570) *Calculus Laboratory: A Companion Course to the Lecture.* Preliminary report.
Michael P Saclolo, St. Edward's University (1056-Z1-1612)

8:30AM ► (1571) *Science in the Mathematics Classroom.*
George Rublein, College of William and Mary (1056-Z1-1750)

8:45AM ► (1572) *A 21st century makeover of a classic introductory differential equations course.*
Anand L. Pardhanani, Earlham College (1056-Z1-1007)

9:00AM ► (1573) *Recruitment and Retention: Flip Sides of the Same Coin.* Preliminary report.
Lisa A Lister, Bloomsburg University (1056-Z1-1385)

9:15AM Break.

9:30AM ► (1574) *Redesigning a Mathematics Course to Meet the Needs of Business Majors.* Preliminary report.
Kathleen D. Lopez*, **Diane G. Fisher**, **Michael W. Totaro** and **Lee E. Price**, University of Louisiana at Lafayette (1056-Z1-947)

9:45AM ► (1575) *Changes in Students' Perceptions about Learning Mathematics in a Redesigned Mathematics Course for Business Majors.* Preliminary report. **Diane G Fisher***, **Kathleen Lopez**, **Michael Totaro** and **Lee Price**, University of Louisiana at Lafayette (1056-Z1-888)

10:00AM ► (1576) *Grading Done Right.* Preliminary report. **Dustin D. Keck*** and **Michael A. Brilleslyper**, U.S. Air Force Academy (1056-Z1-1680)

10:15AM ► (1577) *Wii™ Derivatives: Learning Derivatives Through Competition.* Preliminary report. **Keith W. DeGregory***, **Aaron C. Elliott**, **William L. Fehlman II** and **Alex A. Heidenberg**, United States Military Academy at West Point (1056-Z1-904)

10:30AM (1578) *Survivor Math: Using Pop Culture to Enhance Learning Mathematics.* **Robert E Burks**, United States Military Academy (1056-Z1-55)

10:45AM (1579) *Composition Operators on $S^2(\mathbb{D})$.* **Katherine Heller**, University of Virginia (1056-Z1-643)

MAA Session on Mathematics and Sports, II

8:00 AM – 10:55 AM

Organizer: **Howard L. Penn**, U.S. Naval Academy

8:00AM ► (1580) *Did Humidifying the Baseball Decrease the Number of Homers at Coor's Field?* **Howard L. Penn**, U.S. Naval Academy (1056-H5-380)

8:20AM ► (1581) *A nonlinear approach to modeling success in baseball.* **Jeff Hamrick***, Rhodes College, and **John M. Rasp**, Stetson University (1056-H5-762)

8:40AM (1582) *Biomechanics of Running and Walking.* **Anthony Tongen**, James Madison University (1056-H5-1975)

9:00AM ► (1583) *Mathematics Awareness Month 2010: Mathematics and Sports.* **Douglas Ensley**, Shippensburg University, **Joseph A. Gallian***, University of Minnesota Duluth, and **Howard Penn**, United States Naval Academy. (1056-H5-374)

9:20AM ► (1584) *Tigermetrics: Statistical Analysis of the PGA Tour.* Preliminary report. **Roland Minton**, Roanoke College (1056-H5-314)

9:40AM ► (1585) *Creating a Sports Video Game using Mathematical Modeling.* **Paul Raymond Bouthellier**, University of Pittsburgh-Titusville (1056-H5-236)

10:00AM (1586) *Introducing some new and already existing statistical studies related to a sports mostly popular in the eastern hemispheres.* **Santanu Chakraborty**, University of Texas - Pan American, Edinburg, Texas (1056-H5-81)

10:20AM ► (1587) *Analysis of a Table Tennis Game: A Teaching Tool.* **Reza D. Noubary**, Bloomsburg University (1056-H5-928)

10:40AM ► (1588) *Exploring NFL Data to Determine "Who is the Greatest of Them All?".* Preliminary report. **Jacqueline Brannon Giles**, (1) HCC Central College (2) Texas Southern University (1056-H5-512)

MAA Session on Visualization in Mathematics, I

8:00 AM – 9:35 AM

Organizers: **Sarah J. Greenwald**, Appalachian State University

Walter Whiteley, York University

8:00AM ► (1589) *Spatial Visualization for Pre-Service Teachers.* **Lily Moshe**, York University, **Margaret Sinclair**, Faculty of Education, York University, and **Walter Whiteley***, York University (1056-R5-1562)

8:20AM ► (1590) *Picture This: Making Connections in 3-Space.* **Sarah L Mabrouk**, Framingham State College (1056-R5-2001)

8:40AM ► (1591) *Drawing by hand and machine: Visualizing solids of revolution.* **John W Hoggard**, Edinboro University of Pennsylvania (1056-R5-1482)

9:00AM (1592) *Visualizing the Popcorn Box.* **Ami Mamolo***, York University, Toronto, and **Walter Whiteley**, York University (1056-R5-1268)

9:20AM ► (1593) *Spatial Visualization: Is There a Gender Difference?* **Terri L. Bennett**, Southern CT State University (1056-R5-1256)

SIAM Minisymposium on New Trends in Mathematical Biology

8:00 AM – 10:55 AM

Organizers: **Mariel Vazquez**, San Francisco State University

Javier Arsuaga, San Francisco State University

8:00AM (1594) *Strings, Trees, and RNA Folding.* **Christine E Heitsch**, Georgia Institute of Technology (1056-92-1911)

8:30AM (1595) *The Other Half of Our Genome.* **Jun S Song**, UC San Francisco (1056-92-1133)

9:00AM (1596) *Topological methods for mapping biological data sets.* **Gunnar Erik Carlsson**, Stanford University (1056-92-1701)

9:30AM (1597) *A Multi-type Branching Process Model of Tumor Expansion.* **Jasmine Foo***, **Kevin Leder** and **Franziska Michor**, Sloan Kettering Institute (1056-92-1728)

10:00AM ► (1598) *Analysis of difference topology experiments on a Protein-DNA complex.* **John Luecke***, University of Texas at Austin, **Isabel Darcy**, University of Iowa, and **Mariel Vazquez**, San Francisco State University (1056-58-1965)

10:30AM ► (1599) *Fast Protein Dynamics Simulations: Dominant Pathways for Protein Conformational Transitions.* Preliminary report. **Patrice Koehl***, University of California, Davis, **Joel Franklin**, Reed College, **Sebastian Doniach**, Stanford University, and **Marc Delarue**, Institut Pasteur, Paris, France (1056-65-1945)

AMS Session on Group Theory, III

8:15 AM – 10:55 AM

8:15AM (1600) *Fundamental domains for congruence subgroups of SL_2 in positive characteristic.* **Lisa Carbone**, Rutgers University, **Leigh Cobbs***, Lebanon Valley College, and **Scott Murray**, University of Sydney (1056-22-203)

8:30AM (1601) *Homomorphisms on compact subsets of βS.* **Neil Hindman***, Howard University, and **Dona Strauss**, University of Leeds (1056-22-311)

8:45AM (1602) *Whittaker Modules for a Lie Algebra of Block Type.* **Bin Wang**, Changshu Institute of Technology, Changshu, China, and **Xinyun Zhu***, University of Texas of Permian Basin (1056-22-348)

9:00AM (1603) *Members of sums of idempotents in $\beta\mathbb{N}$.* Preliminary report.
Kendall Williams, Howard University (1056-22-724)

9:15AM (1604) *Hyperreflection groups.*
David G Radcliffe, Century College (1056-20-1895)

9:30AM (1605) *Zeta Functions of Complexes Arising from PGL_n.*
Ming-Hsuan Kang, Pennsylvania State University (1056-20-139)

9:45AM (1606) *On solvable minimal non-p-closed and non-p-exponent closed groups.*
Luise-Charlotte Kappe, **Marcin Mazur**, Binghamton University, **Gabriela Mendoza**, Riverside Community College, and **Michael B. Ward***, Western Oregon University (1056-20-877)

10:00AM (1607) *On simple minimal non-p-closed and non-p-exponent closed groups.*
Luise-Charlotte Kappe*, **Marcin Mazur**, Binghamton University, **Gabriela Mendoza**, Riverside Community College, and **Michael B Ward**, Western Oregon University (1056-20-1247)

10:15AM (1608) *The Hausdorff dimension of limit sets of subgroups of Kleinian groups.*
Andrew Lazowski, Wesleyan University (1056-00-1171)

10:30AM (1609) *The descent spectral sequence for SL_2 and PSL_2.*
Rebecca E Field, James Madison University (1056-55-2135)

10:45AM (1610) *The Generalized Burnside and Representation Rings.*
Eric B. Kahn, Bloomsburg University (1056-55-727)

AWM Workshop

8:20 AM – 4:30 PM

This session has several parts that will be listed separately by time in this program. All presentations are open to all JMM participants.

AMS Special Session on Permutations, I

8:30 AM – 10:50 AM

Organizers: **Persi Diaconis**, Stanford University
Ira M. Gessel, Brandeis University
Richard P. Stanley, Massachusetts Institute of Technology

8:30AM (1611) *Flag descents and P-partitions.*
Ira M. Gessel, Brandeis University (1056-05-1512)

► 9:00AM (1612) *Descents and drops of permutations.* Preliminary report.
Fan Chung, UC San Diego, **Anders Claesson**, Reykjavik Univ., **Mark Dukes**, Univ. of Iceland, and **Ron Graham***, UC San Diego (1056-05-1787)

9:30AM (1613) *Eulerian quasisymmetric functions.*
John Shareshian*, Washington University, and **Michelle L Wachs**, University of Miami (1056-05-1607)

10:00AM (1614) *Eulerian quasisymmetric functions and cyclic sieving.*
Bruce Sagan, Michigan State University, **John Shareshian**, Washington University, and **Michelle L Wachs***, University of Miami (1056-05-1888)

10:30AM (1615) *Combinatorial interpretations for γ-vectors.*
T. Kyle Petersen*, DePaul University, and **Eran Nevo**, Cornell University (1056-05-457)

MAA Session on General Contributed Papers, XI

8:30 AM – 10:25 AM

Organizers: **Eric S. Marland**, Appalachian State University
Daniel J. Curtin, Northern Kentucky University

8:30AM (1616) *Mathematics and English: A Joint Venture.*
Amanda I Beecher*, **Hilary DeRemigio** and **Gerald Kobylski**, United States Military Academy at West Point (1056-Z1-876)

8:45AM (1617) *Geometric Transformations in Design and Their Self-assembling and Self-organizing Structures.*
Fatma Mete, Cornell University (1056-Z1-1837)

► 9:00AM (1618) *An investigation of attribution theory with College Algebra students via Mathematics Attribution Scale (MAS): Implications to Teaching and Learning Undergraduate Mathematics.*
Jerry C. Obiekwe, The university of Akron-Wayne College (1056-Z1-948)

9:15AM (1619) *Getting pumped for math: An investigation of student motivations.*
Fabiana Cardetti* and **P. Joseph McKenna**, University of Connecticut (1056-Z1-1574)

► 9:30AM (1620) *The Mathematicians Roll With GEAR-UP.* Preliminary report.
Edward D Smith, Pima Community College (1056-Z1-1304)

► 9:45AM (1621) *Mentoring Underrepresented Students in Science and Mathematics.* Preliminary report.
Rebekah Dupont, Augsburg College (1056-Z1-1687)

► 10:00AM (1622) *Over 20 Years of Success in the Emerging Ethnic Engineers Program at the University of Cincinnati.*
Joy Moore* and **Kenneth Simonson**, University of Cincinnati (1056-Z1-1986)

► 10:15AM (1623) *A Comparative Study of Online and Traditional Classroom Learning of College Algebra for Non-Traditional Students in Non-Traditional Higher Education Programs.*
Darcel H Ford, Strayer University (1056-Z1-1924)

AWM Workshop: Research Presentations by Recent Ph.D.s, I

8:30 AM – 10:20 AM

8:30AM (1624) *Families over special base manifolds and a conjecture of Campana.*
Kelly Jabbusch* and **Stefan Kebekus**, University of Freiburg (1056-14-169)

9:00AM (1625) *Shift Automorphism Varieties Are Not Residually Finite.*
Kate S Owens, College Station, TX (1056-08-213)

9:30AM (1626) *Oscillation Criteria for Second Order Linear Delay Dynamic Equations.* Preliminary report.
Raegan Higgins, Texas Tech University (1056-39-118)

10:00AM (1627) *An obstruction to slicing iterated Bing doubles.*
Cornelia A. Van Cott, University of San Francisco (1056-57-216)

AMS Committee on Education Panel Discussion

8:30 AM – 10:00 AM

The common core State Standards: Will they become our national K–12 math curriculum?
Moderator: **Lawrence Gray**, University of Minnesota

MAA Session on General Contributed Papers, X

8:45 AM – 10:40 AM

Organizers: **Eric S. Marland**, Appalachian State University
Daniel J. Curtin, Northern Kentucky University

8:45AM ► (1628) *A Matrix Approach to Linear Statistical Models.* Preliminary report.
David R Gurney, Southeastern Louisiana University (1056-Z1-578)

9:00AM ► (1629) *Utilizing Web-based Statistical Resources in Teaching Nontraditional Undergraduate Students in Online Learning Environments.*
Michael D. Miner, American Public University System (1056-Z1-1896)

9:15AM ► (1630) *Using Authentic Discovery Projects to Improve Student Outcomes in Statistics.* Preliminary report.
Dianna J Spence*, **A. Robb Sinn** and **Brad Bailey**, North Georgia College & State University (1056-Z1-734)

9:30AM ► (1631) *The Extended Law of Total Probability.* Preliminary report.
Zengxiang Tong* and **Zhen Huang**, Otterbein College (1056-Z1-351)

9:45AM ► (1632) *Integrating Mathematical Modeling into Science and Mathematics Curricula in Challenged School Districts.*
Molli R. Jones, Immaculata University (1056-Z1-797)

10:00AM ► (1633) *A Transition Course From Advanced Placement to College Calculus.*
Timothy A Lucas*, Pepperdine University, and **Joseph Spivey**, Wofford College (1056-Z1-1107)

10:15AM ► (1634) *Does Peer Assessment Help Improve Mathematical Writing for Pre-Service Elementary and Middle School Teachers?*
Cheryl Beaver and **Scott Beaver***, Western Oregon University (1056-Z1-1502)

10:30AM (1635) *A Taxonomic Analysis of Standard Calculus Tasks: Bloom in Calculus Education.* Preliminary report.
Gizem Karaali, Pomona College (1056-Z1-25)

AMS Invited Address

9:00 AM – 9:50 AM

(1636) *Evolution problem in General Relativity.*
Igor Y. Rodnianski, Princeton University (1056-83-7)

ASL Invited Address

9:00 AM – 9:50 AM

(1637) *Decidability and Undecidability in Theories of Real Vector Spaces.*
John Harrison, Intel Corporation, JF1-13 (1056-03-75)

MAA Minicourse #10: Part B

9:00 AM – 11:00 AM

The hitchhiker's guide to mathematics.
Organizers: **Dan Kalman**, American University
Bruce F. Torrence, Randolph Macon College

MAA Minicourse #3: Part B

9:00 AM – 11:00 AM

Educating about the state of the planet and sustainability while enhancing calculus.
Organizer: **Thomas J. Pfaff**, Ithaca College

MAA Minicourse #8: Part B

9:00 AM – 11:00 AM

The Fibonacci and Catalan numbers.
Organizer: **Ralph Grimaldi**, Rose-Hulman Institute of Technology

Student Hospitality Center

9:00 AM – 2:00 PM

MAA Committee for the Teaching of Undergraduate Mathematics Panel Discussion

9:00 AM – 10:20 AM

Beyond grading and tutoring: New approaches to students helping students.
Organizers: **Daniel E. Flath**, Macalester College
Lewis D. Ludwig, Denison University
Steven R. Benson, Lesley University
Panelists: **Sonny Painter**, University of Missouri-Kansas City
Karen Saxe, Macalester College
Catherine A. Beneteau, University of South Florida

NAM Panel Discussion

9:00 AM – 9:50 AM

Exhibits and Book Sales

9:00 AM – NOON

Employment Center

9:00 AM – NOON

AMS Session on Real and Special Functions

9:15 AM – 10:55 AM

9:15AM (1638) *Solution for nonlinear initial-value problems via orthogonal functions.*
Mohsen Razzaghi, Mississippi State University (1056-33-369)

9:30AM (1639) *Resultants of Chebyshev Polynomials.*
Jemal Emina Gishe*, Western Kentucky University, and **Mourad E. H. Ismail**, University of Central Florida (1056-33-899)

9:45AM (1640) *Representations of quantum group $U_q(so(n))$ and q-orthogonal polynomials.*
Alexander Rozenblyum, New York City College of Technology, CUNY (1056-33-922)

10:00AM ► (1641) *Subpolynomial and Subexponential Functions.* Preliminary report.
Houshang H. Sohrab, Towson University (1056-26-46)

10:15AM (1642) *On the Hilbert Transform of a Measure.*
Maxim Zinchenko, Caltech (1056-26-104)

10:30AM *Aspects of Stochastic Quasi-Cantoresque Sets.*
► (1643) Preliminary report.
Padraig M. McLoughlin*, Kutztown University of Pennsylvania, and **Christopher R. Krizan**, Auburn University (1056-26-613)

10:45AM *An analogue of L'Hospital's rule.*
► (1644) **J Marshall Ash**, DePaul University (1056-26-1354)

ASL Invited Address

10:00 AM – 10:50 AM

(1645) *Tukey Reducibility as a Setup for Classifying Mathematical Structures.*
Stevo Todorcevic, Universite Paris 7 - C.N.R.S., and University of Toronto (1056-03-73)

NAM Business Meeting

10:00 AM – 10:50 AM

MAA Invited Address

10:05 AM – 10:55 AM

(1646) *Symplectic embeddings and continued fractions.*
Dusa McDuff, Barnard College, Columbia University (1056-A0-5)

AWM Workshop: Poster Session with Presentations from Women Graduate Students

10:30 AM – 11:00 AM

10:30AM (1647) *Siphons in biochemical reaction systems: an algebraist's point of view.*
Anne Shiu* and **Bernd Sturmfels**, University of California Berkeley (1056-13-98)

10:30AM (1648) *Backward-iteration sequences and boundary repelling fixed points in higher dimension.*
Preliminary report.
Olena Ostapyuk, Kansas State University (1056-30-147)

10:30AM (1649) *Invariance and Automorphisms of the Computably Enumerable Sets.*
Rachel Epstein, University of Chicago (1056-03-159)

10:30AM ► (1650) *A bijection between partially directed paths in the symmetric wedge and matchings.*
Svetlana Poznanović, Texas A&M University (1056-05-162)

10:30AM (1651) *Point Parameter Rings.*
Chelsea M Walton, University of Michigan (1056-00-164)

10:30AM (1652) *Direct-sum decompositions of modules over rings of infinite Cohen-Macaulay type.*
Silvia Saccon, University of Nebraska-Lincoln (1056-13-180)

10:30AM (1653) *A partial generalization of the Gross-Kohnen-Zagier theorem to higher weight modular forms.*
Kimberly Hopkins, University of Texas at Austin (1056-11-193)

10:30AM (1654) *The core and the adjoint: a condition for equality.*
Angela L Kohlhaas, University of Notre Dame (1056-13-196)

10:30AM (1655) *What is a $\mathbb{Q}$ curve?*
Ekin Ozman, University of Wisconsin-Madison (1056-11-197)

10:30AM (1656) *Ihara Zeta Functions and Some Ramified Covers of Graphs.*
Beth Malmskog*, Colorado State University, and **Michelle Manes**, University of Hawaii (1056-05-199)

10:30AM (1657) *The Abelian-Nonabelian Correspondence in Gromov-Witten Theory.*
Kaisa E Taipale, University of Minnesota (1056-14-212)

10:30AM (1658) *Computable distributive lattices and Heyting algebras.*
Amy Turlington, University of Connecticut (1056-03-214)

10:30AM ► (1659) *The most interesting surface homeomorphisms.*
Chia-Yen Tsai, University of Illinois at Urbana-Champaign (1056-57-218)

10:30AM (1660) *Toric models of graphs.*
Weronika J Buczynska, Texas A&M University (1056-14-220)

10:30AM (1661) *On stable states in a coupled energetic model for incompressible nematic elastomers.*
Andrea Catalina Rubiano, Purdue University (1056-35-235)

10:30AM (1662) *Approximating invariant densities of metastable systems.*
Cecilia Gonzalez Tokman, University of Maryland (1056-37-977)

MAA Business Meeting

11:10 AM – 11:40 AM

Organizer: **Martha J. Siegel**, Towson University
Moderator: **David M. Bressoud**, Macalester College

AMS Business Meeting

11:45 AM – 12:15 PM

NAM Claytor-Woodard Lecture

1:00 PM – 2:00 PM

(1663) *The Impact of Periodic Proportional Harvesting Policies on TAC-Regulated Fishery Systems.*
Abdul-Aziz Yakubu, Howard University (1056-92-1763)

AMS-MAA-SIAM Special Session on Research in Mathematics by Undergraduates, IV

1:00 PM – 5:50 PM

Organizers: **Darren Narayan**, Rochester Institute of Technology
Bernard Brooks, Rochester Institute of Technology
Jacqueline Jensen, Sam Houston State University
Carl V. Lutzer, Rochester Institute of Technology
Vadim Ponomarenko, San Diego State University
Tamas Wiandt, Rochester Institute of Technology

1:00PM ► (1664) *Computer-Created Human-Comprehensible Logic Games.* Preliminary report.
Corneliu A. Bodea, **Arthur Charlesworth**, **Diana A. Iovan** and **Andrew D. Jones***, University of Richmond (1056-03-105)

1:30PM ► (1665) *The Spread of A Rumor.* Preliminary report.
Nick C Fedewa*, **Emily E Krause**, **Alexandra M Sisson** and **James R Angelos**, Central Michigan University (1056-00-106)

2:00PM ► (1666) *Structural Adaptation of Microvascular Networks.* Preliminary report.
Rachel S Nancollas* and **Benjamin Y Small**, Franklin W. Olin College of Engineering (1056-92-132)

2:30PM ► (1667) *The Relative Gain Array of Cayley Graphs.*
Sara D. Townsend*, **Suzi Gearheart** and **John Owen**, Sam Houston State University (1056-05-134)

3:00PM ► (1668) *Analysis of the Repackaging of Risk in the Sub-Prime Mortgage Crisis.* Preliminary report.
Angela King*, McGill University, **Adam Biesenbach**, University of Rochester, and **Kuni Natsuki**, Brown University (1056-91-138)

3:30PM (1669) *Matroids, Geometry, Symmetry and the 4th Dimension.*
Chencong Bao, Lafayette College, **Camila Friedman-Gerlicz**, Claremont McKenna, **Peter McGrath***, Lafayette College, and **Jessica Vega**, Loyola Marymount (1056-05-146)

4:00PM ► (1670) *Classical and Virtual Pseudodiagram Theory and New Bounds on the Unknotting Numbers and Genus of Knots.*
Allison Henrich, Seattle University, **Noël MacNaughton**, Williams College, **Sneha Narayan**, **Oliver Pechenik**, Oberlin College, and **Jennifer Townsend***, Scripps College (1056-57-148)

4:30PM (1671) *Excellent Local Rings with Semi-Local Formal Fibers.*
R. Karpman*, Scripps College, **N. Arnosti**, Williams College, **C. Leverson**, Wellesley College, **J. Levinson** and **S. Loepp**, Williams College (1056-13-179)

5:00PM ► (1672) *Time to Failure: A Stochastic Model of the Formation and Development of Abdominal Aortic Aneurysms.* Preliminary report.
Jeremy E Brooks, East Tennessee State University (1056-92-325)

5:30PM ► (1673) *A Knot or Not a Knot?* Preliminary report.
Karleigh Frederick, **Samantha Hilker** and **Megan Savage***, Sam Houston State University (1056-55-1201)

AMS-MAA Special Session on History of Mathematics, III

1:00 PM – 5:50 PM

Organizers: **Craig Fraser**, University of Toronto
Deborah Kent, Hillsdale College
Sloan Despeaux, Western Carolina University

1:00PM ► (1674) *Euler, Dilog, and Zeta(2).*
Dan Kalman*, American University, and **Mark McKinzie**, St. John Fisher College (1056-01-849)

1:30PM (1675) *The Genesis of Generating Functions in Abraham De Moivre's Work.*
David R Bellhouse, University of Western Ontario (1056-01-278)

2:00PM ► (1676) *What is a Great Book? A Case Study of Legendre's Éléments de Géométrie (1794) and Playfair's Elements of Geometry (1795).*
Amy Ackerberg-Hastings, University of Maryland University College (1056-01-625)

2:30PM ► (1677) *Understanding Early Laplacian Simplifications.* Preliminary report.
Menolly Lysne, Simon Fraser University (1056-01-1072)

3:00PM ► (1678) *Maxwell, Poincaré and the Rings of Saturn.* Preliminary report.
Tom Archibald, Simon Fraser University (1056-01-254)

3:30PM (1679) *The n-body problem in spaces of constant curvature.*
Florin N. Diacu, University of Victoria (1056-01-393)

4:00PM ► (1680) *Italian Mathematics and Mechanics Between the 18th and 19th Centuries.*
Sandro Caparrini, Institute for the History and Philosophy of Science and Technology, Toronto ON, Canada (1056-01-1596)

4:30PM (1681) *Federigo Enriques' Obsession: A Tale from Italian Algebraic Geometry.* Preliminary report.
Donald Babbitt*, UCLA, and **Judith Goodstein**, Einstein Papers Project, Cal Tech (1056-01-306)

5:00PM ► (1682) *Pinning Down Outliers: 19th Century Stabs at Exact Probabilities for Rare Events.* Preliminary report.
Byron E. Wall, York University (1056-01-548)

5:30PM ► (1683) *If Brute Force Does Not Work You Are Not Using Enough: the rise of Numerical Integration in 20th Century Astronomy.*
Allan D. G. Olley, University of Toronto - IHPST (1056-01-1124)

AMS-SIAM Special Session on Applications of Algebraic Geometry, II

1:00 PM – 5:50 PM

Organizers: **Frank Sottile**, Texas A&M University
Luis Garcia-Puente, Sam Houston State University

1:00PM ► (1684) *ArtinProver: a truly hybrid symbolic/numeric global optimization algorithm.* Preliminary report.
Erich Leo Kaltofen*, North Carolina State University, **Zhengfeng Yang**, East China Normal University, Shanghai, China, and **Lihong Zhi**, Academy of Mathematics and Systems Science, Beijing, China (1056-14-1157)

1:30PM ► (1685) *Experimentation at the Frontiers of Reality in Schubert Calculus.*
Chris Hillar, MSRI, **Luis García-Puente**, Sam Houston State University, **Abraham Martín del Campo**, Texas A&M University, **James Ruffo**, SUNY Oneonta, **Stephen L. Johnson**, **Zach Teitler*** and **Frank Sottile**, Texas A&M University (1056-14-396)

2:00PM ► (1686) *Nested canalyzing polynomial dynamical systems.* Preliminary report.
Reinhard Laubenbacher*, Virginia Bioinformatics Institute, and **David Murragarra**, Virginia Polytechnic Institute and State University (1056-92-1524)

2:30PM (1687) *Computing siphons in biochemical reaction systems.*
Anne Shiu* and **Bernd Sturmfels**, University of California Berkeley (1056-13-2006)

3:00PM (1688) *A persistence tree-based method for calling peaks in ChIP-seq protein binding analysis.*
Valerie Hower* and **Lior Pachter**, University of California, Berkeley (1056-92-1506)

3:30PM (1689) *Algebraic geometry of Gaussian graphical models.*
Seth Sullivant, North Carolina State University (1056-14-1155)

4:00PM (1690) *On a parametrization of positive semidefinite matrices with zeros.*
Mathias Drton*, University of Chicago, and **Josephine Yu**, MSRI, Berkeley, CA (1056-15-1159)

4:30PM Discussion

5:00PM ► (1691) *The convex algebraic geometry of rank minimization.*
Pablo A Parrilo, Massachusetts Institute of Technology (1056-90-2136)

5:30PM (1692) *Orbitopes.*
Raman Sanyal, UC Berkeley, **Frank Sottile**, Texas A&M University, and **Bernd Sturmfels***, UC Berkeley (1056-14-424)

AMS Special Session on Biomathematics: Modeling in Biology, Ecology, and Epidemiology, III

1:00 PM – 5:50 PM

Organizers: **Olcay Akman**, Ilinois State University
Linda Allen, Texas Tech University
Timothy D. Comar, Benedictine University
Sophia Jang, Texas Tech University
Lih-Ing Roeger, Texas Tech University

1:00PM (1693) *Effect of host heterogeneity on the coevolution of parasite and host.*
Yiding Yang*, **Zhilan Feng**, Purdue University, **Dashun Xu**, Southern Illinois University, Carbondale, and **Dennis Minchella**, Department of Biological Sciences, Purdue University (1056-92-1396)

1:30PM ► (1694) *Is the resurgence of syphilis a backward bifurcation?*
Ruijun Zhao*, Purdue University, and **Fabio A. Milner**, Arizona State University (1056-92-1239)

2:00PM (1695) *A comparison of spatial interactions at different scales.*
Andrew L Nevai*, University of Central Florida, and **Benjamin M Bolker**, University of Florida (1056-92-1839)

2:30PM (1696) *Construction and Analysis of a New SIR Model.*
Ronald E. Mickens* and **Sandra Rucker**, Clark Atlanta University (1056-92-416)

3:00PM (1697) *Dynamically consistent discrete-time Lotka-Volterra models.* Preliminary report.
Lih-Ing W Roeger, Texas Tech University (1056-39-347)

3:30PM (1698) *Infectious diseases in amphibians: adults as reservoir for epidemics in larvae.*
Thanate Dhirasakdanon* and **Horst R. Thieme**, Arizona State University (1056-92-413)

4:00PM ► (1699) *Mathematical Modeling of Data describing Worker Bee Aggression towards a Foreign Queen.*
Suzanne Sumner* and **Wyatt A. Mangum**, University of Mary Washington (1056-92-501)

4:30PM ► (1700) *Discrete hierarchical competition with reward and cost of dispersion.*
Jemal S. Mohammed-Awel*, Valdosta State University, **Kbenesh W. Blayneh**, Florida A&M University, and **Abdul-Aziz Yakubu**, Howard University (1056-92-43)

5:00PM ► (1701) *Biological Data Mining and Analysis.* Preliminary report.
Alice L. Loth, University of Massachusetts, Dartmouth (1056-92-1834)

5:30PM (1702) *Parameter Estimation and Uncertainty Quantification for an Epidemic Model.*
Alex Capaldi*, Center for Quantitative Sciences in Biomedicine and Department of Mathematics North Carolina State University, and **A. L. Lloyd**, Graduate Program in Biomathematics and Department of Mathematics North Carolina State University (1056-92-730)

AMS Special Session on Categorical and Algebraic Methods in Representation Theory, II

1:00 PM – 5:50 PM

Organizers: **Jon Brundan**, University of Oregon
Julia Pevtsova, University of Washington
Eric Friedlander, University of Southern California

1:00PM (1703) *A problem of Kollár and Larsen on finite linear groups and crepant resolutions.* Preliminary report.
Robert M. Guralnick, University of Southern California, and **Pham Huu Tiep***, University of Arizona (1056-20-722)

1:30PM (1704) *Associated variety of simple finite-dimensional modules over classical Lie superalgebras and Kac-Wakimoto conjecture.* Preliminary report.
Vera Serganova, UC Berkeley (1056-16-927)

2:00PM (1705) *Categorifying quantum groups.*
Aaron D Lauda, Columbia University (1056-16-857)

2:30PM (1706) *On Khovanov-Lauda algebras.*
Aaron Lauda, Columbia University, and **Monica Vazirani***, UC Davis (1056-05-479)

3:00PM (1707) *Representations of Khovanov-Lauda-Rouquier algebras and combinatorics of Lyndon words.*
Alexander Kleshchev*, University of Oregon, and **Arun Ram**, University of Melbourne (1056-17-464)

3:30PM (1708) *Categorification via Quiver Varieties.*
Anthony Licata*, Stanford, **Sabin Cautis**, Columbia, and **Joel Kamnitzer**, University of Toronto (1056-14-524)

4:00PM (1709) *Blocks in Deligne's category* $Rep(S_t)$.
Victor Ostrik, University of Oregon (1056-20-502)

4:30PM (1710) *Generalized Trace and Dimension Functions in Ribbon Categories.*
Nathan Geer, Utah State University, **Jonathan Kujawa***, University of Oklahoma, and **Bertrand Patureau-Mirand**, Université de Bretagne-Sud (1056-17-238)

5:00PM (1711) *On quantum foldings.* Preliminary report.
Arkady Berenstein, University of Oregon, Eugene, and **Jacob Greenstein***, University of California, Riverside (1056-17-1394)

5:30PM (1712) *Colored tangle invariants and quantum sl(2) categorification.*
Joshua Sussan, University of California Berkeley (1056-16-1509)

AMS Special Session on Differential Galois Theory and Group Representations: A Tribute to Andy Magid, II

1:00 PM – 5:50 PM

Organizers: **James Carrell**, University of British Columbia
Lourdes Juan, Texas Tech University
Alex Lubotzky, Hebrew University
Brian Parshall, University of Virginia
Marius van der Put, University of Groningen

1:00PM (1713) *Iterated Antiderivative Extensions.* Preliminary report.
V. Ravi Srinivasan, Rutgers University-Newark (1056-12-429)

1:30PM (1714) *Some 1- and n-cohomology results for finite and algebraic groups.*
Leonard L Scott, The University of Virginia (1056-20-1001)

2:00PM (1715) *Support varieties and complexity for algebraic, finite, and quantum groups.* Preliminary report.
Brian Parshall, University of Virginia (1056-20-861)

2:30PM (1716) *A Survey On Representation Zeta Functions.*
Nir Avni, Harvard University (1056-20-782)

3:00PM (1717) *Analogies between differential Galois theory and additive Galois structure theory.* Preliminary report.
Ted Chinburg*, University of Pennsylvania, **Lourdes Juan**, Texas Tech University, and **Andy Magid**, University of Oklahoma (1056-16-1103)

3:30PM (1718) *On a remarkable formula of Kostant and Macdonald, pattern avoidance and smoothness of Schubert varieties in a generalized flag variety.*
Jim Carrell, University of British Columbia (1056-14-1126)

4:00PM (1719) *Groups defined by arithmetic differential equations.*
Alexandru Buium, University of New Mexico (1056-11-384)

4:30PM (1720) *On subgroup induction in group representation and group cohomology.*
Eli Aljadeff* and **Ehud Meir**, Technion-Israel Institute of Technology (1056-20-592)

5:00PM (1721) *The Hall index of a subgroup of a free group.*
Shmuel Rosset, Mathematics, Tel Aviv University, Israel. (1056-20-1204)

5:30PM (1722) *Some Problems in Galois Theory and Representation Theory.* Preliminary report.
Andy R. Magid, University of Oklahoma (1056-13-1259)

AMS Special Session on Harmonic Analysis and Representations of Reductive p-adic Groups, II

1:00 PM – 5:50 PM

Organizers: **Robert Doran**, Texas Christian University
Paul Sally, University of Chicago
Loren Spice, Texas Christian University

1:00PM (1723) *Tame supercuspidal representations of* GL(n) *distinguished by orthogonal groups.*
Joshua M Lansky* and **Jeffrey L Hakim**, American University (1056-22-1764)

1:30PM (1724) *Tamely ramified tori.* Preliminary report.
Jeffrey D Adler*, American University, and **Stephen M. DeBacker**, University of Michigan (1056-22-1820)

2:00PM (1725) *On the Heisenberg groups and Weil representations in characteristic 2.* Preliminary report.
Jiu-Kang Yu, Purdue University (1056-22-2018)

2:30PM (1726) *Revisiting the Local Langlands Correspondence for GL(n,F), n a prime.*
Moshe Adrian, University of Maryland (1056-11-337)

3:00PM (1727) *Some irreducible representations of SL(2,O), where O is the integer ring of a p-adic field.* Preliminary report.
Monica Nevins, University of Ottawa, Canada (1056-22-1293)

3:30PM (1728) *An application of Gamma asymptotic expansions.* Preliminary report.
Ju-Lee Kim, MIT (1056-22-1435)

4:00PM (1729) *Motivic integration and Harish-Chandra characters.* Preliminary report.
Raf Cluckers, University of Lille, **Clifton Cunningham**, University of Calgary, **Julia Gordon***, University of British Columbia, and **Loren Spice**, Texas Christian University (1056-22-1046)

4:30PM (1730) *Distinguished representations of reductive p-adic groups.* Preliminary report.
Fiona Murnaghan, University of Toronto (1056-22-463)

5:00PM (1731) *An Integral Formula of Shahidi.*
Steven T Spallone, University of Oklahoma (1056-22-829)

5:30PM (1732) *On the Langlands-Shahidi method for the classical groups in non-zero characteristic and applications.* Preliminary report.
Luis Alberto Lomeli, The University of Iowa (1056-22-117)

AMS Special Session on Integrability of Dynamical Systems and Solitons Equations, II

1:00 PM – 5:50 PM

Organizers: **Zhijun Qiao**, University of Texas-Pan American
Taixi Xu, Southern Polytechnic State University
Wenxiu Ma, University of South Florida

1:00PM (1733) *Solitons, boundary value problems and a nonlinear method of images.*
Gino Biondini*, SUNY at Buffalo, and **Guenbo Hwang**, University of Vermont (1056-35-1722)

1:30PM (1734) *The exact solutions of Lund-Regge equation and its soliton surfaces.*
Chunli Chen, Shanghai Jiao Tong University (1056-35-1498)

2:00PM (1735) *A Detailed Bifurcation Diagram and Semi-Analytic Solutions of the Forced Korteweg-de Vries Equation.*
Aaron S. Donahue and **Samuel S. P. Shen***, San Diego State University (1056-35-725)

2:30PM (1736) *Peakons of b-family and Qiao Equations.* Preliminary report.
Taixi Xu, Southern Polytechnic State University (1056-35-1606)

3:00PM (1737) *On the Lagrangian Description of Discrete Integrable Systems.* Preliminary report.
Anton Dzhamay, University of Northern Colorado (1056-39-1943)

3:30PM ► (1738) *Symmetries and algebras for a MKdV-type equation in (2+1)-dimension.* Preliminary report.
Jun Yu, Institute of Nonlinear Science, Shaoxing University (1056-35-686)

4:00PM ► (1739) *Optical soliton perturbation by He's variational principle.*
Anjan Biswas, Delaware State University (1056-78-582)

4:30PM (1740) *A Novel Adaptive Method for SAR Jamming Suppression.* Preliminary report.
Feng Zhou*, **Guangcai Sun**, **Xueru Bai** and **Mengdao Xing**, National Key Laboratory for Radar Signal Processing (1056-78-864)

5:00PM (1741) *Study on ISAR imaging of steadily moving targets with large observation angles.* Preliminary report.
Xueru Bai*, **Mengdao Xing**, **Feng Zhou** and **Zheng Bao**, National Key lab. for radar signal processing (1056-78-708)

5:30PM ► (1742) *PDE Analysis and Cross-Range Imaging of Synthetic Aperture Radar.* Preliminary report.
Zhijun Qiao*, **Jaime Lopez** and **Guillermo Garza**, Univ Texas - Panam (1056-35-765)

AMS Special Session on Optimal Frames and Operator Algebras, II

1:00 PM – 5:50 PM

Organizers: **David Larson**, Texas A&M University
Deguang Han, University of Central Florida
Shidong Li, San Francisco State University

1:00PM (1743) *Dual Gramian Analysis and its development.*
Zuowei Shen, National University of Singapore (1056-41-770)

1:30PM (1744) *Can one hear the shape of a fractal?*
Dorin Dutkay, University of Central Florida (1056-46-781)

2:00PM (1745) *Irregular Gabor tight frames associated with rough windows.* Preliminary report.
Jean-Pierre Gabardo, McMaster University (1056-42-819)

2:30PM (1746) *A Quantitative Notion of Redundancy.*
Peter Casazza, University of Missouri, and **Gitta Kutyniok***, University of Osnabrueck (1056-42-854)

3:00PM (1747) *Gabor frames and Strichartz estimates.* Preliminary report.
Kasso A. Okoudjou, University of Maryland (1056-41-906)

3:30PM (1748) *Function spaces and representations.*
Gestur Olafsson*, Louisiana State University, and **Jens Christensen**, University of Maryland and the Norbert Wiener Center (1056-46-1079)

4:00PM (1749) *Perturbations of finite frames and projections.*
Victor Kaftal*, University of Cincinnati, and **David R. Larson**, Texas A&M University (1056-47-1084)

4:30PM (1750) *Classification of filter systems giving rise to generalized multiresolution analyses.* Preliminary report.
Judith A Packer, University of Colorado at Boulder (1056-42-1087)

5:00PM (1751) *Spectral sets for $\frac{1}{2n}$-Bernoulli convolutions.*
Keri Kornelson*, University of Oklahoma, **Palle Jorgensen**, University of Iowa, and **Karen Shuman**, Grinnell College (1056-47-1091)

5:30PM (1752) *Regularity for exact Gabor systems on a lattice.*
Alexander Powell*, Vanderbilt University, and **Christopher Heil**, Georgia Institute of Technology (1056-42-1145)

AMS Special Session on Parabolic Geometries, Integrable Systems, and Twistor Theory, II

1:00 PM – 5:50 PM

Organizers: **Dana Mihai**, Carnegie Mellon University
Jonathan Holland, University of Pittsburgh
George Sparling, University of Pittsburgh

1:00PM (1753) *Generic rank two distributions on five-manifolds and associated conformal structures.*
Katja Sagerschnig, University of Vienna, Austria (1056-53-792)

1:30PM (1754) *Symplectification, Generalized Tanaka Prolongations, and Geometry of Distributions.* Preliminary report.
Igor Zelenko, Texas A&M University (1056-53-805)

2:00PM (1755) *Local twistors and the conformal field equations.*
Jörg Frauendiener, University of Otago (1056-53-375)

3:00PM (1756) *Third order odes and conformal Finsler geometries.*
Jonathan E Holland, University of Pittsburgh (1056-53-593)

3:30PM (1757) *Variational calculus in non-commutative frames.* Preliminary report.
Irina A Kogan, North Carolina State University (1056-53-551)

4:00PM ► (1758) *Non-compact Hopf Maps, Quantum Hall Effect, and Twistor Theory.* Preliminary report.
Kazuki Hasebe, Takuma National College of Technology (1056-51-696)

4:30PM (1759) *Integrable models and the gauge/string duality.*
Radu S Roiban, Pennsylvania State University (1056-00-2004)

5:00PM (1760) *The Chern-Moser chains of left-invariant CR structures on SU(2) via Fefferman approach.*
Alex L Castro* and **Richard Montgomery**, UCSC (1056-32-654)

5:30PM (1761) *The exceptional Lie group $\mathbb{G}_2$ and gravity.*
George Arthur Sparling, Laboratory of Axiomatics, University of Pittsburgh (1056-53-1661)

AMS Special Session on Permutations, II

1:00 PM – 5:50 PM

Organizers: **Persi Diaconis**, Stanford University
Ira M. Gessel, Brandeis University
Richard P. Stanley, Massachusetts Institute of Technology

1:00PM ► (1762) *Permutations associated with random interval partitions.* Preliminary report.
Jim Pitman, University of California, Berkeley (1056-05-1620)

1:30PM (1763) *$n!$ matchings, $n!$ posets.*
Anders Claesson*, The Mathematics Institute, School of Computer Science, Reykjavik University, and **Svante Linusson**, KTH-Royal Institute of Technology (1056-05-1939)

2:00PM ► (1764) *The absence of a given pattern and the number of occurrences of another.*
Miklos Bona, University of Florida (1056-05-932)

2:30PM (1765) *Extension of the d-divisible partition lattice.*
Richard Ehrenborg* and **JiYoon Jung**, University of Kentucky (1056-05-1585)

3:00PM (1766) *Bijective enumeration of permutations starting with a longest increasing subsequence.*
Greta Panova, Harvard University (1056-05-1077)

3:30PM (1767) *From random permutations to random matrices — an alternative for RSK.*
Alexei Borodin, California Institute of Technology (1056-05-2152)

4:00PM ► (1768) *Carries and shuffling.*
Persi Diaconis, Stanford Univeristy, and **Jason Fulman***, University of Southern California (1056-05-1709)

4:30PM (1769) *Distribution of Segment Lengths in Genome Rearrangements.*
Glenn P Tesler, University of California, San Diego (1056-05-2013)

5:00PM *Permutation problems.*
► (1770) **Donald E. Knuth**, Stanford University (1056-05-168)

5:30PM (1771) *How to encipher small messages: Encryption using the Thorp shuffle.*
Ben J Morris*, **Phillip Rogaway** and **Till Stegers**, UC Davis (1056-60-1404)

MAA Minicourse #1: Part B

1:00 PM – 3:00 PM

Remodeling data analysis.
Organizers: **Daniel Kaplan**, Macalester College
Vittorio Addona, Macalester College

MAA Minicourse #5: Part B

1:00 PM – 3:00 PM

Active learning approaches for the foundational mathematics for elementary teachers courses.
Organizers: **Laurie J. Burton**, Western Oregon University
Cheryl Beaver, Western Oregon University
Klay Thomas Kruczek, Western Oregon University

AMS Session on Geometry and Topology, IV

1:00 PM – 5:25 PM

1:00PM (1772) *Weak Solutions to a Degenerate Monge-Ampère Type Equation on Kähler Surfaces.*
Arvind S. Rao, University of Iowa (1056-53-187)

1:15PM (1773) *Low dimensional cohomogeneity one manifolds.*
Corey A. Hoelscher, Rutgers University (1056-53-509)

1:30PM
► (1774) *Duality Properties of Indicatrices of Knots.*
Charmaine Sia, Massachusetts Institute of Technology (1056-53-566)

1:45PM (1775) *Volume of Meromorphic Vector fields on Flat Tori.*
Preliminary report.
Amine Fawaz, The University of Texas of the Permian Basin (1056-53-728)

2:00PM (1776) *Symmetric Almost r-Paracontact Connections.*
Preliminary report.
Andrew Bucki, Langston University (1056-53-1127)

2:15PM Break

2:30PM (1777) *Singular reduction of generalized complex manifolds.*
Timothy E Goldberg, Cornell University (1056-53-1467)

2:45PM (1778) *Behavior of the Chern-Simons forms under the Ricci flow.*
Christopher R Godbout, Lehigh University (1056-53-1720)

3:00PM (1779) *Curvature-adapted hypersurfaces of 2-type in quaternion space forms.*
Ivko M Dimitric, Penn State University Fayette (1056-53-1752)

3:15PM (1780) *Uniqueness of folded symplectic toric manifolds.*
Preliminary report.
Christopher R Lee, University of Portland (1056-53-2066)

3:30PM (1781) *Characteristics of a Classical and Quantum Two-Sphere Singularity.*
Deborah A. Konkowski*, U.S. Naval Academy, and **Thomas M. Helliwell**, Harvey Mudd College (1056-83-884)

3:45PM Break

4:00PM (1782) *Local uniqueness of Minkowski space.*
Didier A. Solis* and **Luis A. Farfan**, Universidad Autonoma de Yucatan (1056-83-1577)

4:15PM (1783) *A spectral notion of Gromov-Wasserstein distances.*
Facundo Memoli, Stanford University, Mathematics (1056-68-440)

4:30PM (1784) *A Mathematical Theory of Stochastic Microlensing.*
Alberto M Teguia*, **Arlie O. Petters**, Duke University, and **Brian Rider**, University of Colorado (1056-83-1767)

4:45PM (1785) *Geometric properties of continued fractions.*
Avraham Bourla, University of Connecticut at Storrs (1056-52-595)

5:00PM (1786) *A new argument for the exactness at the (n+1)-thickening term in the C.T.C Wall's exact sequence for thickenings.*
Mokhtar B. Aouina, Jackson State University (1056-55-1671)

5:15PM *Resolvable maps preserve complete metrizability.*
► (1787) **Su Gao** and **Vincent Kieftenbeld***, University of North Texas (1056-54-408)

AMS Session on Research by Undergraduates, II

1:00 PM – 5:55 PM

1:00PM (1788) *The Fractal Beauty of Byzantine Music.*
Firas Y Hindeleh and **Jessica R Sears***, Grand Valley State University (1056-37-717)

1:15PM
► (1789) *Manifolds with Density as Quotients of Riemannian Manifolds.*
Alexander Diaz, Univeridad de Puerto Rico, Mayaguez, **Nathan Harman***, University of Massachusetts, Amherst, **Sean Howe**, University of Arizona, and **David Thompson**, Williams College (1056-53-101)

1:30PM
► (1790) *Isoperimetric Regions in Planar Sectors with Density r^p.*
Alexander Diaz, University of Puerto Rico, **Nate Harman**, University of Massachusetts - Amherst, **Sean P Howe***, University of Arizona, and **David Thompson**, Williams College (1056-53-100)

1:45PM
► (1791) *The Spherical Stick Index and Compositions of Trefoils.*
Colin Adams, Williams College, **Dan Collins***, Cornell University, **Katherine Hawkins**, Williams College, **Charmaine Sia**, Massachusetts Institute of Technology, **Rob Silversmith**, Williams College, and **Bena Tshishiku**, Washington and Lee University (1056-57-546)

2:00PM
► (1792) *The game chromatic index of trees.*
Charles Dunn, Linfield College, **David Morawski***, University of California, Berkeley, and **Jennifer Nordstrom**, Linfield College (1056-00-435)

2:15PM (1793) *Moduli spaces of low dimensional associative algebras and their deformations.*
Daniel Joseph Wackwitz* and **Michael Robert Penkava**, University of Wisconsin-Eau Claire (1056-16-1344)

2:30PM
► (1794) *Proving Summation Identities: The WZ Method versus Counting.*
Timothy D. Ferdinands, Calvin College & Grand Valley State University REU (1056-05-1545)

2:45PM *An elementary proof of Touchard's Congruence.*
► (1795) **Gregory B Hurst**, University of Illinois at Urbana (1056-05-992)

3:00PM *Competitive Graph Coloring on Outerplanar*
► (1796) *Graphs.* Preliminary report.
Cassandra Naymie*, University of Waterloo, **Charlie Suer**, University of Dayton, and **Erin Pitney**, Beaverton School District (1056-05-1330)

3:15PM *On λ-fold Rosa-type Labelings.*
(1797) **Jeffrey Mudrock***, University of Illinois, Champaign-Urbana, **Lucas Allen**, Morton High School, **Ryan Bunge**, Normal Community High School, **Saad El-Zanati**, **Daniel Gannon**, **Kyle Knee**, Illinois State University, and **Jessica Smith**, Morehead State University (1056-05-1749)

3:30PM *On Cyclic Cycle Plus a Chord Designs.*
► (1798) **Desiree Masters***, Dunlap High School, **Ryan Bunge**, Normal Community High School, **Saad El-Zanati**, Illinois State University, **Theresa Kamykowski**, Loyola University, Chicago, and **Isai Almeida-Arrieta**, Western Michigan University (1056-05-1775)

3:45PM *Minimal Sufficient Sets and the Commutativity of*
► (1799) *Patterns.*
Zhexiu Tu*, Bard College, and **Olivia Walch**, College of William and Mary (1056-15-1428)

4:00PM *Inverse Inertia Problem for Graphs.*
► (1800) **Emily McHenry***, Xavier University, and **Robert Lang**, Florida Atlantic University (1056-15-355)

4:15PM *Sudoku, Shidoku, and . . . Gröbner Bases? An*
► (1801) *Algebraic and Computer Systems Approach to Counting Equivalent Puzzles.* Preliminary report.
Matthew J. Menickelly* and **Katharina M. Carella**, James Madison University (1056-14-1419)

4:30PM *Galois groups via Galois modules in Artin-Schreier*
► (1802) *theory.* Preliminary report.
Jennifer S Berg, University of Illinois at Urbana-Champaign (1056-12-1534)

4:45PM Break

5:00PM *Some Remarks on Diophantine Triples.* Preliminary
► (1803) report.
Xuemei Ye* and **Aklilu Zeleke**, Michigan State University (1056-11-1637)

5:15PM *Rubric-scored Assessments: A Study of Inter-rater*
► (1804) *Reliability.* Preliminary report.
Loree Kim Killebrew* and **Xinyan Yan**, Birmingham-Southern College (1056-62-814)

5:30PM *Steady State Rimming Flow of non-Newtonian Fluid.*
► (1805) **Jared Debrunner***, California State University, Chico, **Anton Mazurenko**, Massachusetts Institute of Technology, **Brent Nelson**, University of Illinois at Urbana-Champaign, and **Sergei Fomin**, California State University, Chico (1056-76-773)

5:45PM *A study of a two species battle between an*
► (1806) *intelligent army and insurgent defenders.*
Nicholas De Meglio, **Rebecca Hager***, **Jorge Wu Mok**, **Matthew Westley**, University at Buffalo, and **Surajit Sen**, Physics Department, University at Buffalo (1056-91-1704)

AMS Session on Discrete Mathematics, VI

1:00 PM – 4:55 PM

1:00PM *Characterizing linear programming*
(1807) *pseudocodewords using graphical methods.*
Nathan Axvig, University of Nebraska-Lincoln (1056-05-1281)

1:15PM *Forbidden Subgraphs in Oriented Line Graphs.*
(1808) **Elizabeth Moseman***, USMA at West Point, and **Chris Storm**, Adelphi University (1056-05-1315)

1:30PM *Some Results On λ-Designs With Two Block Sizes.*
(1809) Preliminary report.
Tariq Akef Alraqad*, Northern State University, and **Mohan Shrikhande**, Central Michigan University (1056-05-1319)

1:45PM *Using Analysis of Algorithms to Derive*
► (1810) *Combinatorial Equalities.*
Amy Mihnea, Florida Atlantic University (1056-05-1377)

2:00PM *Minimal Percolating Sets in Trees.*
(1811) **Eric Riedl**, University of Notre Dame (1056-05-1386)

2:15PM *Intermediate Ordered Colorings of Graphs.*
► (1812) **Darren A Narayan**, Rochester Institute of Technology (1056-05-1139)

2:30PM *Spectra of Coronae.*
► (1813) **C McLeman** and **E M McNicholas***, Willamette University (1056-05-1391)

2:45PM *The Excess Range of Factorizations of Regular*
(1814) *Graphs.* Preliminary report.
Sarah-Marie Belcastro* and **Michael Young**, Smith College (1056-05-1478)

3:00PM Break

3:15PM *A graph-theoretic generalization of the*
(1815) *Erdös-Ko-Rado theorem.*
Vikram M. Kamat* and **Glenn Hurlbert**, Arizona State University (1056-05-1519)

3:30PM *First-Fit coloring of p-tolerance graphs.*
(1816) **Karin R. Saoub***, Roanoke College, and **H. A. Kierstead**, Arizona State University (1056-05-1636)

3:45PM *Spectral Properties of Abelian Gain Graphs.*
(1817) Preliminary report.
Nathan H Reff, Binghamton University (1056-05-1796)

4:00PM *Multigraph Detachments, Hamiltonian*
(1818) *Decompositions and Graph Embeddings.*
M Amin Bahmanian* and **C A Rodger**, Auburn University (1056-05-1806)

4:15PM *A probability method to prove combinatorial*
► (1819) *identities.*
Tong Zhu, University of Pennsylvania (1056-05-1863)

4:30PM *The Hamiltonian decomposition problem for Cayley*
► (1820) *graphs on abelian groups.*
Erik E Westlund, Michigan Technological University (1056-05-1999)

4:45PM *Vertex coloring of graphs by total 2-weightings.*
(1821) **Jonathan Darren Hulgan***, The University of Memphis, **Jeno Lehel**, The University of Memphis; Computer and Automation Research Institute, Hungarian Academy of Sciences, **Kenta Ozeki**, Keio University, and **Kiyoshi Yoshimoto**, Nihon University (1056-05-2083)

AMS Session on Optimization and Control

1:00 PM – 5:25 PM

1:00PM *Generalized Steiner and Schwarz Symmetrization.*
(1822) **Frank Morgan***, Williams College, **Alexander Diaz**, University of Puerto Rico, **Nate Harman**, University of Massachusetts, Amherst, **Sean Howe**, University of Arizona, and **David Thompson**, Williams College (1056-49-401)

1:15PM (1823) *Higher Order Sufficient Conditions for Strict Minimality in Smooth Scalar Optimization.*
Elena Constantin, University of Pittsburgh at Johnstown (1056-49-1049)

1:30PM (1824) *The asymptotic behavior of power-law functionals and applications.*
Cristina Popovici, NDSU (1056-49-1104)

1:45PM (1825) *On the Principle of Smooth Fit for Some Convex Optimal Control Problems.*
Jesus A. Pascal, American University of Nigeria (1056-49-1194)

2:00PM ► (1826) *Optimal Control and its Application to Hepatitis C Treatment.*
Siddartha P. Chakrabarty, Indian Institute of Technology Guwahati, India, and **Hem R Joshi***, Xavier University, Cincinnati OH (1056-49-1645)

2:15PM Break

2:30PM ► (1827) *Application of Nonlinear Optimization in the Design of a Doubly Convergent Multiple-Beam Electron Gun.*
Adam Attarian*, **Tallis J William**, **Hien T Tran**, North Carolina State University, and **Lawrence Ives**, Calabazas Creek Research, Inc. (1056-49-1654)

2:45PM (1828) *The Minimal Time Problem On Stratified Domains.*
Richard C Barnard* and **Peter R Wolenski**, Louisiana State University (1056-49-1675)

3:00PM (1829) *Analysis of Tendon-Reinforced Piecewise-Isotropic Pressurized Membranes.*
Michael C. Barg*, Niagara University, **Jieun Lee** and **Frank Baginski**, The George Washington University (1056-49-1690)

3:15PM ► (1830) *Sensitivity-Based Optimization Applied to Equations Modeling Film Casting.*
David C Szurley, Francis Marion University (1056-49-1702)

3:30PM (1831) *Morrey Regularity for Asymptotically Convex Variational Problems with (p,q) Growth.*
Kyle Fey* and **Mikil Foss**, University of Nebraska - Lincoln (1056-49-1850)

3:45PM (1832) *A Modified Piecewise Constant Mumford-Shah Model Based Simultaneous Image Segmentation and Registration.* Preliminary report.
Jung-Ha An*, California State University Stanislaus, and **Yunmei Chen**, University of Florida (1056-49-1967)

4:00PM Break

4:15PM (1833) *Generalized shearlets and the extended metaplectic group.*
Emily J King*, National Institutes of Health / Norbert Wiener Center UMD, and **Wojciech Czaja**, University of Maryland (1056-43-1718)

4:30PM ► (1834) *Remarks on the Apportionment of the U. S. House of Representatives.* Preliminary report.
Daniel D Sheng*, Westwood High School, and **Edwin Oxford**, Baylor University (1056-00-511)

4:45PM (1835) *An Estimate of The Radius of an Attraction Ball for TV-Minimization Problems in Image Denoising.*
L. A. Melara*, Shippensburg University, and **A. J. Kearsley**, NIST (1056-90-1776)

5:00PM (1836) *Production Inventory Planning in a Stochastic Manufacturing System with Discounted Cost.*
Anton Abdulbasah Kamil* and **Md Azizul Baten**, Universiti Sains Malaysia (1056-90-176)

5:15PM (1837) *Relaxed Matching for the Method of Controlled Lagrangians.*
David A Long*, North Carolina State University, **Anthony M Bloch**, University of Michigan, **Jerrold E Marsden**, California Institute of Technology, and **Dmitry V Zenkov**, North Carolina State University (1056-70-1372)

AMS Session on Computational Math, IV

1:00 PM – 2:40 PM

1:00PM (1838) *Optimization in Developing Prediction Scoring Function for Mutagenesis Solubility.*
Ye (Alice) Tian, Washington State University (1056-90-2129)

1:15PM ► (1839) *Applications of Ensemble based Simulated Annealing to Intensity Modulated Radiation Therapy Planning (IMRTP).* Preliminary report.
Abebaw Tadesse* and **Franklin Fondjo Fotou**, Langston University (1056-90-608)

1:30PM (1840) *Multiresolution Shannon-type wavelet on the Heisenberg group.*
Azita Mayeli, City University of New York (1056-43-755)

1:45PM (1841) *Equivalence of Curves Under Generalized Weak Perspective Projection.*
Joseph M Burdis* and **Irina A Kogan**, North Carolina State University (1056-00-626)

2:00PM ► (1842) *Extraction of Transport Coefficients in Stochastic Production Systems.*
Ali Kemal Unver, Coral Academy of Science Las Vegas (1056-90-1745)

2:15PM (1843) *Closure of a Saint Venant model for free surface flows on an open channel with cross stream variation of the bottom roughness.*
Ahmed Kaffel*, Virginia Tech, **Amel Soualmia**, LMHE, and **Masbernat Lucien**, IMFT (1056-70-1432)

2:30PM ► (1844) *Modeling Network Traffic as a Filtered Semi-Markov-Process.* Preliminary report.
Ahlam E Tannouri* and **Sam F Tannouri**, Morgan State University (1056-90-2041)

MAA Session on Innovative and Effective Ways to Teach Linear Algebra, II

1:00 PM – 5:15 PM

Organizers: **David M. Strong**, Pepperdine University
Gilbert Strang, Massachusetts Institute of Technology
David C. Lay, University of Maryland

1:00PM (1845) *Linear Algebra Done Right! Back to Grassmann.*
K. Rohan Attele*, **Dan Hrozencik** and **Victor Akatsa**, Chicago State University (1056-G1-2056)

1:20PM (1846) *One course to serve them all: mathematicians, computer scientists, and engineers.*
David Mazur, Western New England College (1056-G1-1707)

1:40PM ► (1847) *Learning technology to teach mathematics.*
Josep Ferrer*, Universitat Politecnica de Catalunya, **Carmen Ortiz**, Universidad de Extremadura, and **Marta Pena**, Universitat Politecnica de Catalunya (1056-G1-600)

2:00PM ► (1848) *Use of Technology in Teaching the Mathematics of Linear Algebra.* Preliminary report.
Carl C. Cowen, IUPUI (1056-G1-587)

2:20PM ► (1849) *ICT Linear algebra class model with Sage-math.*
Sang-Gu Lee* and **Duk-Sun Kim**, Sungkyunkwan University (1056-G1-1131)

2:40PM ► (1850) *Enhancing Students' Attitudes towards Linear Algebra with Technology.*
Karsten Schmidt, Schmalkalden University of Applied Sciences, Germany (1056-G1-378)

3:00PM *Programming Linear Algebra.*
► (1851) **Daniel R. Jordan**, Columbia College Chicago (1056-G1-1380)

3:20PM *Looking at Conceptual Online Linear Algebra*
► (1852) *applets.*
David E. Meel, Bowling Green State University (1056-G1-1931)

3:40PM *Matrix Multiplication and Applications: A Chicken*
► (1853) *and Egg Problem.*
Murphy Waggoner, Simpson College (1056-G1-411)

4:00PM *Inverses for Matrices that Don't Have Inverses.*
► (1854) **Jeffrey L Stuart**, Pacific Lutheran University (1056-G1-958)

4:20PM *Inclusion of new applications in a Linear Algebra*
► (1855) *course, without compromising the coverage of the traditional topics.*
Mohammad Khadivi, Jackson State University (1056-G1-970)

4:40PM *Using Linear Algebra to Measure Power.*
► (1856) **Jennifer Wilson***, Eugene Lang College the New School for Liberal Arts, **Karrolyne Fogel**, California Lutheran University, **Kay Somers**, Moravian College, and **Angela Spalsbury**, Youngstown State University (1056-G1-1528)

5:00PM *Applying Image Processing Techniques to Promote*
► (1857) *Conceptual Understanding in Linear Algebra Classes.* Preliminary report.
Jen-Mei Chang* and **Xuhui Li**, California State University, Long Beach (1056-G1-111)

MAA Session on Arts and Mathematics, II

1:00 PM – 5:35 PM

Organizer: **Douglas E. Norton**, Villanova University

1:00PM *Material Properties of hyperbolic space in relation*
► (1858) *to history of clothing.* Preliminary report.
Rebecca E Field, James Madison University (1056-C1-2131)

1:20PM *Symmetry Preference and Meaning in Tibetan Sand*
► (1859) *Mandalas.*
Valerie Ng and **Darrah Chavey***, Beloit College (1056-C1-1887)

1:40PM *Modeling Heraldic Design Using Shape Grammars.*
► (1860) Preliminary report.
Barbara A. Ashton, BMCC - City University of New York (1056-C1-1547)

2:00PM *Hyperbolic Conic Section through Kinetic Sculpture.*
► (1861) **Jeff Chyatte**, Montgomery College (1056-C1-1410)

2:20PM *Mathematics, art, and the Fusion Project.*
(1862) Preliminary report.
Benjamin Wells, University of San Francisco (1056-C1-1320)

2:40PM *The Mathematical Development of Music.*
(1863) **Alan Levine**, Franklin and Marshall College (1056-C1-1236)

3:00PM *Group explorations and art projects in a*
► (1864) *mathematics of art course for first-year students.*
Debra L. Hydorn, University of Mary Washington (1056-C1-1757)

3:20PM *What is sangaku?* Preliminary report.
► (1865) **Peter N Wong**, Bates College (1056-C1-382)

3:40PM *Writing Critically with Enthusiasm for*
(1866) *Mathematicians.*
Suzanne Galayda*, New Mexico State University, and **Alexandra D'Italia**, Southwestern Law School (1056-C1-1405)

4:00PM *Visualizing the Dynamics of the Unit Circle Group.*
► (1867) Preliminary report.
Anne M. Burns, Long Island University, C.W. Post Campus (1056-C1-353)

4:20PM *A Feigenbaum Face.*
► (1868) **Ann Robertson**, Connecticut College (1056-C1-1955)

4:40PM *Lithographs Representing Some Mathematical*
► (1869) *Topics.*
Lisl Gaal, University of Minnesota (1056-C1-1789)

5:00PM *Monument to Error, Perspectives: The Love of Form,*
► (1870) *and Solution Set.*
Jeffrey M Groah, Lone Star College-Montgomery (1056-C1-392)

5:20PM *Further Aesthetic Explorations in Phase Space.*
(1871) **Douglas E. Norton**, Villanova University (1056-C1-1801)

MAA Session on General Contributed Papers, XII

1:00 PM – 5:10 PM

Organizers: **Eric S. Marland**, Appalachian State University
Daniel J. Curtin, Northern Kentucky University

1:00PM *On Determining the Number of Clusters–An*
► (1872) *Empirical Study of Different Algorithms.*
Brian Bies, Washington University in St Louis, **Kathryn Dabbs**, University of Tennessee, and **Hao Zou***, Macalester College (1056-Z1-1500)

1:15PM *The Spaghetti Model: DNA Sequencing using Graph*
► (1873) *Theory.*
Faun C. C. Doherty, **Peter A. Gentile***, **Jennifer M. Magee** and **Christian J. Miedel**, Washington and Jefferson College (1056-Z1-240)

1:30PM *Uniquely H-Saturated Graphs.*
► (1874) **Joshua Cooper**, University of South Carolina, **John Lenz**, **Timothy LeSaulnier**, **Paul Wenger*** and **Douglas B. West**, University of Illinois at Urbana-Champaign (1056-Z1-1195)

1:45PM *A vertex ordering result for an application of DNA*
► (1875) *sequencing using tripartite unit probe interval graphs.*
Faun C. C. Doherty, **Christian J. Miedel***, **Peter A. Gentile** and **Jennifer M. Magee**, Washington and Jefferson College (1056-Z1-239)

2:00PM *Higher Reciprocity.* Preliminary report.
► (1876) **Nancy Carol Buck**, University of North Carolina Greensboro (1056-Z1-754)

2:15PM Break.

2:30PM *A connectivity preserving discontinuous function.*
► (1877) **Jeffrey M Groah**, Lone Star College-Montgomery (1056-Z1-389)

2:45PM *PTA(9)s fixed under multiplier -1.*
► (1878) **Chirashree Bhattacharya**, Randolph-Macon College (1056-Z1-1795)

3:00PM *Linear Operators and Zeros of Polynomials.*
(1879) Preliminary report.
Andrzej Piotrowski, University of Alaska Southeast (1056-Z1-2038)

3:15PM *Be the Volume: A hands-on method for presenting*
► (1880) *the estimation of volume under a surface.*
Jessica M Mikhaylov, U.S. Military Academy, West Point (1056-Z1-1282)

3:30PM *Dual Enrollment vs Duel Enrollment.*
(1881) **Larry Bouldin*** and **Benjamin King**, Roane State Community College (1056-Z1-1364)

3:45PM (1882) *Is Mathematics Indispensable and Are Pre-requisites Needed in Mathematics Courses?*
Padraig M. McLoughlin, Kutztown University of Pennsylvania (1056-Z1-356)

4:00PM ► (1883) *Teaching a Course on Women in Mathematics.* Preliminary report.
Cynthia J Woodburn, Pittsburg State University (1056-Z1-516)

4:15PM (1884) *A Basic College Level Mathematics course for a lay man knowing only four basic operations with nonnegative integers.*
Santanu Chakraborty, University of Texas - Pan American, Edinburg, Texas (1056-Z1-80)

4:30PM ► (1885) *Experiences in Recruiting, Retention and Graduation in the Kean STEM Scholarship Program.*
Louis Beaugris*, **Pablo Zafra** and **Kikombo NGoy**, Kean University (1056-Z1-875)

4:45PM ► (1886) *Riverbend Community Math Center – Promoting mathematical thinking in local elementary and middle schools.* Preliminary report.
Amanda Katharine Serenevy, Riverbend Community Math Center (1056-Z1-989)

5:00PM (1887) *Reversing the Pattern of Low Performance in College Algebra Using the National Center for Academic Transformations' Roadmap Model.*
A. Dale Magoun*, **A. Serpil Saydam** and **Charlotte H. Owens**, University of Louisiana at Monroe (1056-Z1-833)

MAA Session on Mathlets for Teaching and Learning Mathematics

1:00 PM – 5:35 PM

Organizers: **Joe Yanik**, Emporia State University
Thomas E. Leathrum, Jacksonville State University
David M. Strong, Pepperdine University

1:00PM ► (1888) *Mathlets for Visualizing the Geometry of Numbers.*
Karl-Dieter Crisman, Gordon College (1056-K1-1741)

1:20PM ► (1889) *Number Lab: Experiencing Numbers.*
David B Posner, Napa CA (1056-K1-302)

1:40PM (1890) *National Curve Bank.*
Shirley B. Gray, California State University, Los Angeles (1056-K1-119)

2:00PM ► (1891) *Retrieving old mathematics with new technology.*
Susan L. Addington, California State University, San Bernardino (1056-K1-1810)

2:20PM ► (1892) *Linear programming with mathlets.*
H. Smith Risser, Montana Tech (1056-K1-189)

2:40PM (1893) *A Picture is Worth a Thousand Words in Geogebra.*
Joanne C Caniglia, Kent State University (1056-K1-150)

3:00PM ► (1894) *Multivariable Calculus Java Applets with Blaise.* Preliminary report.
Elisha Peterson, United States Military Academy (West Point) (1056-K1-1272)

3:20PM ► (1895) *Geometric Constructions as Interactive Java Applets with Feedback Feature.*
Tibor Marcinek, Central Michigan University (1056-K1-1474)

3:40PM ► (1896) *Dynamic Visualization Tools for Multivariable Calculus.* Preliminary report.
Paul E Seeburger, Monroe Community College (1056-K1-907)

4:00PM ► (1897) *Hypothesis Testing: Tools for Exploration and Practice.*
Sarah L Mabrouk, Framingham State College (1056-K1-1486)

4:20PM (1898) *Google-opoly.*
Tim Chartier, Davidson College (1056-K1-1532)

4:40PM ► (1899) *The Lurch Project: Validation on Demand.* Preliminary report.
Nathan Carter, Bentley University, **Paul F Christiano**, MIT, and **Kenneth G Monks***, University of Scranton (1056-K1-1588)

5:00PM ► (1900) *Applets for Discovery and Assessment in Math for Liberal Studies.*
Doug Ensley* and **James Hamblin**, Shippensburg University (1056-K1-1966)

5:20PM ► (1901) *Graph2D: An Interactive Graphing Library using the HTML Canvas.*
R. Alexander Milowski, San Francisco, CA (1056-K1-1499)

MAA Session on Research on the Teaching and Learning of Undergraduate Mathematics, II

1:00 PM – 4:55 PM

Organizers: **Keith Weber**, Rutgers University
Stacy Brown, Pitzer College
Natasha A. Speer, University of Maine
Karen A. Marrongelle, Portland State University

1:00PM ► (1902) *Early Eigen Thinking: Students' Interpretations of the Matrix Equation Ax=2x.*
Christine Larson*, Indiana University, **Michelle Zandieh**, Arizona State University, **Chris Rasmussen** and **Frances Henderson**, San Diego State University (1056-P5-1366)

1:40PM ► (1903) *Investigating Student Conceptions of Function Composition.* Preliminary report.
Stacey A. Bowling, Arizona State University (1056-P5-1101)

2:00PM (1904) *How beginning teachers understand student thinking in calculus.* Preliminary report.
Thomas W Judson*, Stephen F. Austin State University, and **Matthew Leingang**, New York University (1056-P5-680)

2:20PM ► (1905) *The Role of Angle Measure and the Radius as a Unit of Measurement in Developing Coherent Understandings of Trigonometric Functions.*
Kevin C. Moore, Arizona State University (1056-P5-671)

2:40PM ► (1906) *Parameter or variable or unknown? The special case of the definite integral.* Preliminary report.
May F Hamdan, Lebanese American University (1056-P5-446)

3:00PM ► (1907) *Students' Understandings of Equivalence Relations.*
Jim Brandt, Southern Utah University (1056-P5-1956)

3:20PM ► (1908) *Learning the phase plane: How two students' understandings of time and rate affected their learning of exponential functions.*
Carlos W Castillo-Garsow, Arizona State University (1056-P5-1568)

3:40PM ► (1909) *The Role of Homework in Developing Students' Mathematical Conceptions.* Preliminary report.
Eric D Weber* and **Marilyn P Carlson**, Arizona State University (1056-P5-303)

4:00PM ► (1910) *Enhancing Undergraduate Students' Views and Experiences of Learning Mathematics in Inquiry-Based Learning Contexts.*
Marja-Liisa Hassi*, **Sandra Laursen** and **Anne-Barrie Hunter**, Ethnography & Evaluation Research, University of Colorado at Boulder (1056-P5-1694)

4:20PM (1911) *Researching the Integration of Mathematical and Educational Perspectives in Mathematics Teacher Preparation.* Preliminary report.
Rebecca H McGraw* and **Priya Prasad**, University of Arizona (1056-P5-1692)

4:40PM ► (1912) *A Theoretical Framework for Designing Professional Development Workshops for Mathematics Faculty.*
Stan T Yoshinobu, California State Polytechnic University, San Luis Obispo (1056-P5-622)

MAA Session on Visualization in Mathematics, II

1:00 PM – 5:15 PM

Organizers: **Sarah J. Greenwald**, Appalachian State University
Walter Whiteley, York University

1:00PM ► (1913) *Visual Analytics to Explore Elementary Probability.* Preliminary report.
James D. Factor, Alverno College, and **Edmond J. Nadler***, Eastern Michigan University (1056-R5-2027)

1:20PM ► (1914) *Visualization via Excel in Mentoring Mathematics Faculty of a Developing Nation.*
Deane E. Arganbright, Divine Word University, Madang, Papua New Guinea (1056-R5-362)

1:40PM ► (1915) *Using Computer Graphics as an Aid to Visualizing Functions of a Complex Variable.*
Laurene V. Fausett, TAMU-Commerce (1056-R5-252)

2:00PM (1916) *Efficient Graph Visualization for Applications: Databases, Data Mining, and Video Games.*
Charles Andrew Tannouri, Towson University (1056-R5-1978)

2:20PM ► (1917) *Confluent Graphs: Making Graphs Pretty.*
Talitha M Washington, University of Evansville (1056-R5-1614)

2:40PM (1918) *Pedagogical Understanding of Non-Textual Elements in Mathematics Textbooks among Teachers and Curriculum Developers.* Preliminary report.
Rae Young Kim* and **Sharon Senk**, Michigan State University (1056-R5-2045)

3:00PM ► (1919) *Diagrams in Abstract Algebra: How are Diagrams used in the Proving Process?* Preliminary report.
Nissa Yestness, University of Northern Colorado (1056-R5-2072)

3:20PM (1920) *Visualization Lessons from Visual Group Theory.*
Nathan Carter, Bentley University (1056-R5-1812)

3:40PM ► (1921) *Visualizing the polyhedral geometry of algebraic systems.*
Marshall Hampton, University of Minnesota Duluth (1056-R5-290)

4:00PM (1922) *Visualization for the Simulation of the Chemical Vapor and Infiltration Process.*
Joyati Debnath*, Winona State University, Winona, MN, **Srabasti Dutta**, College of Saint Elizabeth, and **Andrew Jones**, Florida A&M University (1056-R5-657)

4:20PM ► (1923) *Educational Applications of Projective Geometry.* Preliminary report.
David Booth, Austin Texas (1056-R5-1064)

4:40PM ► (1924) *Projective Geometry as a Vehicle for Schooling the Imagination, I.*
Martin Levin, Silver Spring, MD (1056-R5-1090)

5:00PM (1925) *Projective Geometry as a Vehicle for Schooling the Imagination II.*
Martin Levin, Silver Spring, MD (1056-R5-1589)

SIAM Minisymposium on New Trends in Mathematical Methods in Imaging Science

1:00 PM – 5:50 PM

Organizers: **Rick Chartrand**, Los Alamos National Laboratory
Stacey E. Levine, Duquesne University
Jennifer L. Mueller, Colorado State University
Luminita A. Vese, University of California Los Angeles

1:00PM ► (1926) *Nonconvex compressive sensing: getting the most from very little information.*
Rick Chartrand, Los Alamos National Laboratory (1056-90-1078)

1:30PM (1927) *This is SPIRAL TAP: Sparse Poisson intensity reconstruction algorithms (theory and practice).*
Zachary T. Harmany, Duke University, **Roummel F. Marcia***, University of California, Merced, and **Rebecca M. Willett**, Duke University (1056-68-662)

2:00PM (1928) *Locally Adaptive Kernel Regression: A Non-parametric Framework for Multidimensional Signal Processing and Analysis.*
Hiroyuki Takeda, **Hae Jong Seo** and **Peyman Milanfar***, University of California, Santa Cruz (1056-62-1599)

2:30PM (1929) *Hyperspectral Image Classification by Matching Node Connectivities.*
Naoki Saito*, University of California, Davis, and **Linh Lieu**, New York, NY (1056-62-1209)

3:00PM ► (1930) *Comparisons of reconstruction methods in electrical impedance tomography on a mammography geometry.*
Ethan K Murphy*, **David Isaacson**, **Gary Saulnier** and **Jon Newell**, Rensselaer Polytechnic Institute (1056-65-1216)

3:30PM (1931) *Local stability in a minimization problem for conductivity imaging.*
M. Zuhair Nashed* and **Alexandru Tamasan**, University of Central Florida (1056-49-1684)

4:00PM (1932) *Total Variation and Cheeger Ratio Cuts.* Preliminary report.
Arthur D Szlam*, Courant Institute and UCLA math, and **Xavier Bresson**, UCLA math (1056-49-1013)

4:30PM ► (1933) *Variational methods for data fusion, segmentation, deblurring, and image inpainting.*
Andrea Bertozzi, UCLA (1056-49-695)

5:00PM (1934) *Novel Integro-differential equations in image processing and its applications.*
Eitan Tadmor, University of Maryland, College Park, and **Prashant Athavale***, University of California, Los Angeles (1056-49-1717)

5:30PM ► (1935) *Multiscale Flat Norm Shape Signatures.*
Kevin R. Vixie, Washington State University (1056-28-1677)

MAA Committee on Technology in Mathematics Education Panel Discussion

1:00 PM – 3:55 PM

Technology in teaching mathematics: History and current practices. (There will be a 15-minute break halfway through this discussion)

Organizers: **Marilyn A. Reba**, Clemson University
Lila F. Roberts, Georgia College & State University

SIGMAA on Math Circles for Students and Teachers, Part II

1:00 PM – 5:00 PM

Fostering, supporting, and propogating Math Circles.

Organizers: **James S. Tanton**, St. Mark's Institute of Mathematics
Tatiana Shubin, San Jose State University

AWM Workshop Panel Discussion

1:00 PM – 2:00 PM

Career opportunities: The early years.

Moderator: **Rachelle C. Decoste**, Wheaton College
Panelists: **Ann Almgren**, Lawrence Berkeley National Lab
Maura B. Mast, University of Massachusetts-Boston
Sharon M. Frechette, College of the Holy Cross
Ulrica Y. Wilson, Morehouse College

AMS Session on Number Theory, IV

1:15 PM – 4:25 PM

1:15PM (1936) *On the Density of Abundant Numbers.* Preliminary report. ►
Mitsuo Kobayashi, Dartmouth College (1056-11-1527)

1:30PM (1937) *On the parity of k-th powers mod p.*
Jennifer Paulhus*, **Todd Cochrane** and **Christopher Pinner**, Kansas State University (1056-11-1554)

1:45PM (1938) *The Constant Terms of Eisenstein Series on Loop Groups over a Function Field.*
Kyu-Hwan Lee and **Philip J Lombardo***, University of Connecticut (1056-11-1556)

2:00PM (1939) *Ramanujan-type congruences in partition-theoretic counting functions.*
Michael Patrick Dewar, University of Illinois at Urbana-Champaign (1056-11-1557)

2:15PM Break

2:30PM (1940) *Monogenity in cyclotomic fields.*
Leanne Robertson, Seattle University (1056-11-1735)

2:45PM (1941) *An elementary approach to proving and discovering BBP-type formulas.*
John R. Greene* and **Melissa Larson**, University of Minnesota Duluth (1056-11-1738)

3:00PM (1942) *Values of Asai L-functions and combinatorial identities.* Preliminary report.
Dominic Lanphier, Western Kentucky University (1056-11-1864)

3:15PM (1943) *Cyclic Base change and Rankin-Selberg Convolutions.*
Timothy Lee Gillespie, University of Iowa (1056-11-1871)

3:30PM (1944) *Gauss' Method for determining cyclotomic numbers.*
Ciarán Mac an Bhaird* and **Pat McCarthy**, National University of Ireland Maynooth (1056-11-2118)

3:45PM (1945) *Supersingular distribution on average for congruence classes of primes.*
Nahid Walji, California Institute of Technology (1056-11-1936)

4:00PM (1946) *Green-Tao theorem in function fields.*
Thai Hoang Le, UCLA (1056-11-1906)

4:15PM (1947) *An asymptotic formula for Goldbach's conjecture with monic polynomials.* ►
Mark Kozek, Whittier College (1056-11-1900)

ASL Invited Address

2:00 PM – 2:50 PM

(1948) *Model theory and non-archimedean tame topology, with a view towards Berkovich spaces.*
Francois Loeser, Ecole Normale Superieure (1056-03-76)

MAA-Project NExT Panel Discussion

2:00 PM – 3:15 PM

Organizing and running an effective seminar/capstone course for mathematics majors.

Organizers: **Karrolyne Fogel**, California Lutheran University
Russell Goodman, Central College
Thomas Langley, Rose-Hulman Institute of Technology
Panelists: **Mariah Birgen**, Wartburg College
Lipika Deka, California State University-Monterey Bay
Nezam Iraniparast, Western Kentucky University
Brian Miceli, Trinity University

AMS Session on Algebras, II

2:30 PM – 3:40 PM

2:30PM (1949) *"Separating the Degree Spectra of Structures" and Beyond: An Overview of My Dissertation in Computable Model Theory with Some New Extensions.*
Tyler J Markkanen, Saint Mary-of-the-Woods College (1056-03-1592)

2:45PM (1950) *Model Theory of Stable Groups.*
Paul Baginski, Université Lyon 1 (1056-03-1682)

3:00PM (1951) *Continuous Control in Exact Non-Split Categories.* Preliminary report.
Timothy K Lance, Francis Marion University (1056-19-647)

3:15PM (1952) *Motivic symmetric ring spectrum representing algebraic K-theory.*
Youngsoo Kim, University of Illinois at Urbana-Champaign (1056-19-1069)

3:30PM (1953) *Simply Un-Real: Grassmann hypercomplex numbers, geometric algebra, and the (past and) future of "vector" calculus.* Preliminary report. ►
Debra A. Warne* and **Paul G. Warne**, James Madison University (1056-08-1553)

AWM Workshop: Research Presentations by Recent Ph.D.s, II

2:30 PM – 4:20 PM

2:30PM (1954) *Interpolation on Rational Surfaces.*
Amanda Knecht, University of Michigan (1056-14-152)

3:00PM (1955) *Killing Forms of Isotropic Lie Algebras.*
Audrey Malagon, Mercer University (1056-17-181)

3:30PM (1956) *The mixed boundary value problem in Lipschitz domains.*
Katharine A. Ott* and **Russell Brown**, University of Kentucky (1056-35-744)

4:00PM (1957) *K3 surfaces with discrete symmetry groups.*
Ursula Anne Whitcher, Harvey Mudd College (1056-14-201)

AMS-MAA-SIAM Gerald and Judith Porter Public Lecture

3:00 PM – 4:45 PM

► (1958) *The calculus of friendship.*
Steven Strogatz, Cornell University (1056-00-40)

4:00PM Reception: Please come to greet and chat with the speaker. Light refreshments will be served.

ASL Contributed Papers, II

3:10 PM – 5:20 PM

3:10PM (1959) *A simple epsilon substitution method for ID1.*
Grigori Mints, Stanford University

3:35PM (1960) *Trees, sheaves and definition by recursion.*
Nate Ackerman, University of California, Berkeley

4:00PM (1961) *A bimodal deontic evidential logic for the right to prove truths.*
Billy Joe Lucas, Manhattanville College

4:35PM (1962) *Characterizations of stable and NIP theories by generalized indiscernible sequences.*
Lynn Scow, University of California, Berkeley

5:00PM (1963) *Expansion of Presburger Arithmetic with a predicate for $\lfloor \sqrt{2}x \rfloor$.*
Demirhan Tunc, University of Notre Dame

MAA Minicourse #2: Part B

3:30 PM – 5:30 PM

Using GeoGebra to create activities and applets for visualization and exploration.

Organizer: **Michael K. May**, Saint Louis University

MAA Minicourse #9: Part B

3:30 PM – 5:30 PM

Getting students involved in undergraduate research.

Organizers: **Aparna W. Higgins**, University of Dayton
Joseph A. Gallian, University of Minnesota Duluth

Reception in Honor of Retiring MAA Secretary Martha Siegel

5:00 PM – 6:15 PM

AMS Banquet Reception

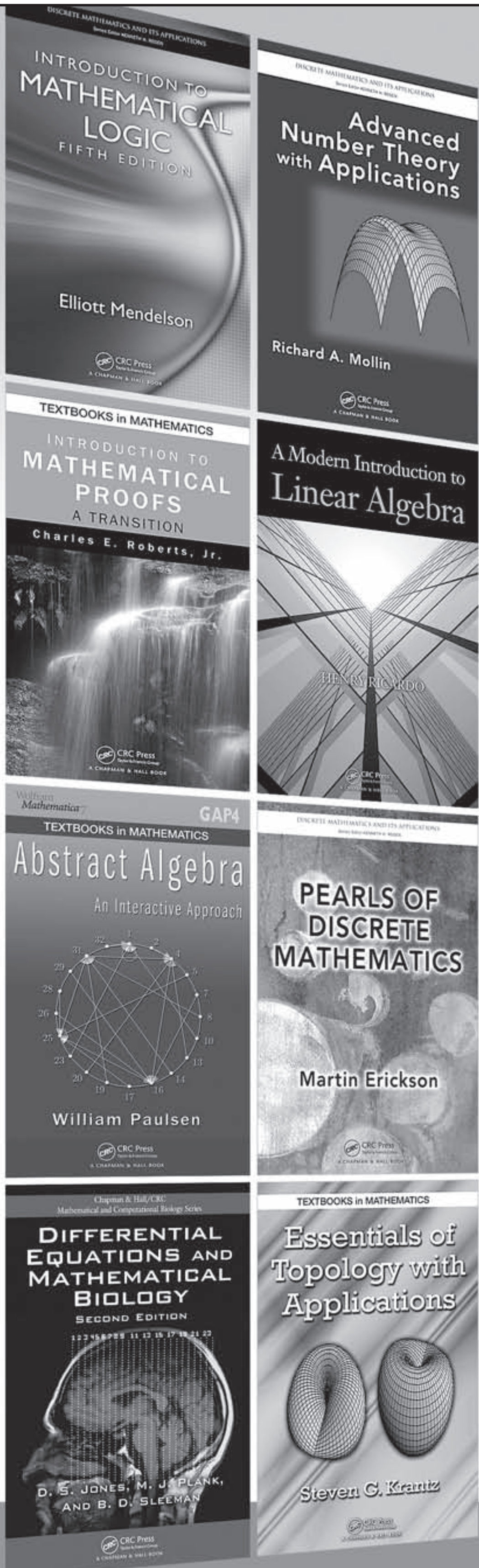
6:30 PM – 7:30 PM

AMS Banquet

7:30 PM – 10:00 PM

Matthew Miller
AMS Associate Secretary
Columbia, South Carolina

Gerard A. Venema
MAA Associate Secretary
Grand Rapids, Michigan



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Southeastern Section: **Matthew Miller,** Department of Mathematics, University of South Carolina, Columbia, SC 29208-0001, e-mail: miller@math.sc.edu; telephone: 803-777-3690.

2009 Seoul, Korea Meeting: Georgia Benkart, University of Wisconsin-Madison, Department of Mathematics, 480 Lincoln Drive, Madison, WI 53706-1388; e-mail: benkart@math.wisc.edu; telephone: 608-263-4283.

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 can be found at** www.ams.org/meetings/.

Meetings:

Important Information Regarding AMS Meetings

Potential organizers, speakers, and hosts should refer to page 92 in this issue of the *Notices* for general information regarding participation in AMS meetings and conferences.

Abstracts

Speakers should submit abstracts on the 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 similarly coded material (such as accent marks in text) must be typeset in LaTeX. Visit http://www.ams.org/cgi-bin/abstracts/abstract.pl. Questions about abstracts may be sent to abs-info@ams.org. 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.)

Co-sponsored conferences:

February 18–22, 2010: AAAS Meeting in San Diego, CA (please see www.aaas.org/meetings for more information).

March 18-21, 2010: First International Conference on Mathematics and Statistics, AUS-ICMS '10, American University of Sharjah, Sharjah, United Arab Emirates (please see http://www.aus.edu/conferences/icms10/ for more information).

May 24-29, 2010: From Carthage to the World, the Isoperimetric Problem of Queen Dido and its Mathematics Ramifications, Carthage, Tunisia (for more information please see http://math.arizona.edu/~dido/welcome.html).

June 17-19, 2010: Coimbra Meeting on 0-1 Matrix Theory and Related Topics, University of Coimbra, Portugal (for more information please see http://www.mat.uc.pt/~cmf/01MatrixTheory).

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MODERN TRENDS IN OPTIMIZATION AND ITS APPLICATION

September 13 – December 17, 2010

ORGANIZING COMMITTEE: Stephen Boyd (Stanford), Emmanuel Candes (Caltech), Masakazu Kojima (Tokyo Inst Tech), Monique Laurent (CWI), Arkadi Nemirovski (Georgia Tech), Yurii Nesterov (Université Catholique de Louvain), Bernd Sturmfels (UC Berkeley), Michael Todd (Cornell), Lieven Vandenberghe (UCLA)

Scientific Overview

Today, fundamental advances in mathematical optimization occur at a furious pace. In recent years, spectacular progress has been made in our understanding of convex optimization problems whose expressive power make them suitable for a wide spectrum of important applications. We have also learned how to approximate combinatorially hard optimization problems by simpler convex problems, which are tractable and provide accurate solutions. Further, robust optimization offers new techniques for preventing solutions to be too sensitive to noise or model errors. Finally, recent remarkable advances in algorithms have made possible solving optimization problems involving tens of thousands of variables and/or constraints---even tens of millions in some instances---in reasonable time. These and other fundamental developments, along with progress in high-quality software, have expanded the scale and complexity of optimization problems that can be addressed in practice, and are leading to a wider adoption of optimization techniques throughout many fields in science and engineering. Centered around five workshops, the goal of this program is to bring together scientists from many different backgrounds to develop and exchange ideas about modern optimization which can be influenced by, and influence in turn, progress in engineering and science.

Workshop Schedule

- Optimization Tutorials: September 14 – 17, 2010
- Workshop 1: Convex Optimization and Algebraic Geometry, September 28 – October 1, 2010
- Workshop 2: Numerical Methods for Continuous Optimization, October 11 – 15, 2010
- Workshop 3: Discrete Optimization, October 26 – 29, 2010
- Workshop 4: Robust Optimization, November 16 – 19, 2010
- Workshop 5: Applications of Optimization in Science and Engineering, November 29 – December 3, 2010
- Culminating Workshop at Lake Arrowhead Conference Center, December 12 – 17, 2010

Participation

This long program will involve a community of senior and junior researchers. The intent is for participants to have an opportunity to learn about Optimization, and to meet a diverse group of people and have an opportunity to form new collaborations. Full and partial support for long-term participants is available. We are especially interested in applicants who intend to participate in the entire program (September 13 – December 17, 2010), but will consider applications for shorter periods. Funding is available for participants at all academic levels, though recent PhDs, graduate students, and researchers in the early stages of their careers are especially encouraged to apply. Encouraging the careers of women and minority mathematicians and scientists is an important component of IPAM's mission and we welcome their applications. More information and an application is available online.

www.ipam.ucla.edu/programs/op2010

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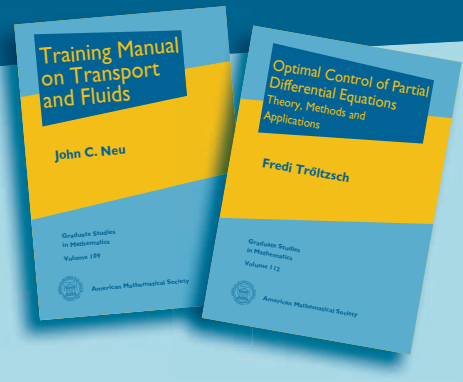

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