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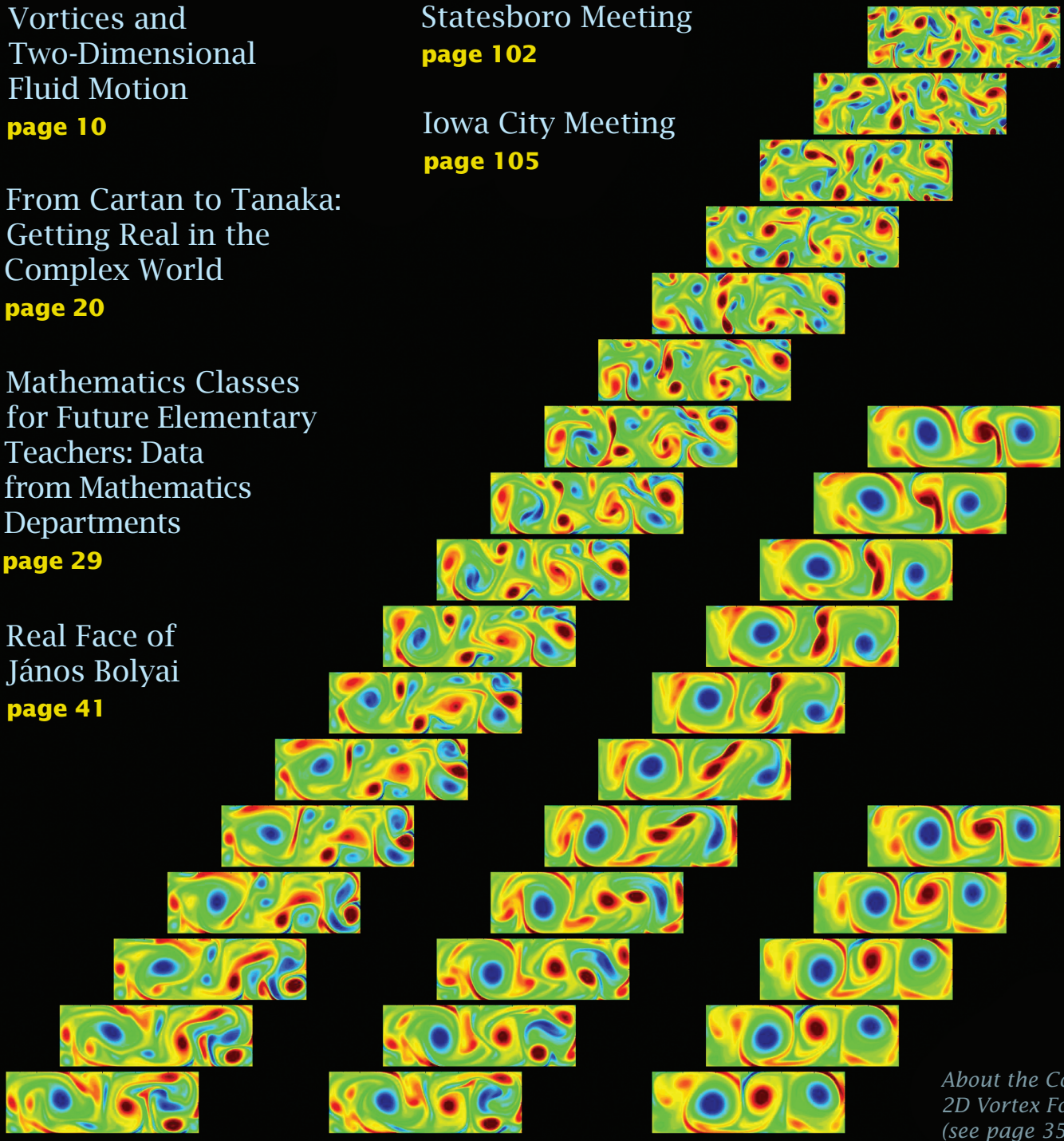

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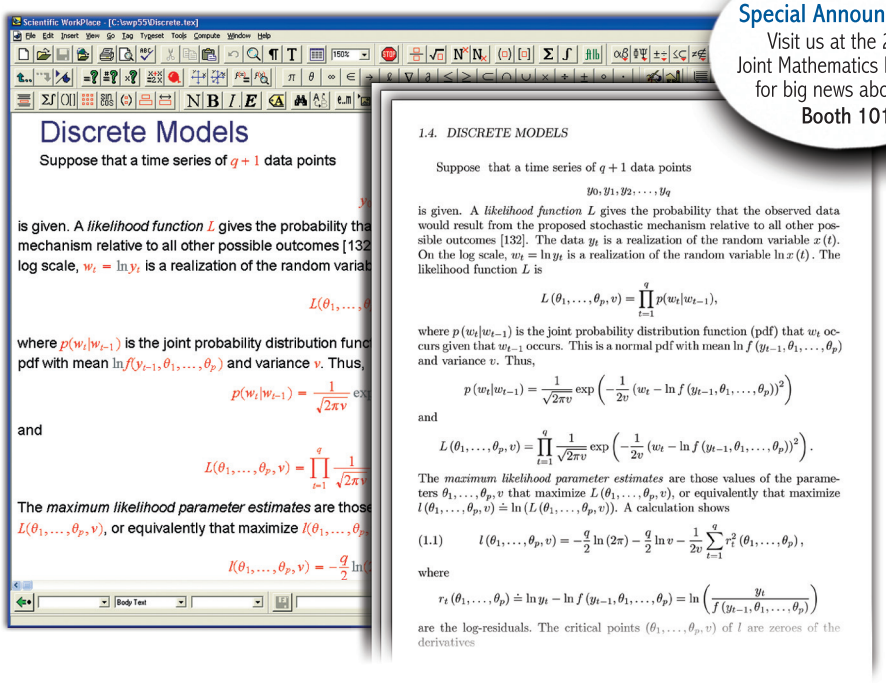

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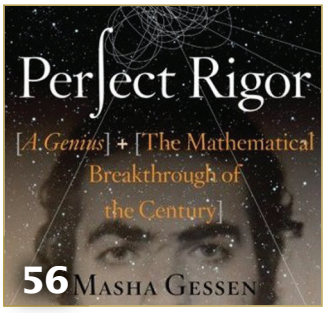
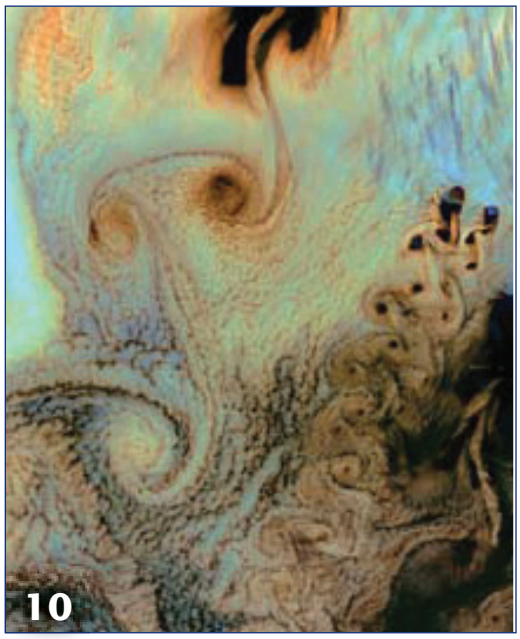
of the American Mathematical Society
January 2011

Communications

Commentary





Features

From a mistaken portrait of János Bolyai to complex geometry to vortices and fluid flow to mathematics education, we see this month the panorama of mathematical life. Our lives consist of research, teaching, service, and a great variety of scholarship. Learning is what we do, and the *Notices* supports that effort.

—Steven G. Krantz
Editor

Notices
of the American Mathematical Society

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I thank Randi D. Ruden for her splendid editorial work, and for helping to assemble this issue. She is essential to everything that I do.

—Steven G. Krantz
Editor

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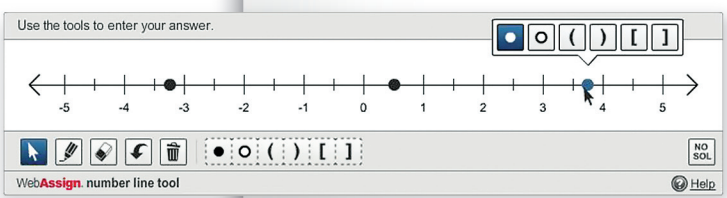

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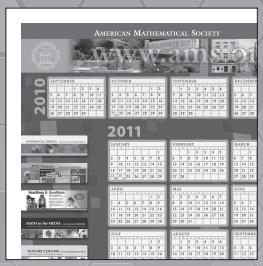

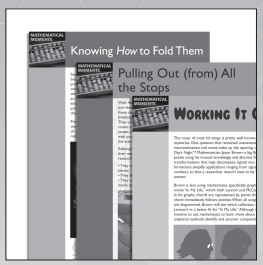

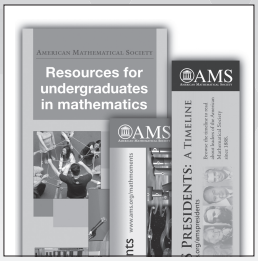

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Commentary on Education Legislation: A Mathematical Perspective

In the years since the Bush administration's No Child Left Behind (NCLB) Act, it has become increasingly clear that federal policy can affect the general climate in American schools. Improvements in student mathematics performance have been isolated and minimal, a fact that is not surprising considering that the policies in NCLB were primarily determined by those with partisan political agendas, not mathematicians or teachers. The interested parties, not to mention the American public, seem to agree that students are not performing adequately in math, yet the question of what to do about the problem remains. In March the Obama administration released *A Blueprint for Reform*, its vision for rewriting NCLB, once again making the pipeline to higher education the subject of Congressional debate. Mathematicians can best guide this debate by addressing the shortcomings of NCLB and lobbying for reform in the mathematics preparation of college-bound students.

Unfortunately, it is difficult to identify specific learning outcomes from NCLB because of its ubiquitous implementation. That is, because no adequate control group exists, changes in mathematics proficiency cannot be directly attributed to NCLB. However, an analysis of teacher responses and resulting trends show a problematic shift in classroom teaching. The results of a survey of Washington, DC-area middle school mathematics teachers a few years after NCLB had been in effect indicated that most teachers had increased the time spent on standardized test preparation but had not meaningfully engaged with their students in mathematics lessons. Teacher interviews then identified a third effect: a narrowed mathematics curriculum that selectively discarded material known not to be on standardized tests.

These trends are related. High-stakes assessments provoke test training, which forces teachers to abandon potentially important and relevant material; this, in turn, limits mathematically engaging activities that are unfortunately too time-consuming. Now is the time for the mathematics community to voice its concern.

Reactions by those involved in NCLB provide a controversial context for these trends. Pat O'Connell Ross, the highest federal official responsible for school mathematics in the Bush administration's U.S. Department of Education (USDE), responded by suggesting that mathematics teaching "is very rarely teaching for understanding"; she nevertheless defended NCLB: "if they're [teachers] not teaching better, that's not NCLB's fault." But Cathy Seeley, president of the National Council of Teachers of Mathematics (NCTM) at the time, remarked that "most of the additional test preparation…has been the lower level kind…where you can do some things that will help test scores next week or this month or even this year, but that might not be serving students well for the future." She and David Klein, a leading "back-to-basics" advocate, agreed that NCLB provided little incentive for directly engaging students in learning more. Representative Chris Van Hollen (D-MD) noted that it was obviously "a mistake to [teach to] a test that the teacher did not feel was actually measuring mastery of the material."

Regrettably, Obama's *Blueprint* appears to resolve only slightly the problems of NCLB. Those in higher education should pay attention to the evolution of the next education legislation because it will directly affect the mathematics that their incoming students will have been exposed to and understand. The belief that teachers of mathematics should be competent in the subject matter will be important, but a continued dependence on standardized assessments as a measure of achievement will perpetuate the dangerous cycle described above, leading to a narrow and disconnected curriculum. Both teaching and learning will be compromised. But if testing mandates are restructured so that tests are deemphasized, the focus can return to the material itself, thereby improving performance.

New education law should promote good mathematics teaching, which cannot be accomplished by simply telling teachers or schools what to do. The long debate over the merits of reform-oriented and traditional mathematics instruction developed some consensus on what good mathematics teaching is, and legislation should address important aspects of contemporary mathematics education such as engagement and conceptual understanding. It should provide incentives for teachers to be connected to and involved in research on mathematics teaching and learning. And while standardized assessment may be a necessary evil of centrally controlled education, its regulation should be softened, and incentives should exist for meaningful, formative evaluation. Even with good standards and standards-based tests, if the stakes are too high, then goals can become blurry and education compromised.

Lastly, it is important that new education law consider possible adverse effects. Under NCLB, schools must meet specific established benchmarks in the form of *Adequate Yearly Progress*, and their failure to meet them can result in action by the state or school district. As an example, consider that more than two hundred teachers in Washington, DC, were fired by the district in July 2010, many allegedly over NCLB-related issues. Later explanations cast doubt on the proffered justification for the firings, and the resulting controversy became politicized to the extent that genuine reform of the system has been jeopardized.

The innate pressure in the system creates an environment in which teachers are more inclined toward unethical teaching practices. The practice of teaching to the test and

the existence of cheating by teachers and administrators by guiding test-takers to the correct answers or making available advance copies of tests have been documented. When it is in the best interest of each state to have larger percentages of proficient students, standards can be relaxed and tests watered down so that more students pass. The Common Core Standards recently adopted by a number of states may represent a start in reducing this tendency, as most states will be judged by the agreed-on national standards. Another negative influence lies in the emphasis on the proficiency threshold. It has been shown that in order to optimize the number of students labeled as proficient, schools and teachers may focus on students near the cutpoint. Students perceived to be well above or hopelessly below that cutpoint may not receive attention equal to that given to their peers.

Perhaps most importantly, new legislation must incorporate the input of both teachers of mathematics and mathematicians. Van Hollen said that "the teachers are… essential to making anything successful," yet 70 percent of the teachers in the survey did not support NCLB. They argued that NCLB is "making teaching [mathematics] a difficult profession" and that "teachers get no support to achieve [NCLB's] goals," producing a "one-size-fits-all format of teaching." This is not an appropriate setting for future math majors.

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Letters to the Editor

Cartan, Europe and Human Rights

I was surprised to read some erroneous information in the paper "Cartan, Europe, and human rights" in the September 2010 issue of the *Notices*. I am referring in particular to the information regarding the 1950 International Congress of Mathematicians, held in Cambridge, Massachusetts. Jean-Pierre Bourguignon writes:

"The visa application Laurent Schwartz had made to attend the ICM where he was to receive the Fields Medal had been set aside by the U.S. Embassy in Paris. In order to exert maximum pressure, Henri Cartan collected the passports of all the French ICM participants and threatened that there would be no French participation if Schwartz was not allowed to enter the United States."

There are a few wrong assertions in this sentence, for instance that Henri Cartan collected passports (they in fact were boat tickets) and that this concerned all the French participants (of course, a few French participants decided they would go to Cambridge in any case). A useful piece of information, the fact that Cartan was acting as the president of the Société Mathématique de France, is missing.

But the main error is the name of the French mathematician to whom the State Department refused to give a visa. There had indeed been a problem with Schwartz's visa, but it had been solved. The problem concerned Jacques Hadamard, who was eighty-five and a vice president of the Congress. He had spent the wartime in the States and was by 1950 considered a dangerous communist, and thus the State Department did not want to give him a visa.

References for that are numerous (Schwartz's autobiography *A Mathematician Grappling with His Century*, the biography *Jacques Hadamard: A Universal Mathematician* by Mazia and Shaposhnikova, to quote only accessible sources).

This error appeared in the original publication of Bourguignon's piece in the *Newsletter of the European Mathematical Society*, and it is surprising that it was not corrected before publication in the *Notices*. That Hadamard was considered a dangerous figure by the U.S. government seems unbelievable today… so unbelievable, that this episode seems to have disappeared from the collective memory of French mathematicians. But the fact that such a thing seems unbelievable does not prevent it from happening again in the future. This is the reason why I find it important to correct the error.

—Michéle Audin
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(Received October 4, 2010)

Remembering Paul Cohen

Regarding the recent article "Remembering Paul Cohen" in the *Notices*, I hope that the following few further reminiscences might be of interest. My educational path somewhat paralleled Paul's, since I was a student at Stuyvesant High School and did my graduate work at the University of Chicago, albeit in both cases about four years later than Paul. I had already heard about Paul while at Stuyvesant from the coach of the Math Team, Mr. Greenberg, who was still raving about Paul's abilities in mathematics a few years after Paul had graduated. While I was a graduate student at Chicago I attended Paul's lecture about his then new solution of Hilbert's First Problem, the Continuum Hypothesis.

I did not, however, meet him personally until the early 1970s, when I frequently visited Stanford as a result of collaborations with Jim Milgram. I

was perhaps most amazed at Paul's universal thirst for knowledge in *all* areas. As one example, on my second visit to Stanford I was met by Jim at the San Francisco airport, and he told me we were also picking up Paul, who was arriving about the same time. On the drive back to Stanford, I was first of all surprised that Paul remembered me (we had just met briefly a couple of years previously), and secondly that he also remembered that I was living in Alberta, Canada. He then totally amazed me when he asked me for many details about all of the native Indian tribes of the province (he already knew the names of these tribes), followed by questions about the mean temperatures in Calgary and Edmonton during the winter months.

Although I did not have any direct mathematical interaction with Paul, we did share the common hobby of magic. I always make a point of telling my students which tricks I learned from Paul Cohen when I show them in class. In closing, it seems fitting to quote my colleague Sashi Srivastava in Kolkata (Calcutta), "There has been much wonderful mathematics developed in the twentieth century, but what Paul Cohen did with his principle of forcing goes beyond that, it was 'divine inspiration'."

—Peter Zvengrowski,
University of Calgary

(Received October 1, 2010)

Response to Underwood Dudley

I recently had the opportunity to reread Underwood Dudley's essay on the purpose of mathematics education. On the one hand I was tickled by it and found its main argument compelling: as an instructor at a community college, I have scrupulously refrained from insulting my students' intelligence by suggesting that they might use the quadratic formula in any way outside of a mathematics classroom.

But I do have two objections to make. The first is that there is one unambiguous application of algebra in many workplaces: spreadsheets. While not everyone who uses a spreadsheet knows how to enter formulas, at least one person in every workplace presumably has (or should have) the algebraic skill to do so. Knowing (some) algebra then becomes a valuable tool for job advancement.

The second objection is that algebra may not be used in many jobs, but there is no question that it acts as a barrier to access to many jobs—particularly the most desirable and empowering ones.

This is hardly controversial: college entrance exams like the SAT and ACT are heavy on algebra; an overwhelming majority of colleges and universities also require students to pass a math placement exam, or suffer through one or more quarters of remedial algebra (even if their intended path is an associate's in child development, so that they can work at Head Start). At the other extreme, think about the engineer's licensing exam, which includes a paper-and-pencil test on integral and differential calculus, differential equations, and matrix operations—none of which the working engineer would ever dream of doing by hand. Finally, consider that many (most?) people who try to get graduate degrees in the social "sciences" these days are required to use statistics at a fairly sophisticated level for their thesis, one that would be immeasurably helped by a solid understanding of algebra.

In short, the broader society has another answer to the question "What is mathematics for?" It is a mechanism by which we screen out people who are (overwhelmingly) poor (and disproportionately people of color) from participating meaningfully in our economic arrangements.

—Matteo Tamburini, Instructor,
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(Received October 14, 2010)

Speaking with the Natives Redux

I was disappointed to read in the October 2010 issue in Gerald B. Folland's article "Speaking with the natives" the sentence "As far as I know, that unfortunate bit of whimsical nomenclature has not caused us any serious embarrassment yet, but if it does, I suggest that its perpetrators be sentenced to a year of hard labor teaching remedial algebra." This is an arrogant, snide remark about a large number of teachers and students. Here is what I know. The teachers of what we call developmental mathematics are dedicated educators who care for their students, who care for mathematics, and who are excellent teachers. They do an important task for mathematics departments for which they deserve the respect of the mathematical community. I believe that we should encourage and appreciate the teaching and learning of mathematics at all levels.

—John Grant,
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(Received October 15, 2010)

Correction

The September 2010 issue of the *Notices* featured a series of four articles under the heading "A Tribute to Henri Cartan". The photographs for these articles were kindly provided to the *Notices* by the family of Henri Cartan. Unfortunately, this information was not included in the article.

In the particular article entitled "A tribute to Henri Cartan", the photo caption on page 948 was truncated. It should have read "Nicole and Henri Cartan, Paris, 1961". The caption for the photograph on page 947 should have read "Henri Cartan, at his home desk in Paris, 1981".

—Sandra Frost
Managing editor

Vortices and Two-Dimensional Fluid Motion

C. Eugene Wayne

The study of fluid motions is of obvious importance for a host of applications ranging in scale from the microscopic to the atmospheric. Since we live in a three-dimensional world, it may be less obvious why the understanding of two-dimensional fluid flows is of interest. However, in many applications, such as the atmosphere or the ocean, the fluid domain is much smaller in one direction than in the other two—and also smaller than the typical size of features of interest in the fluid. For example, in the case of the atmosphere, the thickness is a few tens of kilometers, while the lateral extent is tens of thousands of kilometers and the diameter of a feature such as a hurricane can be several hundreds of kilometers. Furthermore, in both the atmosphere and the ocean, the applicability of a two-dimensional approximation is enhanced by two additional effects: the stratification of the medium (which reduces the effective thickness of the domain) and the rotation of the earth, which tends to reduce variations in the vorticity field with height and means that in any cross-sectional plane, the flow is effectively two-dimensional. In such circumstances a two-dimensional approximation to the fluid motion can provide very accurate insights into the behavior of the physical system.

Even more interesting is the fact that two- and three-dimensional fluids behave in qualitatively different fashions. In three-dimensional flows energy typically flows from large-scale features to small ones until it is dissipated by the viscosity of the fluid. In two dimensions the phenomenon tends to reverse itself, and the energy concentrates itself in a few large vortex-like structures. This phenomenon, known as the "inverse cascade", manifests itself in a striking visual way through the coalescence of many small vortices into a smaller number of larger vortices.

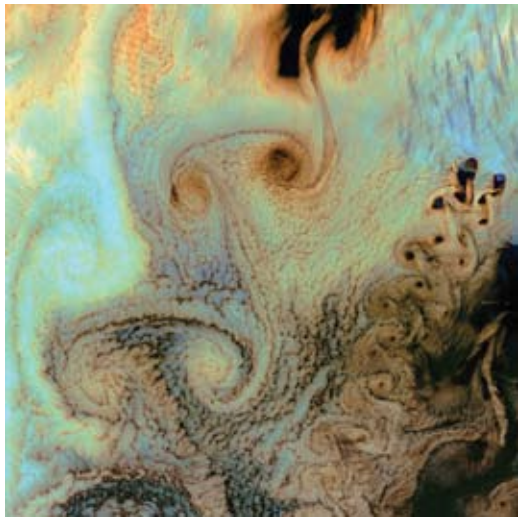

Figure 1. Atmospheric vortices formed by wind flowing past the Aleutian Islands, captured by Landsat 7 [17]. Note that in this image, the vorticity field cannot be directly visualized. Instead, one views passive tracer particles (i.e., clouds!) that are carried along by the background flow and which are believed to accurately mimic the vorticity field.

A beautiful visualization of this effect was created by Maarten Rutgers in turbulent soap films (see Figure 2). The patterns make visible differences in the vorticity of the fluid. The vorticity will be defined more precisely below

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but basically represents the rotational speed of the fluid either clockwise or counterclockwise. In this figure, the flow begins above the top of the picture and falls under the influence of gravity toward the bottom of the picture, so going down in the picture indicates a later stage in the evolution of the flow. The tendency of the vorticity to organize itself into larger and larger structures is clearly visible.

Figure 2. Two-dimensional turbulent flow visualized in a soap film by Maarten Rutgers—for an even more striking illustration of this phenomenon, see the video clip under the "Turbulence" section of http://maartenrutgers.org/ [20].

The growth in the size of vortices and the reduction in their numbers is also visible in numerical experiments, such as those displayed in Figure 3, that are the result of research by the vortex dynamics group at the Technische Universiteit Eindhoven (TUE), Netherlands. One of the main goals in the study of two-dimensional turbulent flows has been to understand and explain this inverse cascade and in particular to explain the tendency of the vorticity to coalesce into a smaller and smaller number of larger and larger vortices. In this article I will explain how by exploiting ideas from the kinetic theory of gases one can show that almost all two-dimensional *viscous* flows eventually approach a single, large vortex.

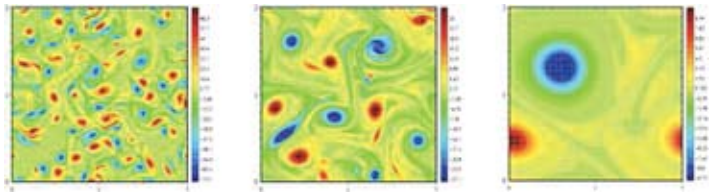

Figure 3. A numerical simulation of a two-dimensional turbulent flow. The figures display the vorticity field (with blue and red representing fluid swirling in opposite directions) at successively later and later times and clearly indicate the tendency of regions of vorticity of like sign to coalesce into a smaller and smaller number of larger vortices [21].

The typical way of describing the motion of a fluid is through its velocity field, $\mathbf{v}(\mathbf{z}, t)$; that is, through a vector field that at each point in space and time gives the velocity of the fluid at that point. However, more than 150 years ago Helmholtz realized that in addition to the velocity, the vorticity of the fluid carries important information about the nature of the flow. As mentioned above, the vorticity roughly measures the swirl in a fluid. More precisely, the vorticity is defined as the curl of the fluid velocity,

$$\boldsymbol{\omega}(\mathbf{z}, t) = \nabla \times \mathbf{v}(\mathbf{z}, t).$$

Note that we see already an important difference between two and three dimensions—in two dimensions, only one component of the vorticity is nonzero, and thus we can treat the vorticity essentially as a scalar field.

For an incompressible fluid, the fluid velocity satisfies the Navier-Stokes equations, the system of coupled nonlinear partial differential equations

$$\partial_t \mathbf{v} + \mathbf{v} \cdot \nabla \mathbf{v} = \nu \Delta \mathbf{v} - \frac{1}{\rho} \nabla p \,, \tag{1}$$

$$\nabla \cdot \mathbf{v} = 0 \,, \tag{2}$$

where ν is the kinematic viscosity of the fluid (which we will assume is constant), ρ is the fluid density (which is constant due to the incompressibility condition), and $p = p(\mathbf{z}, t)$ is the pressure in the fluid. The first of these equations is just Newton's law for the fluid, with the left-hand side representing the acceleration of the fluid and the right-hand side the forces acting on it. We will assume that the only forces present are the internal viscous forces, modeled by the first term on the right-hand side, and the pressure forces, represented by the second. External forces acting on the fluid could be incorporated by adding additional terms to the right-hand side of the equation. We will also ignore the effects of

boundaries on the fluid by assuming that the fluid occupies all of $\mathbb{R}^d$ with $d = 2, 3$.

In order to determine how the vorticity evolves, one can take the curl of both sides of the first of the Navier-Stokes equations. The dynamics represented by the two- and three-dimensional equations are strikingly different despite the close relationship between the equations. In three dimensions one has the system of equations

(3)
$$\partial_t \boldsymbol{\omega}(\mathbf{z},t) - \boldsymbol{\omega}\cdot\nabla\mathbf{v}(\mathbf{z},t) + \mathbf{v}\cdot\nabla\boldsymbol{\omega}(\mathbf{z},t) = \nu\Delta\boldsymbol{\omega}(\mathbf{z},t),$$

while in two dimensions one has only the single, scalar equation

(4)
$$\partial_t \omega(\mathbf{z},t) + \mathbf{v}\cdot\nabla\omega(\mathbf{z},t) = \nu\Delta\omega(\mathbf{z},t).$$

(We will use a boldface $\boldsymbol{\omega}$ to denote the vorticity vector and an ω to denote the single, nonzero component of the vorticity in two dimensions.) The presence of the "vortex stretching term", $-\boldsymbol{\omega}\cdot\nabla\mathbf{v}(\mathbf{z},t)$ in (3), is a critical physical difference between these two equations. For certain special fluid configurations, this term can lead to a sort of feedback mechanism in which the vorticity begins to grow. While it is not known if this growth can continue without bound, there is no obvious mechanism to stop its growth, and this is the physical source of the uncertainty as to whether or not smooth solutions of the Navier-Stokes equations exist for all time in three dimensions. The fact that it is still unknown whether or not the partial differential equations that are believed to describe such a basic system as fluid motion have unique, smooth solutions makes this obviously an extremely important question, and the successful resolution of this question (or the discovery of an example demonstrating the formation of a singularity in the solution in finite time) was chosen by the Clay Mathematics Institute as one of the one-million-dollar Millennium Prize Problems. The role of the vortex-stretching term and its relationship both to the possible formation of singularities and the analysis of the Navier-Stokes equation is discussed in detail in [5]. In contrast, in two dimensions the absence of this term allows one to construct global solutions of the two-dimensional vorticity equation, even for initial data with very little regularity [8].

One respect in which the vorticity formulation of the fluid equations is less convenient than the velocity-pressure formulation is that the velocity still appears in equations (3) and (4) for the evolution of the vorticity. However, if we remember that the vorticity is the curl of a divergence-free vector field (i.e., the velocity), then we can recover the vorticity field from the velocity field via the Biot-Savart law, which inverts the curl, and which in the two-dimensional case on which we will focus from now on takes the form

(5)
$$\mathbf{v}(\mathbf{z},t) = \frac{1}{4\pi}\int_{\mathbb{R}^2} \frac{(\mathbf{z}-\tilde{\mathbf{z}})^\perp}{|\mathbf{z}-\tilde{\mathbf{z}}|^2}\cdot\omega(\tilde{\mathbf{z}},t)\,d\tilde{\mathbf{z}}\,.$$

Here, if $\mathbf{z} = (x,y) \in \mathbb{R}^2$, then $\mathbf{z}^\perp = (-y,x)$. Thus the velocity can be regarded as a linear, but nonlocal, function of the vorticity. With this point of view the two-dimensional vorticity equation (4) can be regarded as a nonlinear heat equation in which the nonlinear term is quadratic and nonlocal. As we will see later, this relationship with the heat equation will play an important role in understanding solutions of (4).

Let's now look more closely at equation (4) and try to understand the influence of various terms in the equation. First consider the case in which $\nu = 0$ (the *inviscid* case). In this case, if we pretend for the moment that the velocity field is given to us, rather than being determined by the vorticity, then the equation becomes simply a transport equation in which the vorticity is carried along by the velocity field. In reality, the situation is more complicated, because as the vorticity is advected by the velocity field, the velocity field itself changes in response to the changing vorticity; and in order to obtain an accurate model of the evolution of the vorticity, one must incorporate the "feedback" of the vortex motion on the velocity field.

Helmholtz, and then later and more systematically Kirchhoff, made the assumption that the vorticity could be written as a finite sum of point vortices (i.e., delta functions) whose positions moved in response to the velocity field they created. Note that the velocity field of a point vortex can be computed explicitly from the Biot-Savart law, and using this, Helmholtz and Kirchhoff could track the dynamical evolution of the velocity field in their model and account for the feedback the vortex motion creates. Thus, if one assumes that the vorticity field can be written as $\omega(\mathbf{z},t) = \sum_{k=1}^{N}\Gamma_k\delta(\mathbf{z}-\mathbf{z}_j(t))$, where Γ_j is the strength of the j^{th} vortex and $\mathbf{z}_j(t)$ is its position and substitutes this into the $\nu = 0$ case of (4) (and interprets the solution in an appropriate weak sense—see [13] for details), then one finds explicit *ordinary* differential equations for the locations of the centers of the vortices. If one sets $\mathbf{z}_j(t) = (x_j(t), y_j(t))$, then one finds that

(6)
$$\begin{aligned}\dot{x}_j(t) &= -\frac{1}{2\pi}\sum_{k\neq j}\Gamma_k\frac{y_j-y_k}{|\mathbf{z}_j-\mathbf{z}_k|^2}\,,\\ \dot{y}_j(t) &= \frac{1}{2\pi}\sum_{k\neq j}\Gamma_k\frac{x_j-x_k}{|\mathbf{z}_j-\mathbf{z}_k|^2}.\end{aligned}$$

These equations have explicit solutions for a number of simple arrangements of small numbers of vortices. For instance, one can easily check that two vortices of equal strength will move on a circle about the point midway between them, while two vortices of opposite strength will move on parallel lines, in a direction perpendicular to the line joining them (see Figure 4).

The set of equations (6) turns out to have a number of remarkable properties [18]. For instance,

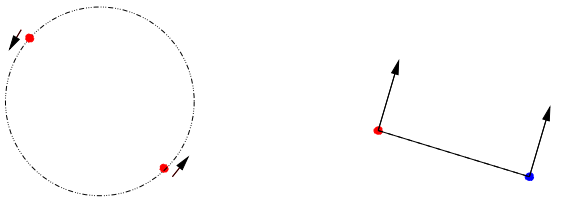

Figure 4. The dynamics of the centers of a pair of point vortices of equal strength and of opposite strength.

it is a Hamiltonian system in which the Hamiltonian is proportional to the sum of the logarithm of the distance between pairs of vortices; furthermore, if the number of vortices is three or less, it is a completely integrable Hamiltonian system. However, if one has four or more vortices, one typically finds chaotic solutions.

In spite of the special properties of the point-vortex equations, analytic solution for general initial data becomes quickly impossible for more than a small number of vortices. (An exception to this general rule are the equilibrium and relative equilibrium solutions, for which there are interesting connections with analogous solutions in the N-body problem in celestial mechanics [1].) However, given the Hamiltonian nature of the equations of motion and the chaotic nature of their solutions for large numbers of vortices, it is natural (at least in retrospect) to attempt to understand the behavior of large collections of vortices with the aid of statistical mechanics. Thus, if one considers the initial vorticity distribution in Figure 3, one can imagine it as a "gas" of point vortices that interact with the other vortices through a potential energy function in which the energy of a vortex pair is proportional to the logarithm of the distance between them. Lars Onsager may have been the first person to adopt this point of view, and it led him to a remarkable conclusion [7]. Onsager found that the statistical mechanical description of a collection of point vortices moving according to the equations of motion (6) could support states in which a parameter analogous to the absolute temperature in a traditional statistical mechanical system was actually negative. Furthermore, Onsager realized that a consequence of these negative temperature states was that vortices of like sign would coalesce and that this could explain the tendency observed in Figure 3 for large vortices of each sign to form as the fluid evolves. As Onsager himself put it ([19], quoted in [7])

> It stands to reason that the large compound vortices formed in this manner will remain as the only conspicuous features of the motion.

Thus Onsager had provided a means of explaining how large vortices could form from random collections of small vortices, provided the effects of viscosity are ignored and assuming that the hypotheses that underlie the theory of statistical mechanics are satisfied.

It is not only in the theoretical understanding of fluid flows that the Helmholtz-Kirchhoff point vortex model has played an important role. Even though one cannot solve the equations (6) analytically for more than a few vortices, they are perfectly amenable to numerical solution, and this idea has formed the basis of "vortex methods" or "meshless methods" in computational fluid mechanics. In this approach, one first approximates the initial distribution of vorticity by a collection of point vortices (or, more frequently in numerical approaches, smoothed vortices with finite size cores). The key quantities are the location and strength of each of the vortices. The vortex strength is typically conserved, and thus the evolution of the fluid can be tracked by following the locations of the centers of the vortices via a system of ordinary differential equations such as (6). It can be shown that vortex methods give convergent approximations (as the number of points used in the approximation tends to infinity) to *inviscid* fluid flows (though sometimes with relatively slow convergence rate). However, one problem that can arise is related to Onsager's observation that in a large collection of vortices, those of like sign will tend to clump together. Thus, after some time, large parts of the computational domain may have only a very few vortices, which leads to a loss of information about the flow in these regions. For a further discussion of the advantages and disadvantages of using vortex methods to numerically approximate two-dimensional flows see the recent monograph of Majda and Bertozzi [12], while [2] contains a survey of recent improvements in the vortex method, with a particular focus on how one can incorporate viscous effects in the method.

Thus far, we have mainly discussed the limiting case of the Navier-Stokes equation in which the viscosity is zero. In realistic fluids (with the spectacular exception of super fluids) the viscosity may be small but is never zero, so we next consider its effects on the preceding scenarios. One can show that for finite (sometimes short) times, the solution of the weakly viscous Navier-Stokes equation with appropriate initial data is well approximated by solutions of the point-vortex model [13]. However, these short-time results cannot provide insight into the long-time phenomena that occur in the "inverse cascade". Indeed, we'll see that even within the long-time regime there are two distinct time scales, one on which the inviscid phenomena predicted by Onsager appear and a second, typically longer, time scale over which viscous effects manifest

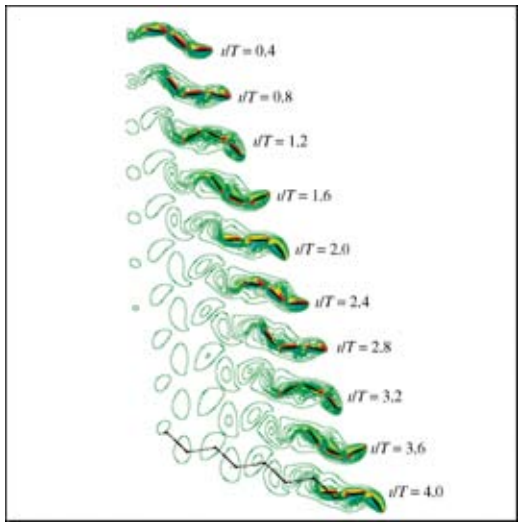

Figure 5. The vorticity field around a swimming "fish", computed with a modern vortex method [6]

themselves and which we show below lead to the formation of a single large vortex in the system.

If we ignore the nonlinear term and focus on the linear terms in the equation, we just find the two-dimensional heat equation

$$\partial_t \omega = \nu \Delta \omega \,. \tag{7}$$

In this equation we know that the effects of the Laplacian term are to spread things out—or diffuse them—at a rate proportional to ν. Indeed, if we were to take a point vortex, i.e., a Dirac δ-mass, as an initial condition, we know that the effect of the equation is just to "smear" this point out into a Gaussian. More precisely, if we take an initial condition $\omega(\mathbf{z}, 0) = \alpha\delta(\mathbf{z})$ for (4), and we ignore the nonlinear term in the equation, then we find immediately that the resulting solution is

$$\omega(\mathbf{z}, t) = \frac{\alpha}{4\pi\nu t} e^{-|\mathbf{z}|^2/(4\nu t)} \,. \tag{8}$$

Remarkably, this explicit Gaussian turns out to be an exact solution not only of the linear heat equation but also of the nonlinear two-dimensional vorticity equation, known as the Oseen-Lamb vortex. To see the reason for this, recall that since the fluid is incompressible, its velocity field is divergence free. In this case the Helmholtz decomposition implies the existence of a stream function $\psi(\mathbf{z})$ such that $\mathbf{v}(\mathbf{z}) = (\partial_y \psi, -\partial_x \psi)$. Thus the vorticity is related to the stream function via the equation

$$\omega(\mathbf{z}, t) = \partial_x \mathbf{v}_2 - \partial_y \mathbf{v}_1 = -\Delta\psi(\mathbf{z}, t). \tag{9}$$

In the present example of the Oseen-Lamb vortex, in which the vorticity is a purely radial function depending only on $|z|$, solving Poisson's equation will give a stream function that is also purely radial and that in turn gives rise to a purely tangential velocity field. Since the nonlinear term in the vorticity equation consists of the dot product of the velocity field with the gradient of the vorticity, we will have the dot product of a tangential with a radial vector; i.e., the value of the nonlinear term is zero when evaluated on the velocity and vorticity fields of the Oseen-Lamb vortex. In this case the vorticity equation reduces to the heat equation, which, as we have already remarked, is solved by the Oseen-Lamb vortex.

Note that in the expression for the vorticity field of the Oseen vortex the space and time variables are linked in a special fashion. This suggests that it may be convenient to study the vorticity equation in new variables, so-called *scaling variables*. With this in mind we define new dependent and independent variables through the change of variables

$$\omega(x, y, t) = \frac{1}{1+t} w\left(\frac{x}{\sqrt{1+t}}, \frac{y}{\sqrt{1+t}}, \log(1+t)\right). \tag{10}$$

If we define $\xi = \frac{x}{\sqrt{1+t}}$, $\eta = \frac{y}{\sqrt{1+t}}$, $\boldsymbol{\zeta} = (\xi, \eta)$, and $\tau = \log(1+t)$, then in terms of these new variables the two-dimensional vorticity equation takes the form

$$\partial_t w = \nu \Delta w + \frac{1}{2} \nabla \cdot (\boldsymbol{\zeta} w) - \mathbf{u} \cdot \nabla w \equiv \mathcal{L}^\nu w - \mathbf{u} \cdot \nabla w, \tag{11}$$

where $\mathbf{u}$ is just the velocity field, rewritten in terms of the scaling variables, and the derivatives in the Laplacian and divergence are now taken with respect to $\boldsymbol{\zeta}$ instead of $\mathbf{z}$.

Note that in terms of these variables, the family of Oseen vortices are all *fixed points* of this equation, i.e., the functions

$$\begin{aligned} \omega(\xi, \eta) = \Omega^\alpha(\xi, \eta) &= \frac{\alpha}{4\pi} e^{-|\boldsymbol{\zeta}|^2/4\nu} \\ &= \frac{\alpha}{4\pi} e^{-(\xi^2+\eta^2)/4\nu} \end{aligned} \tag{12}$$

are all stationary solutions for equation (11). Note that we have normalized the Gaussian so that the parameter α of the Oseen vortex gives the total vorticity (i.e., the integral of the vorticity) of the solution. Note further that both the vorticity equation, (4), and the rescaled vorticity equation, (11), conserve the total vorticity. The presence of this family of fixed points suggests that we might be able to use ideas from dynamical systems theory to study the stability of these fixed points and to try to determine whether they can explain the asymptotic behavior of some or all of the solutions of this partial differential equation.

There are (at least) two different dynamical systems approaches that can be applied to study the stability and influence on the asymptotics of the fixed points (12); namely:

- Linearization about the fixed point and the construction of invariant manifolds in the phase space corresponding to the various spectral subspaces of the linearization, or
- Lyapunov functionals.

In this article I'll focus on the Lyapunov functional approach because of its relationship to the statistical mechanics point of view that we have discussed above. However, one can also use the invariant manifold approach to analyze the asymptotic behavior of solutions of (11). In contrast to the Laplacian, whose spectrum is the entire negative real axis, the linear operator, $\mathcal{L}^\nu$, when considered on spaces of functions that go to zero rapidly at infinity, has a spectrum that consists of a set of discrete eigenvalues, plus a half-plane of essential spectrum. One can construct finite-dimensional, invariant manifolds corresponding to the span of the eigenfunctions of these eigenvalues that describe very precisely the asymptotics of small solutions of (11) [9]. Moreover, the eigenfunctions corresponding to these discrete eigenvalues form a convenient basis with respect to which one can systematically extend the Helmholtz-Kirchhoff point-vortex model described above to include the effects of viscosity and finite core size [16].

Recall that a Lyapunov functional for a dynamical system is a continuous function, bounded below on the phase space of the dynamical system, which when evaluated on an orbit of the dynamical system is monotonic nonincreasing and bounded below. (Very colloquially, it is a function whose value decreases with time when evaluated along solutions of the dynamical system.) Recall that our goal is to understand how the vorticity forms large structures after very long times. One way of characterizing the long-time asymptotics of a dynamical system is through the ω-*limit* set, which is the set of points in the phase space which a trajectory approaches arbitrarily closely to as time tends to infinity. If the trajectory approaches a stable fixed point, then the ω-limit set will consist just of this fixed point. However, the ω-limit set can also be a periodic orbit or even some chaotic attractor. Note that it is not immediately apparent that every trajectory will have an ω-limit. This follows if the solutions of the dynamical system satisfy certain compactness conditions. For the remainder of the article we will assume that the solutions of the vorticity equation satisfy these conditions, though proving this takes some work—the details are explained in [10].

A key tool in locating the ω-limit set is the LaSalle Invariance Principle, which says that given a Lyapunov functional for a dynamical system, the ω-limit set of a trajectory must lie in the set on which the Lyapunov function is constant (when evaluated along an orbit). More precisely, if the points in the phase space of the dynamical system are denoted by w, if the flow or semi-flow defined by the dynamical system is denoted by Φ^t, and if the Lyapunov functional is denoted by $H(w)$ (and it is differentiable), then the ω-limit set must lie in the set of points

$$E = \{w \mid \frac{d}{dt} H(\Phi^t(w))|_{t=0} = 0\}. \tag{13}$$

Let's now return to rescaled vorticity equation (11) and make use of one more analogy. So far, we have considered the equation in which we ignored the dissipative term and retained only the time derivative and the nonlinearity, and we have also ignored the nonlinear term and retained only the dissipative term. Let's finally retain all the terms in (11) but ignore for the moment the fact that the velocity field is linked to the vorticity and pretend that it is just some given, divergence-free vector field. In this case if we use the fact that $\nabla \cdot \mathbf{u} = 0$, we can write (11) as

$$\partial_\tau w = \nu \Delta w - \nabla \cdot (w \nabla \mathbf{U}) \,, \tag{14}$$

where $\nabla \mathbf{U}(\zeta, \tau) = \mathbf{u}(\zeta, \tau) - \frac{1}{2}\zeta$. This equation is just the Fokker-Planck equation, which describes the evolution of the probability distribution of the location of a particle in a gas confined by the potential $\mathbf{U}$ and with diffusive effects modeled by the term $\nu \Delta w$. Equation (14) has been studied extensively by physicists and mathematicians for more than a century, and, in particular, motivated by Boltzmann's theory that the entropy of such a system should never decrease, Lyapunov functionals have been developed that are based on the entropy. (See [14] for a nice discussion of the interplay between physics and analysis in this problem.)

The classical entropy function for solutions of (11) would be $S[w](t) = \int_{\mathbb{R}^2} w(\zeta) \ln w(\zeta) d\zeta$, but as explained in [14] it is often more useful to study the *relative entropy*, that is, the entropy relative to the expected asymptotic state of the system. In this case our candidate for the asymptotic state of the system is one of the Oseen vortices Ω^α defined in (12), which results in a relative entropy functional

$$H[w](\tau) = \int_{\mathbb{R}^2} w(\zeta, \tau) \ln \left(\frac{w(\zeta, \tau)}{\Omega^\alpha(\zeta)} \right) d\zeta. \tag{15}$$

Of course, so far, there is no proof that this is a Lyapunov functional for the (rescaled) vorticity equation. It is a candidate, suggested by the analogy between (11) and the Fokker-Planck equation, but in the actual vorticity equation the fluid velocity is not independent of the vorticity (and in particular the vorticity equation, unlike the Fokker-Planck equation, is a nonlinear equation). Furthermore, a second problem is apparent from formula (15). Since solutions of the Fokker-Planck equation represent probability densities, it is natural to assume that they are nonnegative, and consequently the logarithm in (15) is well defined. However, it is quite unnatural to assume that solutions of the vorticity equation are all of one sign—typical solutions intermingle regions of positive vorticity with regions of negative vorticity, and for such

solutions it becomes impossible to define the relative entropy functional.

We'll return to the second of these problems in a moment, but first consider whether or not (15) at least defines a Lyapunov functional for solutions of the vorticity equation *which are* everywhere positive. As we'll explain below, if the solution of the vorticity equation is positive at some instant of time, it will remain so for all later times. Assuming that the solution is positive for some time t and that the vorticity tends to zero sufficiently rapidly as $|\zeta| \to \infty$ so that the integral in (15) converges, we can compute the derivative of the entropy, and we find:

(16)
$$\frac{d}{d\tau}H[w](\tau) = \int_{\mathbb{R}^2}\left(1 + \ln\left(\frac{w(\zeta,\tau)}{\Omega^\alpha(\zeta)}\right)\right)\frac{\partial w}{\partial \tau}d\zeta.$$

If we now use (11) to rewrite the time derivative of the vorticity and then integrate by parts (and use the relationship between vorticity and velocity), we find

(17)
$$\frac{d}{d\tau}H[w](\tau) = -\int_{\mathbb{R}^2} w(\zeta)\left|\nabla\left(\frac{w}{\Omega^\alpha}\right)\right|^2 d\zeta.$$

Since w is positive, (17) shows that for such solutions the relative entropy function is a Lyapunov function. One can also show H is bounded below for w in an appropriate function space (and that the compactness properties mentioned above also hold), and hence the LaSalle Invariance Principle holds. This means that the ω-limit set for any positive solution of the vorticity equation must lie in the set where $\frac{d}{d\tau}H[w](\tau) = 0$. Since $w(\zeta,t) > 0$, (17) implies that the only way the time derivative of the entropy can vanish is if

(18)
$$\left(\frac{w}{\Omega^\alpha}\right) = \text{constant};$$

i.e., if the solution is an Oseen vortex. This means that for positive solutions of the vorticity equation the only possible asymptotic states are the Oseen vortices.

As we remarked above, the assumption that solutions are positive is *a priori* a very unnatural one for the vorticity equation, and thus we now turn to the question of how to treat solutions that change sign. To deal with such solutions, we need another Lyapunov functional. The clue to finding this second Lyapunov function is the observation we made earlier about the similarity of the two-dimensional vorticity equation (4) to a nonlinear heat equation. Closer inspection shows that, just like the heat equation, solutions of (4) satisfy a maximum principle. In particular:

- A solution that is positive (for all z) for some time t_0 will remain positive for any later time $t > t_0$, and
- If the initial condition for the vorticity equation satisfies $\omega(\mathbf{z},0) \geq 0$ for all z, then the solution will be strictly positive for all times $t > 0$.

Note that these remarks also hold for solutions of the rescaled vorticity equation (11). As a consequence of these two observations, we find a second, surprisingly simple, Lyapunov functional, namely the $L^1(\mathbb{R}^2)$-norm of the solution. Define

(19)
$$K[w](\tau) = \int_{\mathbb{R}^2}|w(\zeta,\tau)|d\zeta.$$

To see that this is a Lyapunov functional, split the solution of (11) into its positive and negative parts, i.e., write $w(\xi,\eta,\tau) = w^+(\xi,\eta,\tau) - w^-(\xi,\eta,\tau)$, where $w^\pm$ are both nonnegative and satisfy the equations:

(20)
$$\partial_\tau w^\pm = \mathcal{L}^\nu w^\pm - \mathbf{u}\cdot\nabla w^\pm.$$

Here, $\mathbf{u}$ is the total velocity field—i.e., the velocity field associated with $w(\zeta,\tau)$ rather than that associated with either w^+ or w^-. We note that one can show (by undoing the change to scaling variables) that solutions of (20) also satisfy two properties listed above. If we choose initial conditions for $w^\pm$ so that $w^+(\zeta,0) = \sup(w(\zeta,0),0)$ and $w^-(\zeta,0) = -\inf(w(\zeta,0),0)$, then $w^\pm|_{\tau=0}$ are both nonnegative and have disjoint support. By the maximum principle, if $\omega^\pm|_{\tau=0} \not\equiv 0$, both $w^\pm$ will be strictly positive for all positive times. From this we find that

$$\begin{aligned}
K[w](\tau) &= \int_{\mathbb{R}^2}|w^+(\zeta,\tau) - w^-(\zeta,\tau)|d\zeta \\
&\leq \int_{\mathbb{R}^2} w^+(\zeta,\tau)d\zeta + \int_{\mathbb{R}^2} w^-(\zeta,\tau)d\zeta \\
&= \int_{\mathbb{R}^2} w^+(\zeta,0)d\zeta + \int_{\mathbb{R}^2} w^-(\xi,\eta,0)d\zeta \qquad (21)\\
&= \int_{\mathbb{R}^2}|w^+(\zeta,0)d\zeta - w^+(\zeta,0)|d\zeta \\
&= K[w](0)\ ,
\end{aligned}$$

where the equality in the middle of (21) follows from the fact that solutions of (20) conserve "mass" (i.e., the integral of the solution), as do solutions of the vorticity equation. From (21) we see that K is a Lyapunov functional for solutions of the vorticity equation. Furthermore, recalling that the maximum principle implies that both $w^\pm$ are strictly positive, we see that the first inequality in (21) will be a strict inequality unless either w^+ or w^- is identically zero. Thus the Lyapunov functional K is strictly decreasing except on the set of functions that is either strictly positive or strictly negative, and, appealing again to the LaSalle invariance principle, we see that the ω-limit set of solutions must lie in the set where K is not strictly decreasing—i.e., in the set of either everywhere positive or everywhere negative solutions.

If we now put together our two Lyapunov functionals, we have the following conclusion, namely,

for general solutions, the Lyapunov functional K implies that the ω-limit set must lie in the set of solutions of one sign. However, for solutions of one sign, the relative entropy functional, H, implies that the ω limit set must be an Oseen vortex. So far, we have been somewhat vague about the function space on which we work, but in fact these results hold for any solution whose initial vorticity is absolutely integrable (for this and other technical details we refer the reader to [10]) and thus we have

Theorem 1.1. *Any solution of the two-dimensional vorticity equation whose initial vorticity is in* $L^1(\mathbb{R}^2)$ *and whose total vorticity* $\int_{\mathbb{R}^2} \omega(\mathbf{z},0)d\mathbf{z} \neq 0$ *will tend, as time tends to infinity, to the Oseen vortex with parameter* $\alpha = \int_{\mathbb{R}^2} \omega(\mathbf{z},0)d\mathbf{z}$.

Extensions and Conclusions

Theorem 1.1 implies that with even the slightest amount of viscosity present, two-dimensional fluid flows will eventually approach a single large vortex. However, if the viscosity is small, this convergence may take a very long time. Furthermore, Onsager's original calculations of vortex coalescence were for an inviscid fluid model, which suggests that some sort of coalescence should occur independent of the viscosity—and, in particular, on a time scale that does not depend on the viscosity. Thus, while Theorem 1.1 says that eventually all two-dimensional viscous flows will approach an Oseen vortex, there should be a variety of interesting and important behaviors that manifest themselves in the fluid prior to reaching the asymptotic state described in the theorem.

One of the most important physical effects, and one of the hardest to understand from a mathematical point of view, concerns the merger of two or more vortices. Clearly such mergers must take place in order for the multitude of small vortices present in an initially turbulent flow to coalesce into the small number of large vortices predicted by Onsager. Furthermore, as discussed in [15], this process plays a key role in many nonturbulent flows such as the wingtip vortices that form behind an airplane wing, as illustrated in Figure 6. As the authors of [15] explain, although the phenomenon is obviously a three-dimensional one, and three-dimensional effects undoubtedly influence the details of the flow, the two-dimensional dynamics "contain all the ingredients necessary to explore and understand the physics involved in vortex merging". While the Oseen vortex that characterizes the long-time asymptotics of the flow has the property that the effects of the nonlinear terms in the vorticity equation vanish, both numerical and experimental studies show that the merger process is highly nonlinear and involves the filamentation and interpenetration of the two vortices into one another, as shown in Figure 7. While physically based criteria exist to predict when merger will occur, a rigorous mathematical understanding of this phenomenon is so far almost completely absent.

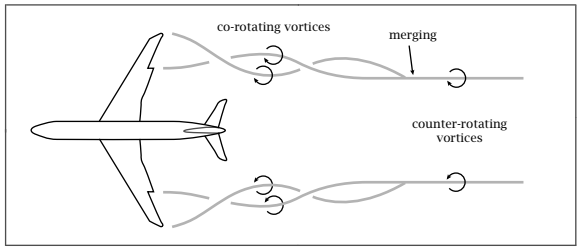

Figure 6. The merger of wingtip vortices behind an airplane (from [15]). Although the flow is obviously three-dimensional, much of the process of vortex merger can be understood by considering cross-sections of the flow as if they were two-dimensional vortices.

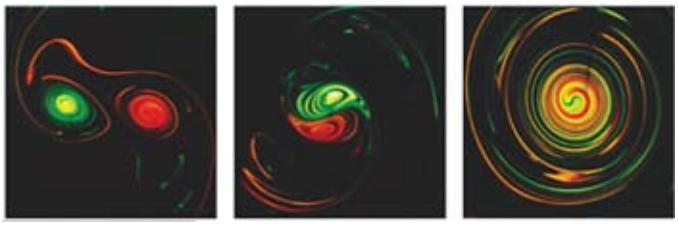

Figure 7. An experimental dye visualization of the merger of two-dimensional vortices, from [15]

A second interesting phenomenon that is particularly noticeable in the numerical simulations of two-dimensional flows on bounded domains is the creation and persistence of metastable structures. For square domains with periodic boundary conditions, the total vorticity is forced to be zero, and as a consequence the asymptotic state is the zero state. Nonetheless, a number of different, very long-lived, metastable states are observed [22]. The origin and properties of these states in the two-dimensional Navier-Stokes equation is still not understood, but statistical mechanical ideas have again been used to propose an explanation associated with the different time scales on which energy and entropy are dissipated [4]. Similar metastable phenomena also occur in the weakly viscous Burgers' equation, which is often used as a simplified testing ground for understanding the Navier-Stokes equations. There, the long-time asymptotics are again governed by a family of self-similar states, analogous to the Oseen vortices in the two-dimensional Navier-Stokes equations. However, for very long times (exponentially long in the reciprocal of the viscosity!), one observes not

the self-similar state but rather a special family of solutions known as "diffusive N-waves" [11], [3]. As in the expected behavior of the two-dimensional Navier-Stokes equation, the metastable states in Burgers' equation are closely related to the N-waves of the inviscid equation, while the self-similar asymptotic state depends crucially on the presence of dissipation in the systems. Because of the simpler nature of Burgers' equation, one can show that the metastable states form a one-dimensional attractive invariant manifold in the phase space of the equation, and one can speculate that a similar dynamical systems explanation might account for the metastable behavior observed in the two-dimensional Navier-Stokes equation, as it has for the long-time asymptotics of solutions.

In summary, two-dimensional fluid motions present interesting differences with three-dimensional fluids from both the mathematical and physical points of view. In spite of the fact that we live in a three-dimensional world, in many situations a two-dimensional fluid model is appropriate. One important situation in which this is the case and for which a two-dimensional fluid model is often used is the earth's atmosphere. In two dimensions, it is particularly convenient to study the evolution of the vorticity, rather than work directly with the velocity field of the fluid. Ever since Helmholtz and Kirchhoff developed an ordinary differential equation model to describe the evolution of point vortices, dynamical systems ideas have played an important role in understanding the evolution of the vorticity in two-dimensional flows, a theme that continues to pay dividends to the present day.

A distinctive feature of two-dimensional flows is the "inverse cascade" of energy from small scales to large ones. Lars Onsager first sought to explain this phenomenon by studying the statistical mechanics of large collections of inviscid point vortices. While Onsager's observation about *inviscid* flows remains unexplained, dynamical systems ideas—in this case Lyapunov functionals inspired by kinetic theory—have been used to show that in the presence of an arbitrarily small amount of viscosity, essentially any two-dimensional flow whose initial vorticity field is absolutely integrable will evolve as time goes to infinity toward a single, explicitly computable vortex.

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From Cartan to Tanaka: Getting Real in the Complex World

Vladimir Ezhov, Ben McLaughlin, and Gerd Schmalz

It is well known from undergraduate complex analysis that holomorphic functions of one complex variable are fully determined by their values at the boundary of a complex domain via the Cauchy integral formula. This is the first instance in which students encounter the general principle of complex analysis in one and several variables that the study of holomorphic objects often reduces to the study of their boundary values. The boundaries of complex domains, having odd topological dimension, cannot be complex objects. This motivated the study of the geometry of real hypersurfaces in complex space. In particular, since all established facts about a particular hypersurface carry over to its image via a biholomorphic mapping in the ambient space, it is important to decide which hypersurfaces are equivalent with respect to such mappings—that is, to solve an equivalence problem for real hypersurfaces in a complex space.

In the case of one complex variable, the Riemann mapping theorem says that any simply connected domain is either $\mathbb{C}$ or equivalent to the unit disc. In contrast, Henri Poincaré [17] showed that in higher dimensions even the ball and the bidisc are not equivalent, which implies that their boundaries cannot be equivalent.

In the same article Poincaré posed the local equivalence problem, i.e., to decide when two hypersurfaces are equivalent in the neighbourhoods of given points. He sketched a heuristic argument that any two real hypersurfaces in $\mathbb{C}^2$ cannot be expected to be locally equivalent.

In order to solve this equivalence problem for real hypersurfaces in $\mathbb{C}^2$, Élie Cartan [6], [7] constructed in 1932 a "hyperspherical connection" by applying his method of moving frames. The technique of Cartan has been further developed by introducing modern geometric and algebraic tools, mainly in the groundbreaking work by Noboru Tanaka (see [22], [23], [24]). These powerful and elegant methods are widely used in conformal geometry and have led to the development of parabolic geometry (see [5]), while Cartan's original approach, applied to hypersurfaces in higher dimensional complex space by Shiing-Shen Chern and Jürgen Moser [8], is still dominant in complex analysis (see, e.g., [12], [13]).

An alternative approach to invariants of boundaries of complex domains has been developed by Charles Fefferman [10]. A recent result by Andreas Čap and Rod Gover [3], based on parabolic geometry, shows the relation between the Cartan-Tanaka and the Fefferman calculi.

In practice it remains difficult even to decide if a given hypersurface is locally equivalent to a sphere. Sidney Webster [25] solved this problem for an ellipsoid in $\mathbb{C}^n$ ($n \geq 3$) in 2000. In this context he states that the methods developed are at least as interesting as the results.

The purpose of this article is to illustrate the basic ideas of Tanaka's theory by deriving the

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principal curvature invariants for hypersurfaces in $\mathbb{C}^2$. This solves the equivalence problem if one of the hypersurfaces is a sphere.

While there is extensive literature on both Cartan connections (see, e.g., [21] and [5]) and CR-geometry (see, e.g., [2], [13], [12] and [9]), the authors feel that there is a need to draw these two subjects together.

Geometric Structures

Before we introduce the concept of CR-geometry, which is the suitable setting for the study of real hypersurfaces in $\mathbb{C}^n$, we would like to take a broader view of a geometric structure as a class of manifolds with additional data given on the tangent spaces. Examples of such structures include Riemannian geometry and almost complex structures.

In his Erlangen programme (1872), Felix Klein observed that geometric structures can be studied by their symmetry groups. These are the groups of the self-mappings that preserve the structure data. The study of a geometric structure hence leads to such problems as:

- What are the symmetries of a given object?
- Which objects have a given symmetry?
- What are the most symmetric objects?
- Is there a transformation between two manifolds M and N that preserves the data (equivalence problem)?
- Determine a complete system of invariants that identifies classes of equivalent manifolds.

A giant leap toward solving these problems was taken by Sophus Lie, who systematically studied, described, and classified transformation groups. It was one of his great discoveries that transformation groups can be decomposed into so-called 1-parametric subgroups. In modern terminology these are smooth homomorphisms from $\mathbb{R}$ into the transformation group. With such a 1-parametric subgroup, $\phi_t \colon M \to M$, one can associate a vector field χ on M by differentiating with respect to the parameter t and setting $t = 0$:

$$\chi(x) = \left.\frac{d\phi_t(x)}{dt}\right|_{t=0} \in T_xM.$$

Geometrically speaking, the vector field χ assigns to each point $p \in M$ the tangent vector to the 1-dimensional orbit $\phi_t(p)$.

The 1-parametric group can then be recovered from χ by solving the ODE

$$\frac{d\phi_t}{dt} = \chi(\phi_t), \quad \phi_0 = \mathrm{id}\,.$$

These vector fields are called infinitesimal automorphisms. Being linear objects, they are rather easy to handle, and they are extremely useful in the study of the transformation group itself.

Photo courtesy of the Académie Des Sciences-Institut de France.

Élie Cartan

Subsequent work by Lie, Engel, Killing, E. Cartan, and others led to the theory of Lie groups, which solves the problems stated above for manifolds that possess "many symmetries", namely so-called *homogeneous* manifolds, i.e., any manifold M such that for any two points $a, b \in M$ there is a transformation ϕ of M with $\phi(a) = b$ and respecting the geometric structure.

The technique of Cartan connections, which is a refinement of Cartan's method of moving frames, permits the study of the geometry of manifolds with few or no symmetries. It is based on the idea to first construct a homogeneous model manifold with a similar geometric structure and then to consider the original manifold as a perturbed version of the model. The resulting notion of Cartan curvature and their invariant derivatives provides the desired complete system of invariants. Moreover, the algebraic nature of Tanaka's construction has led to deep structural results for general types of parabolic geometry and to new techniques such as tractor calculus and general Fefferman spaces (see [4] and references therein). These powerful tools help to give more complete answers to the questions that arise from the Erlangen programme.

Cartan Connections

For a homogeneous manifold Q let G be the group of its symmetries and P be the subgroup of the symmetries that fix a point $a \in Q$. Then Q can be

represented as the quotient manifold G/P, and we have the canonical mapping $\pi\colon G \to Q$ that makes G a fiber bundle with fiber P over Q. The total space G is equipped with a canonical 1-form ω_{MC} that takes values in the Lie algebra $\mathfrak{g} = Lie(G)$ of left-invariant vector fields on G. It is called the *Maurer-Cartan form* and assigns to a vector $X_g \in T_gG$ the left-invariant vector field generated by X_g interpreted as an element of $\mathfrak{g} = T_eG$, the tangent space at the identity of G. That is, it establishes the tautological isomorphy of $\mathfrak{g}$ in both interpretations, namely as the space of the left-invariant vector fields and as T_eG. For a matrix Lie group $G \subseteq \mathrm{GL}(n,\mathbb{R}) \subset \mathbb{R}^{n\times n}$, the left-invariant vector fields have the form

$$X(g) = g^i_j A^j_k \left.\frac{\partial}{\partial g^i_k}\right|_g = gA,$$

where g is the matrix-valued coordinate in $\mathbb{R}^{n\times n}$ (restricted to G), $\frac{\partial}{\partial g^i_k}$ are the coordinate vector fields in $\mathbb{R}^{n\times n}$ and A is a constant matrix that can be identified with $X(e)$. It follows for $X = gA$ and $Y = gB$

$$[X,Y] = g(AB - BA).$$

In this case the Maurer-Cartan form is

$$\omega_{MC} = g^{-1}dg,$$

and

$$\omega_{MC}X(g) = g^{-1}gA = A.$$

Differentiation yields the structure equation

$$\begin{aligned} d\omega_{MC} &= -g^{-1}dg \wedge g^{-1}dg = -\omega_{MC} \wedge \omega_{MC} \\ &= -\frac{1}{2}[\omega_{MC}, \omega_{MC}]. \end{aligned}$$

This is equivalent to the tautological statement that the commutator bracket of the left-invariant vector fields is the same as the Lie algebra product.

A *Cartan connection* is a "curved" version of the bundle $\pi\colon G \to G/P$ with a $\mathfrak{g}$-valued form ω.

To construct a Cartan connection that depends only on the geometric structure of the underlying manifold M one needs first to find the relevant groups G and P and hence the model G/P. This requires the notion of graded Lie algebras, i.e., Lie algebras that split into a direct sum

$$\mathfrak{g} = \mathfrak{g}_{-k} \oplus \cdots \oplus \mathfrak{g}_0 \oplus \mathfrak{g}_1 \oplus \cdots \oplus \mathfrak{g}_\ell$$

so that $[\mathfrak{g}_i, \mathfrak{g}_j] \subset \mathfrak{g}_{i+j}$. The general procedure is as follows:

(1) Determine a graded Lie algebra $\mathfrak{g}_{-k} \oplus \cdots \oplus \mathfrak{g}_0$ solely from the geometric data of M.
(2) Apply Tanaka's algebraic prolongation process to obtain $\mathfrak{g}_+ = \mathfrak{g}_1 \oplus \cdots \oplus \mathfrak{g}_\ell$.
(3) Define G as the connected and simply connected Lie group that corresponds to $\mathfrak{g} = \mathfrak{g}_{-k} \oplus \cdots \oplus \mathfrak{g}_\ell$ and P as the subgroup that corresponds to $\mathfrak{p} = \mathfrak{g}_0 \oplus \cdots \oplus \mathfrak{g}_\ell$.

We demonstrate below how the following three-step procedure is applied in the case of CR geometry of real hypersurfaces in $\mathbb{C}^2$.

The curved analog of the bundle $\pi\colon G \to Q$ is a principal P-fiber bundle $\pi\colon \mathcal{G} \to M$ endowed with a $\mathfrak{g}$-valued *Cartan connection form* ω on $\mathcal{G}$ with the following properties:

(1) $\omega_x\colon T_x\mathcal{G} \to \mathfrak{g}$ is an isomorphism of linear spaces for any $x \in \mathcal{G}$. This permits us to distinguish a space of vector fields $\hat{X}(x) = \omega_x^{-1}X$ for $X \in \mathfrak{g}$, which we will refer to as *constant* vector fields. For G/P with the Maurer-Cartan form the constant vector fields are identical to the left-invariant vector fields on G.
(2) If $\mathfrak{p} \subset \mathfrak{g}$ is the Lie algebra of the fiber group P, then for any $X \in \mathfrak{p}$ the corresponding constant vector field has the form

$$\hat{X}(x) = \left.\frac{d}{dt}\right|_{t=0} R_{\exp tX}(x),$$

where R is the right action of P on $\mathcal{G}$. This means that the constant vector fields on the fibers are the exact analogs of the left-invariant vector fields on G.
(3) For $p \in P$

$$R_p^*\omega = \mathrm{Ad}_{p^{-1}}\omega,$$

i.e., the *analytic* pull-back of the Cartan connection form with respect to the action of p on G is identical to the *algebraic* adjoint action of p^{-1} on the values of ω. Differentiating this identity yields

$$[\hat{X}, \hat{Y}] = [X,Y]_{\mathfrak{g}}$$

for $X \in \mathfrak{p}$ and $Y \in \mathfrak{g}$, i.e., the commutator relations of the constant vector fields $\hat{X} = \omega_x^{-1}(X)$ and $\hat{Y} = \omega_x^{-1}(Y)$ are the same as for X and Y in $\mathfrak{g}$ as soon as one of X, Y is from $\mathfrak{p}$.

It is easy to verify these properties for the Maurer-Cartan form. We point out that the properties (1)–(3) guarantee neither existence nor uniqueness of a Cartan connection. Further conditions are needed to make the Cartan connection form unique. There are sufficient conditions that guarantee the existence of the Cartan connection.

As an application of the Cartan connection construction we consider the equivalence problem: Given two manifolds M and M' with the same geometric structure, does there exist a local diffeomorphism from M to M' that respects the geometric structure? It turns out that a diffeomorphism ϕ would lift to a diffeomorphism Φ of the respective Cartan bundles $\mathcal{G}$ and $\mathcal{G}'$ that transforms the Cartan connection form ω into the

Cartan connection form ω', i.e., $\Phi_*\omega = \omega'$.

$$\begin{array}{ccc} (\mathcal{G},\omega) & \overset{\Phi}{\dashrightarrow} & (\mathcal{G}',\omega') \\ \downarrow{\scriptstyle \pi} & & \downarrow{\scriptstyle \pi'} \\ M & \xrightarrow{\phi} & M' \end{array}$$

This implies that all partial derivatives of Φ are determined and the equivalence problem reduces to the solubility of an initial value problem

$$\frac{\partial \Phi^i}{\partial x^j} = a_{ij}(\Phi, x)$$
$$\Phi(x_0) = x_0'.$$

Note that x_0 and x_0' are points in the principal bundles. As a consequence, the solubility of the initial value problem will depend on the choice of some parameters in the fibre, similar to the accessory parameters in the Christoffel-Schwarz formula. This makes it difficult to solve concrete equivalence problems.

Finally we remark that invariance property (3) of the Cartan connection form is not required for solving the equivalence problem, but it is essential for deriving the curvature invariants.

The Cartan Curvature

According to the construction of groups G and P, the structure algebra $\mathfrak{g}$ is a graded Lie algebra and $\mathfrak{p}$ is its non-negative component. Thus $\mathfrak{g} = \mathfrak{g}_- \oplus \mathfrak{p}$. We call a constant vector field $\hat{X}$ vertical or horizontal if $X \in \mathfrak{p}$ or $X \in \mathfrak{g}_-$, respectively. As stipulated by property (3) of the Cartan connection, the commutator of a constant vector field with a vertical vector field coincides with the commutator in $\mathfrak{g}$. This is not necessarily the case for two *horizontal* constant vector fields. In fact, it follows from Frobenius's theorem that if this were the case it would imply that M is locally equivalent to the model space G/P. The Cartan curvature measures how much such commutators deviate from the commutators in $\mathfrak{g}$ and, thus, "how far" M is from G/P. Consequently, the vanishing of the Cartan curvature can be used to decide if a given geometric structure is equivalent to the homogeneous model.

We introduce the *Cartan curvature* as the $\mathfrak{g}$-valued 2-form on $\mathcal{G}$

$$K_x(\hat{X},\hat{Y}) = \omega_x[\hat{X},\hat{Y}] - [\omega_x\hat{X}, \omega_x\hat{Y}].$$

This can be rewritten as the structure equation

$$d\omega + \frac{1}{2}[\omega,\omega] = -\frac{K}{2}.$$

Notice that $K = 0$ if one of its arguments is vertical. It is convenient to work with the *curvature function* $\kappa\colon \mathcal{G} \to \mathrm{Hom}(\mathfrak{g}_- \wedge \mathfrak{g}_-, \mathfrak{g})$ that is defined by

$$\kappa_x(X,Y) = K_x(\omega_x^{-1}X, \omega_x^{-1}Y).$$

The Algebraic Structure of the Curvature

To explain the algebraic structure of the curvature we introduce the notion of the cochain operator ∂. We consider $\mathrm{Hom}(\mathfrak{g}_- \wedge \mathfrak{g}_-, \mathfrak{g})$ as the space C^2 of 2-cochains in the sequence

$$\cdots C^1 \xrightarrow{\partial_1} C^2 \xrightarrow{\partial_2} C^3 \cdots$$

where $C^k = \mathrm{Hom}(\Lambda^k\mathfrak{g}_-, \mathfrak{g})$ and

$$\partial_k c(X_0,\dots,X_k) = \sum_i (-1)^i [X_i, c(X_0,\dots,\hat{\imath},\dots,X_k)] + \sum_{i,j}(-1)^{i+j} c([X_i,X_j], X_0,\dots,\hat{\imath},\hat{\jmath},\dots,X_k),$$

where $\hat{\imath}, \hat{\jmath}$ stand for terms that have been omitted.

We denote $\mathcal{Z}^k = \ker\partial_k$ and $\mathcal{B}^{k+1} = \mathrm{im}\,\partial_k$. The cohomology H^k is defined by $H^k = \mathcal{Z}^k/\mathcal{B}^k$.

The spaces C^k split into homogeneous components, where a cochain is said to be of *homogeneity* i when it sends arguments of grade $j_1,\dots,j_k$ to a value of grade $i + j_1 + \cdots + j_k$. The splitting into homogeneous components is respected by ∂. We denote the homogeneity i components of $\mathcal{Z}^k, \mathcal{B}^k$ by $\mathcal{Z}^k_{(i)}, \mathcal{B}^k_{(i)}$, respectively, and the curvature component of homogeneity i by $\kappa^{(i)}$.

A Cartan connection is called *regular* if the curvature components of homogeneity ≤ 0 vanish. This condition ensures that the Cartan connection encodes the underlying geometry on M.

The Bianchi identity (see, e.g., [4]) relates the ∂-image of a homogeneous component of the curvature to components of lower homogeneity in the following way:

$$\partial\kappa^{(i)}(X,Y,Z) = -\sum_{cycl}\sum_{j=1}^{i-1}(\kappa^{(i-j)}(\kappa_-^{(j)}(X,Y)),Z) + \hat{Z}\kappa^{(i+|Z|)}(X,Y)),$$

where κ_- denotes the $\mathfrak{g}_-$ component of κ, $|Z|$ is the grade of Z, and $\sum_{cycl}$ is the sum over all cyclic permutations of X, Y, Z.

In particular, it follows that the lowest order nonvanishing curvature must be ∂-closed, and, more generally, any homogeneous curvature component is determined by the lower components up to a ∂-closed component. In this sense we will refer to the ∂-closed components of the curvature as the essential curvature.

Finally, according to Tanaka's results, the choice of the Cartan connection is controlled by the ∂-exact components of the curvature. In order to make the Cartan connection unique, we have to choose a complement to the space $\mathcal{B}^2$ of ∂-exact 2-cochains in the space $\mathcal{Z}^2$ of ∂-closed cochains. This complement is isomorphic to the cohomology group $H^2 = \mathcal{Z}^2/\mathcal{B}^2$.

If $\mathfrak{g}$ is semisimple, there is an adjoint cochain operator ∂^*, and we have the Hodge decomposition

$$\mathcal{Z}^2 = \mathcal{B}^2 \oplus \ker\partial \cap \ker\partial^*,$$

Photo courtesy of *Hokkaido Mathematical Journal*.

Noboru Tanaka

i.e., the space $\mathcal{H}^2 = \ker\partial \cap \ker\partial^*$ of harmonic 2-cochains is a canonical complement to $\mathcal{B}^2$ in $\mathcal{Z}^2$. The corresponding unique Cartan connection is determined by the *normalization* condition $\partial^*\kappa = 0$.

CR Structures and Graded Lie Algebras

A *CR structure*[1] is a combination of two structures:

(1) an even-dimensional distribution D in the tangent bundle of a manifold M, and
(2) a complex structure J_x on each D_x, i.e., a smooth field of endomorphisms J_x with $J_x^2 = -\mathrm{id}$.

The number $n = \dim_{\mathbb{C}} D_x$ is called the CR-dimension of M ,and $k = \dim M - 2n$ is called the CR-codimension.

A CR structure naturally appears on a real hypersurface M of $\mathbb{C}^N$. We may define $D_x = T_xM \cap \mathrm{i}\,T_xM$ for any $x \in M$ where multiplication by i means the restriction of the complex structure $\mathfrak{J}_x$ on $T_x\mathbb{C}^N$ to T_xM. Thus D_x is the biggest subspace of T_xM that is closed with respect to the complex structure of the ambient $\mathbb{C}^N$. The restriction of $\mathfrak{J}_x$ to D_x serves as J_x.

The (local) *equivalence problem* for two CR structures (M, D, J) and $(\tilde{M}, \tilde{D}, \tilde{J})$ can be formulated as follows: Is there a (local) diffeomorphism $\phi\colon M \to \tilde{M}$ such that $d\phi_x D_x = \tilde{D}_{\phi(x)}$ and $\tilde{J}_{\phi(x)} \circ d\phi_x = d\phi_x \circ J_x$?

The Levi Form

The Levi form at a point $x \in M$ is the skew symmetric form

$$\mathcal{L}_x(X, Y) : D_x \wedge D_x \to T_xM/D_x$$

that is defined as follows: extend X, Y to local sections $\tilde{X}, \tilde{Y}$ of D, evaluate $[\tilde{X}, \tilde{Y}]$ at x, and project this vector to the factor space T_xM/D_x.

The Levi form measures the *non*involutivity of the distribution D. It is one of the simplest and most important invariants of a CR manifold. Many nondegeneracy conditions in CR geometry reflect in one or another way the noninvolutivity of D.

With the choice of a basis in D_x and T_xM/D_x, the Levi form identifies with an $\mathbb{R}^k$-valued skew-symmetric form $L_x(\xi, \eta)$ on $\mathbb{C}^n$. A different choice of the basis leads to the form $\rho L_x(C^{-1}\xi, C^{-1}\eta)$ where $\rho \in \mathrm{GL}(k, \mathbb{R})$ and $C \in \mathrm{GL}(n, \mathbb{C})$.

Denote by $[L_x]$ the class of all $\mathbb{R}^k$-valued skew-symmetric forms on $\mathbb{C}^n$ that are equivalent to L_x with respect to the action of matrices C and ρ as above. This equivalence class is a CR-invariant. If $k = 1$ the equivalence class is completely characterised by the rank and the signature of the then scalar Hermitian form.

Furthermore, we will assume that the following compatibility condition of the Levi form and the complex structure holds:

$$\mathcal{L}_x(J_xX, J_xY) = \mathcal{L}_x(X, Y).$$

This condition is automatically satisfied for embedded CR manifolds and is weaker than the usual integrability condition.

Levi-Tanaka Algebra and Tanaka's Prolongation Procedure

We assume that the Levi form at each point is surjective, i.e., $D_x + [D_x, D_x] = T_xM$. Then the direct sum $T_x^{\mathrm{grad}}M = D_x \oplus T_xM/D_x$ has the same dimension as T_xM and is called the associated graded tangent space. Denote $\mathfrak{g}_{-1} = D_x$ and $\mathfrak{g}_{-2} = T_xM/D_x$. The Levi form defines a graded Lie algebra

$$\mathfrak{g}_- = \mathfrak{g}_{-2} \oplus \mathfrak{g}_{-1}$$

by setting $[X, Y] = \mathcal{L}(X, Y)$ if $X, Y \in \mathfrak{g}_{-1}$ and $[X, Y] = 0$ if one of $X, Y \in \mathfrak{g}_{-2}$. The subalgebra $\mathfrak{g}_-$ is the *Levi-Tanaka algebra* at x in the case when the Levi form is surjective.

Tanaka's prolongation of $\mathfrak{g}_-$ is an algebraic procedure to generate a graded Lie algebra $\mathfrak{g}_- \oplus \mathfrak{g}_0 \oplus \mathfrak{g}_1 \oplus \cdots$ that determines to a large extent the geometric properties of the CR structure. The first prolongation component, $\mathfrak{g}_0$, is a Lie algebra whose elements act linearly on $\mathfrak{g}_-$. Hence the elements of $\mathfrak{g}_0$ can be represented as pairs of endomorphisms $(C, \rho) \in \mathrm{End}(\mathfrak{g}_{-1}) \times \mathrm{End}(\mathfrak{g}_{-2})$ that define the Lie algebra product $[(C, \rho), \xi_{-1} \oplus \xi_{-2}] = C\xi_{-1} \oplus \rho\xi_{-2}$

[1] *Here "CR" stands for Cauchy-Riemann, sometimes also interpreted as Complex-Real. Here we ignore the usual integrability condition of the CR structure, as it is not relevant to this article.*

for $\xi_{-1} \in \mathfrak{g}_{-1}$ and $\xi_{-2} \in \mathfrak{g}_{-2}$. The Jacobi identity requires that

$$\mathcal{L}(C\xi, C\eta) = \rho\mathcal{L}(\xi, \eta)$$

for all $\xi, \eta \in \mathfrak{g}_{-1}$, i.e., (C, ρ) is a derivation of $\mathfrak{g}_-$. This defines a linear subspace $\hat{\mathfrak{g}}_0 \subset \mathrm{End}(\mathfrak{g}_{-1}) \oplus \mathrm{End}(\mathfrak{g}_{-2})$. The Lie algebra product in $\hat{\mathfrak{g}}_0$ is the usual commutator in $\mathrm{End}(\mathfrak{g}_{-1}) \oplus \mathrm{End}(\mathfrak{g}_{-2})$.

The component $\mathfrak{g}_0$ is the subspace of pairs (C, ρ) for which C preserves the complex structure J on $\mathfrak{g}_{-1}$, i.e., C is a complex endomorphism of $\mathfrak{g}_{-1}$. Thus $\mathfrak{g}_0$ carries a part of the geometric structure. This is in contrast to the higher prolongation components $\mathfrak{g}_\ell$ for $\ell \geq 1$ that are the maximal possible spaces obtained by the following inductive procedure. Assume that the components $\mathfrak{g}_m$ for $m < \ell$ have been constructed. Then $\mathfrak{g}_\ell$ is defined as the set of linear mappings

$$A\colon \mathfrak{g}_{-1} \to \mathfrak{g}_{\ell-1}$$

and

$$a\colon \mathfrak{g}_{-2} \to \mathfrak{g}_{\ell-2}$$

such that $a[X, Y] = [AX, Y] + [X, AY]$ for all $X, Y \in \mathfrak{g}_{-1}$. This implies that a is determined by A. In particular, $A = 0$ implies $a = 0$.

The Lie bracket in the prolongation is defined by

$$[[A, B], X] = [A, [B, X]] - [B, [A, X]],$$

where $X \in \mathfrak{g}_-$. The method of Cartan connections requires that this prolonged algebra remains finite dimensional. This can be guaranteed by imposing nondegeneracy on the Levi form.

Hypersurfaces in $\mathbb{C}^2$

As an illustration we compute the Cartan curvature for real hypersurfaces in $\mathbb{C}^2$. While this is the simplest instance of CR geometry and the approach is elementary and straightforward, the computations are arduous but can be successfully carried out with the help of computer algebra.

In this case $\mathfrak{g}_- = \mathfrak{g}_{-2} \oplus \mathfrak{g}_{-1}$ is the 3-dimensional Lie algebra with generators $X_1 \in \mathfrak{g}_{-2}$, $X_2, X_3 = JX_2 \in \mathfrak{g}_{-1}$ and such that $[X_2, X_3] = 4X_1$ (all other commutators vanish). The Lie algebra $\mathfrak{g}_0$ is isomorphic to $\mathbb{C}$ with generators X_4, X_5 such that $\gamma X_4 + \mathrm{i}\,\delta X_5$ acts on $\mathfrak{g}_-$ by

$$(X_1, X_2, X_3) \mapsto (2\gamma X_1, \gamma X_2 - \delta X_3, \delta X_2 + \gamma X_3).$$

The Tanaka prolongation yields

$$\begin{aligned}
\mathfrak{g}_1 = \{&\alpha X_6 + \beta X_7 \in \mathrm{Hom}(\mathfrak{g}_{-2} \oplus \mathfrak{g}_{-1}, \mathfrak{g}_{-1} \oplus \mathfrak{g}_0)\colon \\
&(X_1, X_2, X_3) \mapsto ((\alpha + \mathrm{i}\,\beta)X_2, -2\beta X_4 - 6\alpha X_5, \\
&2\alpha X_4 - 6\beta X_5)\} \\
\mathfrak{g}_2 = \{&rX_8 \in \mathrm{Hom}(\mathfrak{g}_{-2} \oplus \mathfrak{g}_{-1}, \mathfrak{g}_0 \oplus \mathfrak{g}_1)\colon \\
&(X_1, X_2, X_3) \mapsto (-rX_4, -rX_6, -rX_7)\}.
\end{aligned}$$

The full prolongation is isomorphic to the semisimple Lie algebra $\mathfrak{su}(2, 1)$. According to Tanaka's theory there exists a unique regular normal Cartan connection. We will outline its construction using a local (noncanonical) trivialization of the Cartan bundle $\mathcal{G}|_U = U \times P$ over some neighbourhood U of 0.

The constant vector fields $\hat{X}_k = \omega^{-1}X_k$ on $\mathcal{G}|_U$ have the form

$$\begin{aligned}
\hat{X}_1 &= a_{11}\zeta + a_{12}\xi + a_{13}\eta + a_{14}\hat{X}_4 + \cdots + a_{18}\hat{X}_8 \\
\hat{X}_2 &= a_{22}\xi + a_{23}\eta + a_{24}\hat{X}_4 + \cdots + a_{28}\hat{X}_8 \\
\hat{X}_3 &= a_{32}\xi + a_{33}\eta + a_{34}\hat{X}_4 + \cdots + a_{38}\hat{X}_8 \\
\hat{X}_4 &= -\gamma\frac{\partial}{\partial\gamma} - \delta\frac{\partial}{\partial\delta} - \alpha\frac{\partial}{\partial\alpha} - \beta\frac{\partial}{\partial\beta} - 2r\frac{\partial}{\partial r} \\
\hat{X}_5 &= \delta\frac{\partial}{\partial\gamma} - \gamma\frac{\partial}{\partial\delta} - \beta\frac{\partial}{\partial\alpha} + \alpha\frac{\partial}{\partial\beta} \\
\hat{X}_6 &= \frac{\partial}{\partial\alpha} - \beta\frac{\partial}{\partial r} \\
\hat{X}_7 &= \frac{\partial}{\partial\beta} + \alpha\frac{\partial}{\partial r} \\
\hat{X}_8 &= \frac{1}{2}\frac{\partial}{\partial r},
\end{aligned}$$

where ξ, η, ζ are vector fields on M with $\xi \in \Gamma(D)$, $\eta = J\xi$, $\zeta = 4[\xi, \eta]$, $\gamma + \mathrm{i}\,\delta \neq 0$, $\alpha + \mathrm{i}\,\beta$, r are coordinates of P and, according to property (2) of the Cartan connection, $\hat{X}_4, \ldots, \hat{X}_8$ are the left-invariant vector fields on the fiber P. The explicit expressions of the curvature depend on the coefficients of the commutator relations

$$\begin{aligned}
[\xi, \zeta] &= c_{11}\zeta + c_{12}\xi + c_{13}\eta \\
[\eta, \zeta] &= c_{21}\zeta + c_{22}\xi + c_{23}\eta.
\end{aligned}$$

Notice that for the homogeneous model one can choose ξ, η in such a way that $[\xi, \zeta] = [\eta, \zeta] \equiv 0$. In general, after a suitable coordinate change, we can achieve $c_{11} = c_{21} \equiv 0$.

It is our task to determine the coefficients $a_{11}, \ldots, a_{38}$. Property (3) of the Cartan connection allows us to determine how they depend on the fiber variables. In particular, it follows that

$$\begin{aligned}
&a_{11} = \gamma^2 + \delta^2, \\
&a_{12} = -\gamma\alpha + \delta\beta, \qquad a_{22} = \gamma, \qquad a_{32} = -\delta \\
&a_{13} = -\delta\alpha - \gamma\beta, \qquad a_{23} = \delta, \qquad a_{33} = \gamma.
\end{aligned}$$

To find the dependence of the coefficients $a_{11}, \ldots, a_{38}$ on the horizontal variables x, y, u we try to make the three commutators $[\hat{X}_i, \hat{X}_j]$ with $i, j = 1, 2, 3$ as close as possible to the corresponding commutators in $\mathfrak{su}(2, 1)$. This is restricted by the ∂-cohomology H^2. Direct computation shows that the cocycles form a 17-dimensional subspace $\mathcal{Z}^2$ of the 24-dimensional space C^2. The subspace $\mathcal{B}^2 \subset \mathcal{Z}^2$ is 15-dimensional, which implies $\dim H^2 = 2$. The space C^2 splits in our case into homogeneous components of order from 0 to 5. The distribution of the dimensions

by homogeneity is displayed in the table below:

Hom	$\dim \mathcal{B}$	$\dim \mathcal{Z}$	$\dim C$	$\dim H^2$
0	1	1	1	0
1	4	4	4	0
2	5	5	6	0
3	4	4	6	0
4	1	3	5	2
5	0	0	2	0

The cohomology occurs in homogeneity 4, which means that all curvature of homogeneity $i < 4$ vanishes. Hence the components of $[\hat{X}_2, \hat{X}_3]$ of grade ≤ 1 and the components of $[\hat{X}_1, \hat{X}_2]$ and $[\hat{X}_1, \hat{X}_3]$ of grade ≤ 0 are exactly as in the Lie algebra $\mathfrak{g}$.

The closedness of the curvature in homogeneity 2 and 3 is a consequence of the Jacobi identity $[\xi,[\zeta,\eta]] + [\eta,[\xi,\zeta]] + [\zeta,[\eta,\xi]] = 0$.

The explicit computations give the nonzero curvature components in homogeneity 4:

(1)

$$\begin{aligned}\kappa(X_1,X_2) = &\left(\frac{\tau^4-\delta^4}{96}k_1 - \frac{\tau\delta^3+\tau^3\delta}{48}k_2\right)X_6\\ &-\left(\frac{\tau^4-\delta^4}{96}k_2 - \frac{\tau\delta^3+\tau^3\delta}{48}k_1\right)X_7\\ \kappa(X_1,X_3) = &-\left(\frac{\tau^4-\delta^4}{96}k_2 + \frac{\tau\delta^3+\tau^3\delta}{48}k_1\right)X_6\\ &-\left(\frac{\tau^4-\delta^4}{96}k_1 - \frac{\tau\delta^3+\tau^3\delta}{48}k_2\right)X_7\end{aligned}$$

where

(2)

$$\begin{aligned}k_1 = &-5\eta^2c_{12} + 15\xi\eta c_{22} + 4\xi^2c_{23} - 15\eta\xi c_{13}\\ &-9\eta\xi c_{22} + 72c_{22}c_{12} + 12c_{13}c_{12} + 84c_{13}c_{23}\\ k_2 = &-7\xi\eta c_{23} - 3\xi^2c_{13} - 18\eta\xi c_{12} + 9\eta\xi c_{23}\\ &-3\eta^2c_{22} + 20\xi\xi c_{22} + 24c_{12}c_{23} - 24c_{23}^2\\ &+48c_{12}^2 - 36c_{22}^2 + 36c_{13}^2.\end{aligned}$$

The X_8 component of $\kappa(X_2, X_3)$ can be made 0 by using the one-dimensional freedom from $\mathcal{B}$.

Finally, the Bianchi identity completely determines the curvature of homogeneity 5.

Ellipsoids

In [25], Webster proved that an ellipsoid

$$|z|^2 + \sum_{j=1}^{n} \frac{A_j}{2}(z_j^2 + \bar{z}_j^2) = 1 \text{ with } 0 < A_j < 1$$

in $\mathbb{C}^n$ for $n \geq 3$ has no umbilic points, i.e., the harmonic Cartan curvature does not vanish at any point. Though his methods seem to be suitable for proving a similar result for $n = 2$, this case would be different because the curvature invariants depend on higher derivatives than for $n \geq 3$.

Our computations from the previous section applied to the ellipsoid

$$|z_1|^2 + |z_2|^2 + \frac{a}{2}(z_1^2 + \bar{z}_1^2) + \frac{b}{2}(z_2^2 + \bar{z}_2^2) = 1$$

in $\mathbb{C}^2$ at the vertex $(0, \sqrt{\frac{2}{2+b}})$ give us the harmonic curvature

$$\begin{aligned}k_1 = &\frac{96(b+1)^4\left(-2(4b+7)a^3\right.}{(b+2)^2}\\ &+\frac{\left(1335b^2+3123b+1450\right)a - 165(b-1)b)}{(b+2)^2}\\ &\neq 0\\ k_2 = &\,0.\end{aligned}$$

Here we have used the vector field

$$\begin{aligned}\xi = &\left((b+1)^2x_2^2 + (b-1)^2y_2^2\right)\frac{\partial}{\partial x_1}\\ &+\left(-(a+1)(b+1)x_1x_2 - (a-1)(b-1)y_1y_2\right)\frac{\partial}{\partial x_2}\\ &+\left((1-a)(b+1)x_2y_1 + (a+1)(b-1)x_1y_2\right)\frac{\partial}{\partial y_2}.\end{aligned}$$

Conclusion

Using the Tanaka prolongation procedure, we have explicitly calculated the Cartan connection and Cartan curvature of a general Levi nondegenerate real hypersurface in $\mathbb{C}^2$ and, in particular, the ellipsoid. An analysis of the algebraic structure of the curvature permits us to isolate two out of twenty-four components (1) from which all invariants can be derived. In particular, two hypersurfaces are equivalent if their two harmonic curvature components match. Though this is difficult to check in general, it provides a simple criterion for equivalence with the sphere, namely the vanishing of (2). Our computations for the ellipsoid allow us to show that the real-analytic subset of umbilic points is proper and therefore the ellipsoid cannot be locally equivalent to the sphere at any point.

The precise expressions of the coefficients of the Cartan connection form, the curvature, and the computations in Mathematica can be found at `http://turing.une.edu.au/~bmclaugh/cartan/`.

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Mathematics Classes for Future Elementary Teachers: Data from Mathematics Departments

Raven McCrory and Marisa Cannata

Mathematicians have a unique opportunity to influence elementary teachers' mathematical knowledge. Nearly all future teachers are required to take mathematics courses in their undergraduate education, and many take courses specifically required for elementary certification. Even in this era of alternative certification, a majority of teachers come to their first job from a four-year teacher certification program in which one or more mathematics courses are required.[1] According to the Conference Board of the Mathematical Sciences (CMBS) 2005 survey of U.S. mathematics departments, 87% of mathematics departments in the United States are in institutions that certify elementary teachers, and of these, 86% offer a special course or sequence of mathematics courses for K–8 teachers (Lutzer, Rodi, Kirkman, & Maxwell, 2007, pp. 49–50). Mathematics departments design and teach these courses and thus can make a huge difference across the United States in what is offered to, and expected of, future elementary teachers.

The responsibility for educating future elementary teachers is shared by institutions across the country and impacts education in every state. Recent data from Title II reporting (`title2.ed.gov`) show that new teachers are now a mobile population, with almost every state importing teachers from other states, and even from other countries. For example, Michigan, where unemployment is high and the teacher population shrinking, exports most of its newly certified teachers to other states, and South Carolina has been bringing in teachers from other states for many years (although this may have changed in the current economic downturn). It is no longer accurate to assume that teachers will stay close to home. We cannot conclude, even if our state or institution is doing a good job, that the mathematical education of elementary teachers is someone else's problem.

Concern about teachers' mathematical knowledge has increased dramatically over the last two decades as U.S. scores on international assessments have slipped relative to other countries. Attention to the problem has led to recognition that it takes more than competence in arithmetic to teach elementary school mathematics successfully. At least since Ball's early work on teacher knowledge (Ball, 1988, 1990) and Ma's book that followed up on Ball's work (Ma, 1999), mathematicians and mathematics educators alike have acknowledged both the importance of elementary school teachers' mathematical knowledge and the nontrivial task of helping teachers learn what they need to know.

In spite of the interest in teachers' mathematical knowledge, information about mathematics courses for future teachers is sparse. The CBMS

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A longer version of this paper is available on the project website, `http://meet.educ.msu.edu`.

[1]*Data from the Title II reporting system* (`title2.ed.govesecReport06.asp`) *show that in 2004, a total of 310,000 teachers received initial certification in the fifty states. Of these, 35,000 were reported as "alternative route" certifications, 11% of the total. Although the number of alternate-route certifications is growing, most teachers will continue to be certified through "traditional" routes for some years to come, providing an important site for improving teachers' mathematical knowledge.*

survey provides the only systematic data about these courses, and it includes only a few questions related to the mathematical education of elementary teachers. Among the things we do not know are: what textbooks are typically used; who teaches the courses (e.g., mathematicians, mathematics educators, graduate students, etc.) and what their qualifications are; what topics are covered, in what depth, and for what purposes; what (and whether) the future teachers actually learn from these courses.

This article reports on part of a study of undergraduate mathematics courses for future elementary teachers (the Mathematical Education of Elementary Teachers, MEET, project). In the larger study, we collected achievement data via pre- and posttests of undergraduate students in mathematics courses required for certification. Those data show that students in such courses make significant gains in their mathematical knowledge, especially in courses that use one of the textbooks written specifically for mathematics courses for elementary teachers (complete reports on the achievement data, instructor survey, and department survey are available on the project website, `http://meet.educ.msu.edu`). Here, we report on data from mathematics departments that offer such courses, with a particular eye on how they structure and staff these courses and how the courses differ across institutions. We also include data from the CBMS 2005 survey of mathematics departments to draw attention to the fact that the CBMS survey, completed every five years, has data of interest to mathematicians who design and teach courses for future elementary teachers.

Data

For the MEET project, we surveyed mathematics departments in 2006–7, prior to other data collection. The data come from South Carolina, Michigan, and New York City, sites chosen because of their varying approaches to improving teacher quality. In these three sites, we identified all undergraduate institutions that offer elementary certification and contacted the mathematics department chair to participate in the survey. Of the seventy institutions that have undergraduate certification programs, fifty-seven (81%) responded to our survey, which was conducted over the telephone. The department chair or someone designated by the chair—the program coordinator, a staff member, or another faculty member—answered our questions about the curriculum and instructors of these mathematics courses, with detailed questions about a focal course in which we later collected data from instructors and students. The focal course was usually the first (or only) mathematics course required for elementary certification, excluding prerequisites or general education courses that constituted distribution requirements. For example, at Michigan State University (where the first author is a faculty member), two mathematics courses are required for elementary certification, but a prerequisite for the first course is either satisfactory completion or testing out of college algebra. In such a case, the focal course is the first of the two courses required for certification, not the college algebra course.

Survey data were complemented by information from *U.S. News and World Report*[2] about school

Table 1
Number of Institutions by Size, Selectivity[a]*, and Carnegie Classification*[b]

Characteristic	All	Bachelor's	Master's	Ph.D.
All institutions	57	17	26	14
Size of elementary cohort (students admitted in a given year)				
Less than 50	27	14	10	3
50–149	15	3	10	2
150 or more	15	0	6	9
Selectivity of institution				
Less selective	11	4	7	0
Selective	29	7	15	7
More selective	17	6	4	7

[a]Selectivity is derived from *U.S. News* categorizations. We combine their five categories to form three categories as follow: *U.S. News* "Most" and "more" selective were combined to form "More selective"; their "selective" was used for our "selective" category; and their "less" and "least" selective were combined to form our "Less selective". The *U.S. News* categories are derived from reported acceptance rates.

[b]The Carnegie classification indicates the highest degree awarded by the institution (e.g., a bachelor's institution does not award master's or doctoral degrees, and a master's institution may offer both a bachelor's and master's degree). Regardless of the institution's Carnegie classification, the programs described here are undergraduate (i.e., bachelor's level) programs.

selectivity; from the Carnegie Foundation for the Advancement of Teaching[3] to classify schools by their highest degree offered; from the U.S. Title 2 website[4] to ascertain the number of elementary candidates and institutional certification requirements; and from state websites to determine statewide certification requirements. Table 1 shows basic data about the institutions included in our sample.

The variability of access to information about certification requirements proved to be both interesting and challenging. It is extremely hard to find in some states (Michigan) and quite easy in others (New York). At the start of the project, before states were selected (2004–5), we investigated more than twenty states in depth and found that the information available to prospective teachers is often obscure if not impossible to find and/or decipher. Although certification requirements address so many different contingencies and thus are complex, it seems counterproductive to make it so hard for prospective teachers to learn what they need to do to become teachers. New York has one of the best systems[5] we have seen, available on the Web to anyone who is interested, while Michigan has one of the worst.

In our interviews with mathematics department chairs, we found a high level of involvement and knowledge about the mathematical education of teachers. The reported schism between mathematicians and mathematics educators did not hold true in this sample of schools. Department chairs knew the details of their programs for elementary education students and were committed to the importance of their work in educating these future teachers, and this was true across the board, from large public Ph.D. institutions to small private schools. Whether from the chair or a designated representative, we heard many passionate explanations of the importance of these courses and the struggles departments experience as they try to ensure that elementary teachers are qualified to teach mathematics. We learned of departments that offer extensive tutoring, high-stakes computation tests with multiple chances to achieve mastery, instructor-written textbooks or materials, and many more examples of efforts aimed at solving the complex problems of the mathematical education of elementary teachers.

[2] www.usnews.com/usnews/edu/college/rankings/rankindex_brief.php, *2006 version.*

[3] www.carnegiefoundation.org

[4] www.title2.org. *Teacher education institutions in the United States are required to make annual reports to the federal government, and data from these reports are made available on the Title 2 website.*

[5] *Available at* http://eservices.nysed.gov/teach/certhelp/CertRequirementHelp.do

Selected findings from the survey are reported briefly here, with particular attention to the following questions:

1. How many mathematics courses are required for future elementary teachers?
2. What is the typical content of these courses?
3. Who teaches the courses?

1. How many mathematics courses are required for future elementary teachers?

Determining and comparing the number of courses required for elementary certification is complex, even when information is readily available, because of variation in how teaching certificates are awarded. In some states, elementary teachers are certified to teach all subjects, K–8. In other states, the certification is divided into lower grades (e.g., K–3) and upper grades (4–8), with different requirements for the two levels. In many states, middle school (typically grades 6–8) teachers can be certified either as secondary subject teachers (e.g., in mathematics) or as elementary teachers who can teach any subject. Sometimes, teachers with a general K–8 certification are required to have a specialization in mathematics to teach middle school mathematics. In other states, prospective elementary teachers are required to have a major or minor in mathematics, in addition to other requirements for elementary certification, in order to teach mathematics at the middle school level. In our data, as in the CBMS survey, we distinguish between institutions based on whether the requirements vary for those who are certified to teach early grades and those certified to teach later grades, including middle school.

In recent years, more states have been requiring subject matter specializations for middle grade teaching. Michigan and New York both have a middle school mathematics certification requirement, and, at the time of the survey, South Carolina was phasing in a policy that was to be completely implemented by 2008. Michigan requires a mathematics major (thirty hours minimum) or minor (twenty hours minimum) and satisfactory performance on the Michigan subject area test for middle school mathematics teaching. New York requires thirty semester hours of mathematics, student teaching specifically in middle school mathematics, and acceptable performance on the New York mathematics content area test. In South Carolina, the policy requires an undergraduate major in mathematics and satisfactory performance on the PRAXIS II content area test.[6, 7]

The CBMS 2005 survey found that 44% of four-year institutions that certify elementary

[6] *PRAXIS II is a test administered by the Educational Testing Service, ETS, and used by a number of states in the United States to assess prospective teachers' knowledge. See* http://www.ets.org/praxis.

teachers have different requirements for early and later grades, with an average of 2.1 mathematics courses required for certification in institutions with a single certification requirement; an average of 2.7 courses in institutions that offer early elementary certification (up from 2.4 in 2000); and 5.6 courses for the later grades certification (up from 3 in 2000; p. 52). In our sample, 36% of institutions had different requirements for later grades. Numbers of required courses are shown in Table 2, with a breakdown of the MEET data by Carnegie classification and selectivity, with requirements for math specialization shown separately.

In the MEET survey, the number of courses required for basic K–8 certification ranged from zero to six, with fifty-five of the fifty-seven schools offering courses specifically designed for elementary teachers. This concurs with the CBMS data, in which 81% of certifying institutions offered a special course or course sequence for future elementary teachers. The most common requirement was two courses, but three institutions required no mathematics (other than general distribution requirements for all students) and one institution required six classes. Table 2 shows that the mean number of required courses is 2.2, with over a third of the institutions offering a specialization with much greater course requirements. Ph.D. institutions and larger schools are more likely to offer mathematics specializations, for which the mean number of required mathematics courses is 6.9. While bachelor's institutions are least likely to offer mathematics specializations to elementary teachers, those that do have more course requirements (9.5) than doctoral institutions (6.3). The same pattern is present when comparing institutions by size. Institutions with over 150 elementary education graduates each year are the most likely to offer math specializations but require students to take fewer courses for the major than smaller programs.

Statistical (chi-square) analysis of the data show that the percentage of institutions with mathematics specialization differs significantly by Carnegie classification ($p < 0.05$ that these differences occurred by chance; the statistic indicates that at least one of the three numbers differs significantly from the others) and by size of the elementary cohort ($p < 0.01$ that the differences occurred by chance, again indicating that at least one of the

[7] *There are similar problems with counting courses, since the number of contact hours can vary considerably. Some institutions use a semester system, others a quarter system. Courses can meet from one to more than five hours a week with different associated credit hours. Adopting methods from the CBMS survey, we report number of required courses. In other parts of the study, we asked about contact hours, credit hours, and semester v. quarter requirements, but we report only number of courses here.*

Table 2
Number of Required Mathematics Content Courses by Institutional Characteristics[1]

	Number of institutions (n)	Number of courses for basic certification		Percent with mathematics specialization	Number of courses for mathematics specialization
		Mean	SD	Percent	Mean
All Institutions	57	2.2	1.20	37	6.9
Carnegie classification					
Ph.D.	14	2.0	.96	50*	6.3
Master's	26	2.3	.79	46*	6.8
Bachelor's	17	2.1	1.80	12*	9.5~
Size of elementary cohort					
Less than 50	27	1.9~	.84	16**	8.0
50–149	15	2.7	1.63	40**	7.5
More than 150	15	2.3	1.07	71**	5.9~
Selectivity of institution					
Less selective	11	2.2	.75	18	7.0
Selective	29	2.1	.83	38	6.6
More selective	17	2.2	1.86	47	7.4

[1] *All but one of the schools in the sample reported a semester schedule. The one different school was on a 4-1-4 schedule. Numbers have not been adjusted to reflect this difference.*

~ $p < 0.1$ for t-test statistic comparing the mean of institutional type to other types.

** $p < 0.05$, **$p < 0.01$ for chi-square statistic indicating the distribution varies by this institutional type.*

three numbers differs significantly). The latter may reflect that the larger institutions are able to require a specialization because they have the student populations to do so. The difference by Carnegie classification suggests that Ph.D. and master's institutions may be better able to adopt policy and research recommendations for increasing the preparation of middle school mathematics teachers than bachelor's institutions, and this may be related to size. T-tests of the difference of means show that the average of 9.5 courses required by bachelor's institutions for a mathematics specialization is significantly different from the other means with less than a 0.1 probability that the difference occurred by chance; and that the average of 5.9 courses required by the institutions with the largest cohorts is significantly less than the number required by the institutions with smaller cohorts. At the same time, the mean of 1.9 courses required for basic certification in schools with the smallest cohorts is statistically different from requirements at schools with larger cohorts. These statistics show that, in this sample, bachelor's institutions and smaller institutions that offer a specialization for later grades are requiring much more mathematics than schools in the other categories. Selectivity of institution shows no significant differences for the likelihood of offering a specialization, or for the number of courses required when the specialization is offered.

What do these data mean? It is hard to interpret definitively, but it is clear here, as in the CBMS data (and using earlier CBMS data as a comparison), that the mathematics requirements for certification are increasing at all kinds of institutions. The specialization requirements are close to seven courses, which could be a respectable minor of twenty-one credits in many schools. The number of courses required for basic certification is still well below CBMS recommendations, especially for the schools in the sample with smaller cohorts.

We asked about the size of classes and the number of sections and found that the mean size was twenty-six students per section, and the mean number of sections was four. The largest class in our sample was sixty, and the smallest fifteen. Both the class size and the number of sections varied by size of the institution, with smaller schools having both fewer sections and smaller class size. In no case in our data did we find classes that met as a large lecture with discussion sections. That is, the sections were independent classes with their own instructors.

2. What is the typical content of these courses?

We asked the department chairs about the content of the course or sequence of courses required for certification and found that 51% of the focal (usually first) courses focused primarily on number and operations, and 41% of the second courses focused on geometry and measurement. Table 3 shows the results across all topics. We asked about both the primary content of the course and the secondary content. As the table shows, there

Table 3

Percent of Institutions with Specific Content Focus by Content and by Course

	Focus in required courses by content		Primary content focus by course	
	Primary content	Secondary content	Focal course	Second course
Data and statistics	17%	22%	6%	26%
Number and operations	25	14	51	10
Problem solving[a]	10	21	19	5
Number theory	7	23	11	5
Geometry and measurement	22	22	8	41
Algebra and prealgebra	8	22	11	5
Logic and/or set theory	6	17	13	0

Note: Respondents were asked to choose one primary content area. However, some respondents indicated two content areas of equal importance and could not choose just one area. For this reason, the percentages of primary content area do not add to 100. The percentages for secondary content area do not add to 100 because respondents were allowed to choose multiple areas.

[a] We include problem solving as a separate content area because, in fact, we found that some courses (and textbooks) do not have a topical focus but rather are problem-based and range across topics, with the focus on problem solving as a process.

Table 4
Textbook Used by Number of Institutions

Book	Percent of institutions	Number of institutions
Billstein et al.	21%	12
Musser et al.	11	6
Other mathematics for elementary education textbook	19	11
Other mathematics textbook	30	17
No textbook	19	11

is considerable attention to number and operations, geometry and measurement, and data and statistics, with other topics included but less often as a focal topic.

Another way to understand the content of the courses is to examine the textbooks and other materials used. We found that most of the courses (83%) use a single textbook for the course and that in schools with multiple sections, all instructors use the same text. Textbook use data are shown in Table 4.

The most commonly used textbook was Billstein, Libeskind, and Lott (2004), and the second most popular was Musser, Burger, and Peterson (2003). Twenty-nine of the schools used textbooks such as these two, written specifically for mathematics courses for teachers, but as shown in the table, seventeen used other mathematics textbooks, and eleven used no textbook. In the last category, schools that did not use a textbook typically used materials developed by the instructor or department or a collection of books and resources, not including a textbook per se. One important finding from analysis of the achievement data is that students in classes that use one of the thirteen textbooks specifically designed for such a class (e.g., the twenty-nine cases shown in the table above) make significantly higher gains than those in classes with other textbooks or no textbook at all. Unfortunately, we did not have enough data to analyze the results by specific textbook to see whether any single book, or subgroup of books, resulted in higher performance.

3. Who teaches the courses?

We asked about the positions held by instructors of the courses and how the department went about staffing. For these data, we asked the respondent about the specific individuals teaching the required courses during the 2006–7 academic year. Data reported here are for all instructors ($n = 81$), not for individual institutions. Fifty-nine percent of the instructors were tenured or tenure-eligible faculty in the mathematics department. The other categories are: other full-time with Ph.D. (5%), other full-time without Ph.D. (13%), part-time faculty (20%), and graduate teaching assistant (4%). The part-time faculty were typically adjuncts who had K–8 classroom experience. These percentages varied significantly by Carnegie classification, where master's and bachelor's institutions had higher percentages of tenure-stream faculty teaching and no graduate assistants; and by size, where smaller institutions had more tenure-stream faculty teaching these courses.

Even though all of the courses were taught in mathematics departments, the degrees of the instructors were not all in mathematics. In the Ph.D. category, nineteen of the forty-seven instructors with Ph.D.s. had Ph.D.s in mathematics, twenty-two in mathematics education, and six in other subjects. Overall, fifty of the eighty-one instructors had at least one degree in mathematics.

One of the questions posed to the department chair (or representative) was about the difficulty of staffing the courses. Fifty-seven percent of the departments reported that it was easy to staff, and 19% reported that it was very difficult. This varied considerably by institution type: only 11% of departments in Ph.D. institutions reported that it was easy to staff the courses, while 80% of the bachelor's institutions did so. The issues surrounding teaching courses for elementary teachers depend on the other obligations and interests of faculty members beyond undergraduate teaching.

Conclusions

The efforts of these department chairs and instructors, combined with increases in the numbers of required courses and in state mandates to staff later grades with teachers who have specializations in mathematics, may bear fruit in the future as the number of teachers who know more mathematics increases in classrooms across the country. Although progress in changing the mathematical profile of elementary school teachers will be slow as new graduates replace retirees and others who leave the profession, it is critical for mathematicians to continue their involvement with designing and teaching these courses so that every newly

certified teacher will be prepared to teach rigorous, accurate, and interesting mathematics to their young students.

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About the Cover

2D vortex formation

This month's cover is a sequence of images of simulated vortex formation in two dimensions. Red patches indicate counterclockwise rotation, blue clockwise. They illustrate that in two dimensions, vortices initially randomly distributed will coalesce. This is the theme of the article by C. Eugene Wayne in this issue.

The images are from an animation produced by Herman Clercx and GertJan van Heijst of the Fluid Dynamics Laboratory at TU Eindhoven. A link to the animation can be found at Figure 6 on the webpage `http://web.phys.tue.nl/nl/de_faculteit/capaciteitsgroepen/transportfysica/fluid_dynamics_lab/turbulence_vortex_dynamics/2d_turbulence/bounded/`.

For more information, see the paper "Self-organization of quasi-2D turbulence in stratified fluids in rectangular containers" by Clercx, van Heijst, and S. R. Maassen in the *Journal of Fluid Mechanics* (volume 495, 19–33, 2003).

WHAT IS . . .

Persistent Homology?

Shmuel Weinberger

In memory of my friend, Partha Niyogi (1967–2010)

Consider the art of Seurat or a piece of old newsprint. The eye, or the brain, performs the marvelous task of taking the sense data of individual points and assembling them into a coherent image of a continuum—it infers the continuous from the discrete.

Difficult issues of a similar sort occur in many problems of data analysis. One might have samples that are chosen nonuniformly (e.g., not filling a grid), and, moreover, one is constantly plagued by problems of noise—the data can be corrupted in various ways.

Pure mathematicians have problems of this sort as well. One is often interested in inferring properties of an enveloping space from a discrete object within it or, in reverse, seeking commonalities of all the discrete subobjects of a given continuous one. To give one example, this theme is a central one in geometric group theory, in which a typical problem, going back to Furstenberg and Mostow, asks to reconstruct a connected Lie group from a lattice in it.

And, ubiquitously in analysis, one often tries to get information about a function from approximations to it. For instance, any function uniformly close to $z \to z^n$ on the complex plane necessarily has at least n roots (with multiplicity).

Because topology is essentially a qualitative field, it is perhaps not surprising that there has been a development of some common topological technology for these problems. Needless to say, the deepest aspects of these problems all have the idiosyncrasies of their particular application domains. The focus here is on what is common to them.

The Seine at La Grande Jatte by Georges Seurat.

For simplicity in what follows, we will take all homology groups to have coefficients in a field.

Definition. Suppose that we have $X = \{X_r | r \in \mathbf{R}\}$ a nested sequence of spaces (satisfying mild technical conditions), parameterized by the real numbers. We define the kth persistent homology $PH_k(X)$ by the formula:

$$PH_k(X) = \Pi H_k(X_r).$$

The product on the right is an awful object: formally it is an uncountable dimensional vector space, but there is a reasonable way to make sense of this, taking into account the fact that

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the inclusion $X_r \subset X_s$ for $r < s$ induces a map $H_k(X_r) \to H_k(X_s)$.

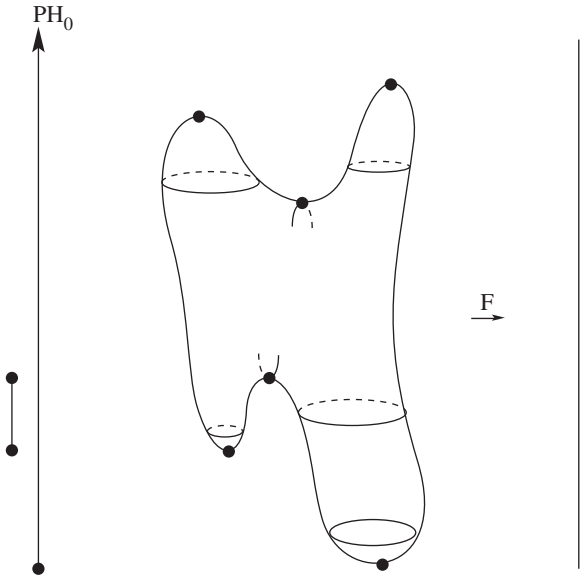
If one considers an element of $H_k(X_r)$, then one can follow it along "further in time" to larger s's and watch whether or not it dies. If it dies, there is a smallest (or actually infimal) s at which it does. If $H_k(X_r)$ is finite dimensional, then it is possible to give it a basis so that every element in the basis has a well-defined moment of death and a sum of basis elements dies in $H_k(X_s)$ if and only if each of the basis elements with nonzero coefficients in its description dies in $H_k(X_s)$. (This is a consequence of elementary linear algebraic considerations.)

A concrete example is given by a positive real valued function $f : Z \to \mathbf{R}^+$; we can think of $f^{-1}[0, r]$ as an approximation to Z. From this point of view, there are some homology classes that are "born immediately" at $r = 0$, i.e., are in the image of $H_k(f^{-1}\{0\})$, but others are born somewhat later. Other classes might be born at one moment and die somewhat later.[1,2]

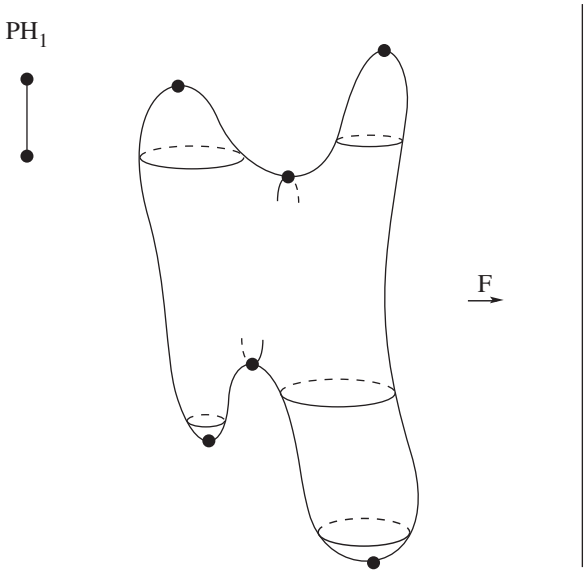
We can summarize this in a "barcode" that encodes these births and deaths. Here is a picture of a function on the 2 sphere and the persistent homology in dimensions 1 and 2 of the associated filtration of the sphere.

In the function setup, persistent homology can be thought of as a variant of Morse theory. Each critical point of a Morse function either announces the birth of a homology class or is the death knell of another. Thus critical points are always visible in the barcode of homology either in the index dimension or one lower.

Now let us return to the kinds of examples that motivated our discussion. If one starts with a submanifold M of Euclidean space (say, a human face) and samples many points from it (pointillistically), we can consider the function $f(x)$ = smallest distance from x to any of the sample points. The homology of these sublevel sets can be computed using computer algorithms. If s is larger than the density of the samples, then at that scale one has all of the homology classes of M present, and if s is not too large, the homology will be that of M (although, after a while, the homology classes of M will die).



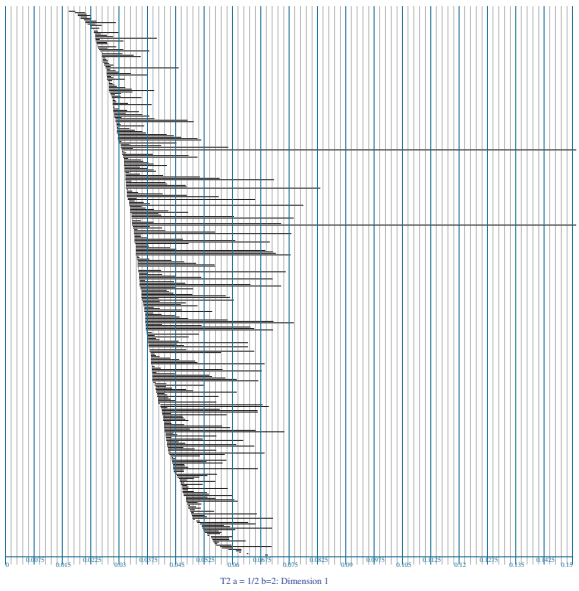
This picture shows, on the left vertical axis, the birth of 0-dimensional homology classes (essentially components) and their deaths (the coalescing of components). For 1-dimensional homology it looks like this:



A typical example of PH_1 taken from 1400 samples of a 2-torus looks like this (with the persistence parameter being drawn horizontally, as is the usual custom):

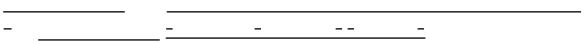
[1] *Even if Z is compact, if the function is just assumed continuous, then at particular levels one can have infinite dimensional homology. However, the homology that persists over any positive length interval is necessarily finite dimensional—already a good reason to look at such homology groups.*

[2] *If the function f is nice, then the persistent homology can be thought of as a derived pushforward sheaf.*

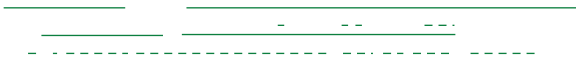


In this example, there was no noise; the short bars are indicative of the irregularities and inefficiencies of the sampling. Much remains to be learned about the shape of barcodes of data, but there are theorems that tell us how to use PH to compute genuine homology from samples that are sufficiently dense and not too noisy.

In almost all applications, a key role is played by a stability theorem that asserts that for nearby functions (or filtrations), the barcodes cannot be very far apart, in a precise quantitative sense. The topology on the space of barcodes has two barcodes being close if by ignoring "short intervals" we can match up their long intervals in such a way that corresponding intervals have nearby endpoints. A picture should suffice:



is "close" to



because, aside from the "short" intervals, the barcodes can be closely aligned.

The stability theorem of Edelsbrunner, Cohen-Steiner, and Harer says that if functions are at most C apart, then the long bars of their persistence diagrams correspond—and indeed their initial and terminal points cannot be shifted by more than C, although short intervals of length $< C$ can be arbitrarily different. The reader can think about the diagrams of the functions $y = x^2$ and $x^2 + \sin(10000x)$ on $\mathbf{R}$ to see why this is true.

When we apply these ideas to a discrete group with the word metric,[3] we form a different nested sequence of spaces. These spaces are all simplicial complexes. The space associated with the number r (for $r > 1$) has k-simplices spanned by $k + 1$ group elements that are a pairwise distance at most $\log(r)$ apart.

It is easy to check that these simplicial complexes for different generating sets or for different uniform lattices in the same Lie group are close to one another (essentially the distance is determined by the length of the words describing one generating set in terms of the other) and therefore have close persistent homology. This can be used to show that certain homological properties of groups only depend on "coarse quasi-isometry type" and, e.g., agree for different uniform lattices in the same Lie group. As an example, essentially due to Gersten, the last dimension for which there is a long, i.e., infinitely long, interval in the persistent homology detects cohomological dimension.

For our last example, consider a Riemannian manifold M. Our space will be $X = \Lambda M = \{\gamma : S^1 \to M\}$, the space of smooth loops in M. Our function is given by the "log energy"

$$\log E(\gamma) = \log \int < \gamma'(t), \gamma'(t) > dt,$$

where $<,>$ denotes the Riemannian inner product. Note that while the log energy depends on the metric, for two metrics on the same compact manifold, the difference between these functions on X is bounded. As a result, by stability, the persistence homology of this loop space—up to finite distance—is an invariant of the manifold, i.e., is independent of the metric. We are most of the way toward proving the following theorem, essentially due to Gromov:

Theorem. *Let M be a compact Riemannian manifold. The question of whether there is a universal constant C so that every closed nullhomotopic geodesic of length L can be contracted through curves of length at most CL is independent of the metric on M; indeed, it only depends on the fundamental group of M. This condition is equivalent to the nonexistence of arbitrarily long persistence intervals in PH_0 of the component of the constant loops in ΛM.*

The final statement of the theorem explains the clause immediately preceding it. The geometric condition about geodesics depends only on the fundamental group (and not on the manifold) because this is true, almost by definition, for the 0 dimensional homology of the space of loops. Examples for which this condition does not hold are finitely presented groups with unsolvable

[3] *For any finitely generated group, we define the distance between two group elements to be the number of multiplications by generators it takes to go from one element to the other. Although this depends on the generating set, many of the large-scale properties of this metric space do not, as is explained in Roe's article* [3].

word problem (for a bound on the size of the persistence intervals could be used to give an algorithm for solving the word problem). For manifolds with such fundamental groups, the theorem asserts the existence of many interesting closed nullhomotopic geodesics. More information can be found in Alex Nabutovsky's talk at the 2010 ICM.

The terminology of persistence homology can be viewed as an example of applied applied math. The needs of applied math have given us a very convenient vocabulary for expressing certain questions and arguments in pure mathematics.

Acknowledgments

I would like to thank Jonathan Block, Gunnar Carlsson, Frederick Chazal, Sasha Dranishnikov, Herbert Edlesbrunner, Benson Farb, Steve Ferry, Rob Ghrist, Alex Nabutovsky, Partha Niyogi, and Steve Smale for many very helpful conversations on these matters.

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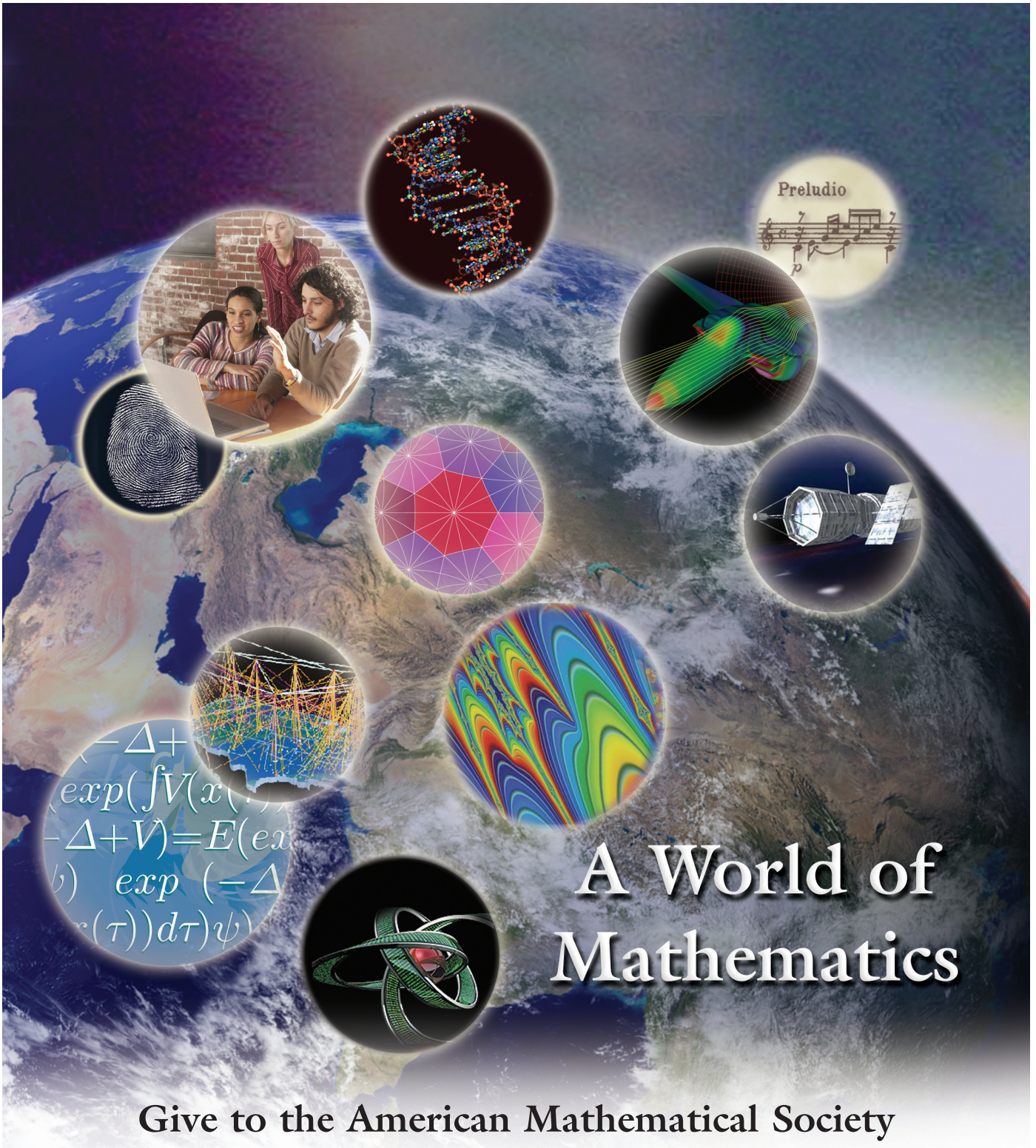

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08/04

Real Face of János Bolyai

Tamás Dénes

On the 150th anniversary of the death of János Bolyai[1]

In Vol. 56, No. 11, of *Notices*, I saw a fascinating article with the title: *Changing Faces—The Mistaken Portrait of Legendre*. The author, Peter Duren, writes with understandable bewilderment: "*It seems incredible that such egregious error could have gone undetected for so many years.*" This encouraged me to publish, in the same journal, the story—no less fascinating—of the real face of János Bolyai.

It should be explained that in the case of János Bolyai two different interpretations of the word "face" are justified: the "face" in terms of the portrait (painting, drawing), and the "face" as an abstract concept. The first part of the article introduces the surprising story of his only portrait, which, although universally accepted, turns out not to be of him at all. The second part explores his intellectual or "mind-face" (it is my own word formation) and outlines a new approach to Bolyai's creative life and work.

The town of Marosvásárhely—which lies in the heart of the Central European Transylvania—fulfills an important role in the history of the Bolyai family: János lived most of his life there, and the local library holds most of his manuscripts. The reader might find it strange that while János Bolyai is well known around the world as an eminent Hungarian, Transylvania (and so Marosvásárhely) can be found within the borders of Romania. This can be explained by the unsettled history of Transylvania. If we look back only to the nineteenth century, the part of Transylvania that was populated mainly by Hungarians was autonomous at times, whereas at other times it belonged to Hungary. In 1947, following World War II, the Treaty of Paris gave this area to Romania, so that is where it is found on today's maps.

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[1]*Dedicated to the memory of Professor Elemér Kiss (1929–2006).*

The article entitled "The real face of János Bolyai" originates from my conversations with Professor Elemér Kiss. Unfortunately his serious illness, followed by his death in 2006, thwarted our writing of a shared article. This piece of work is intended to fill this gap.

Only Two Pictures of János Bolyai Ever Existed, Neither of Which Has Survived

János Bolyai (December 15, 1802–January 29, 1860) emerges like a comet from the history of Hungarian mathematics.

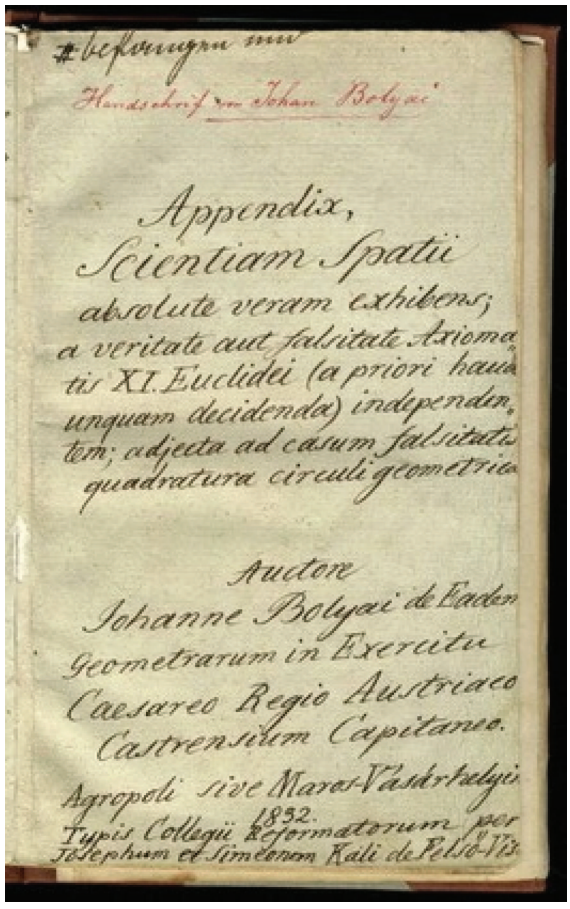
"*He was an illustrious mathematician with a great mind; the first amongst the first*"—read the record of his death in the book of the Reform Church of Marosvásárhely in Transylvania. On November 3, 1823, he had sent a letter to his father from Temesvar, including the words that would later become famous: "*I created a new, different world out of nothing*."

What he meant by this "*new world*" was the idea of hyperbolic geometry, which was outlined in 1832, as an appendix to the book *Tentamen* by Farkas Bolyai,[2] entitled "The absolute true science of space" (*Scientiam Spatii absolute veram exhibens*). This, under the name "Appendix", has become his best known piece of writing.

The theory outlined in this work has been named "Bolyai-Lobachevsky geometry", following a decision made in 1894 at the International Bibliographic Congress of Mathematical Sciences. In January 2009 the "Appendix" by János Bolyai was added to UNESCO's Memory of the World Register.

János Bolyai was the son of Farkas Bolyai—himself a defining figure of nineteenth-century Hungarian mathematics, who was in regular correspondence with Gauss. As a result, it is perhaps not surprising that Farkas Bolyai and his wife Zsuzsanna Árkosi Benkö were immortalized by

[2]*Father of János Bolyai.*



(Source: Hungarian Academy of Sciences Library)

Figure 1. Title page of the "Appendix" by János Bolyai.

contemporary artists in both drawings and oil paintings. It might therefore be assumed that their child, who had already become famous in his lifetime, would be immortalized in a similar manner.

But based on contemporary sources, only two pictures of János Bolyai ever existed, neither of which has survived. One of the "Vienna pictures" was mentioned by Farkas Bolyai himself in a letter written to his son on September 3, 1821. According to other sources, by 1837 this picture could no longer be found.

The other one was made while he was serving as a lieutenant. The destruction of this was accounted for by János Bolyai himself: "*I tore up this picture, which had been taken in a military parade, for I was not worthy of my father. I wasn't craving the outward immortality so wildly promoted by others.*"

The most recent research on Bolyai, by professors Tibor Weszely[3] and Elemér Kiss,[4] also supports the idea that there is no surviving authentic image of János Bolyai.

[3] *Sapientia University, Tg-Mures, Romania.*

[4] *He had been a professor of mathematics until his death (2006) at the Sapientia University, Tg-Mures, Romania.*

The Portrait of János Bolyai That Isn't

The question is: how has this—supposedly authentic—portrait spread around the world with the name of János Bolyai?

Well, exactly fifty years ago, on the centenary of János Bolyai's death, Hungarian and Romanian stamps were published with Bolyai's name on them. Since then there has been an increased presence of this portrait everywhere: in books, on postcards, and most recently on the Internet, too. Today we know for certain that this portrait is not that of János Bolyai.

Figure 2. The portrait, not of János Bolyai (on Hungarian and Romanian stamps in 1960), that has been circulated around the world.

The year 2010 is the 150th jubilee of János Bolyai's death, so it's about time that—after a latent period of fifty years—we resolve this scandalous mystery and bring to the public the results of the latest Bolyai research. In order to do this, I first need to briefly introduce the reader to two contemporaries of Bolyai: two Hungarian painters and a painting that plays a key role in the story.

Mór Adler (1826–1902) was one of the pioneers of Hungarian painting. He stood out as a student of some merit at the Weisenberger School of Graphic Art, from which he went to the Vienna Academy. There he was taught by the then well-known historical and religious painters, between 1842 and 1845. He then traveled to Munich in 1845 to study the works of Zimneirmann and Schnorr von Carolsfeld and for further studies in 1846–1847 in Paris. Next he settled in Pest in 1848, where he would become a respected figure in the art world by the end of his career. He took part in the Pest Artists Group exhibition in 1851 and would take part in this annually for the next fifty-eight years. He was best known for his portraiture and still-life paintings, which he executed in a fine realistic manner.

Mór Adler created the large oil painting above (150 x 100cm) in 1864.

The name of the person depicted in this painting does not appear either on the front or the back of the painting, nor is it mentioned in any contemporary documents. One thing we know for

Figure 3. Oil painting by Mór Adler from 1864.

Figure 4. Károly Lühnsdorf's drawing of Mór Adler's painting. On it, his handwritten note that has, until now, misled the world.

certain is that a drawing by Károly Lühnsdorf (1893–1958)[5] was made, based on this painting. He wrote the name János Bolyai at the bottom of the drawing, accompanied by the following note: "*I have drawn this portrait based on the only remaining picture of János Bolyai, painted from life by Mór Adler (1826–1902) artist from Óbuda in 1864—Károly Lühnsdorf*." The original drawing by Károly Lühnsdorf is now owned by the Bolyai family, but the photo of it and Mór Adler's painting can be found on the walls of the János Bolyai Mathematical Society.

To sum up, taking account of Mór Adler's and János Bolyai's biographical data and the fact that the painting is of a twenty-year-old man, we can draw the following conclusion. If the painting was of János Bolyai, it would have to have been created around 1822, when Mór Adler wasn't yet born.

Lühnsdorf states that he drew his picture "based on Adler's original painting from life", a clear assumption that Adler painted his picture of Bolyai himself. However, we know from biographical data that Mór Adler traveled around Europe until 1848. Only then did he settle in Hungary—at which time Bolyai was already forty-six years old.

To assume that the painter did not paint from life but from memory would also be a mistake, as in 1826, when Mór Adler was born, Bolyai was already twenty-four years old. If they met toward the end of the 1840s, when Adler was beginning his artistic career, János Bolyai would have already been past forty.

Thus Mór Adler's painting cannot be of János Bolyai, and Károly Lühnsdorf must have written his note based on false information, thereby misleading future generations. This is how this portrait, that IS NOT OF JÁNOS BOLYAI, started its journey around the world, being mistakenly recognized by mathematicians, students, and institutions as the only original portrait of him.

The Real Face of János Bolyai

"*He was the first Hungarian mathematician who (according to Loránd Eötvös)*[6] *created something world*

[5] *He studied at the Hungarian Academy of Arts between 1921 and 1928. His main interest was in painting portraits and biblical scenes; he acquired fame in the field of portrait painting. These depicted scientists, historical figures, and personalities from religious and public life.*

[6] *Loránd Eötvös (1848–1919) is remembered today for his experimental work on gravity, in particular his study of the equivalence of gravitational and inertial mass (the so-called weak equivalence principle) and his study of the gravitational gradient on the Earth's surface. Eötvös's law of capillarity (weak equivalence principle) served as a basis for Einstein's theory of relativity, and the Eötvös experiment was cited by Albert Einstein in his 1916 paper "*The foundation of the general theory of relativity*". (Capillarity: the property or exertion of capillary attraction of repulsion, a force that is the resultant of adhesion, cohesion, and surface tension in liquids that are in contact with solids, causing the liquid surface to rise—or be depressed.) The Eötvös torsion balance, an important instrument of geodesy and geophysics throughout the whole world, studies the Earth's physical properties.*

Figure 5. Here is the picture of the only authentic relief of János Bolyai on the front of the Culture Palace in Marosvásárhely (Romania).

> *famous. Unfortunately, of this scientist-giant no picture survives, his features being forever hidden from future generations. The only source describing his appearance is his passport (made when he was forty-eight): he was of average build, blue-eyed and with a long face.*" (Elemér Kiss)

From contemporary descriptions we may learn what he looked like. We know that he sported a dark brown beard, that his hair was the same color, that his eyes were dark blue. According to József Koncz (historian of the College of Marosvásárhely), János Bolyai looked very much like General György Klapka.[7] Another important fact: his son, Dénes Bolyai, stated that there was a huge resemblance between himself and his father.

I took this thinking further. On the facade of the Culture Palace in Marosvásárhely, above the

mirror room windows, there are six carved stone reliefs of nineteenth-century intellectual geniuses. Underneath them, faded but readable subtitles identify each figure.

It is used for mine exploration and also in the search for minerals, such as oil, coal, and ores.

[7] *György Klapka was a heroic general of the Hungarian freedom fight in 1848–1849.*

Figure 6. The only authentic relief of János Bolyai.

The third one from the left is Farkas Bolyai, the fourth one is János Bolyai. With the exception of János Bolyai, we have authentic pictures of all of the others. I compared these pictures with the reliefs, and I found the features to be easily recognizable.

Then I looked at portraits of György Klapka and Dénes Bolyai and placed them beside the János Bolyai representation from the Culture Palace. I was fascinated by the likeness: as if they were showing the same person.

The Culture Palace in Marosvásárhely was built between 1911 and 1913. At that time there were people living in the town who knew or saw János Bolyai, including his son Dénes Bolyai. He was a retired judge who took part in the exhumation of his father and grandfather on June 7, 1911. The artist who set János Bolyai's features in stone at this time must have—naturally—consulted the son (Dénes Bolyai) and his acquaintances regarding his father's looks.

Help of Computer Graphics

Based on the above reasoning, we have to accept that there isn't any authentic portrait of János Bolyai. We have proved that Mór Adler's and Károly Lühnsdorf's pictures aren't of János Bolyai, and there is little likelihood of ever coming upon an authentic photo or painting in the back of the archives. It is very important, however, that we have authentic portraits of his father, Farkas Bolyai, his mother, Zsuzsanna Benkö, and his son, Dénes Bolyai.

From these data, with the help of computer graphics (Meesoft SmartMorph software), Róbert

Figure 7. Computer transformation of a face: János Bolyai—Dénes Bolyai.

Figure 8. Computer transformation of a face: Dénes Bolyai—Farkas Bolyai (The likeness of grandson and grandfather can only be explained by the genetic mediation of János Bolyai between the two generations.)

Figure 9. Computer transformation of a face: György Klapka—János Bolyai.

Oláh-Gál[8] and Szilárd Máté[9] have created a virtual portrait of János Bolyai [20]. The aim of this experiment was to reduce the subjective element in deciding which portrait is more accurate, the picture painted by Mór Adler in 1864 or János Bolyai's half-relief on the building of the Culture Palace in Marosvásárhely.

After much experimentation, using the facial transformation technique on the computer, the following conclusion was drawn: in all probability, only one of the pictures comes close to János Bolyai's real likeness, and it is the half-relief on the Culture Palace.

After several decades of silence, attention needs to be drawn to the fact that the face of János Bolyai

[8] *Sapientia University, Department of Mathematics and Informatics, Miercurea-Ciuc, Romania.*

[9] *Sapientia University, Department of Mathematics and Informatics, Miercurea-Ciuc, Romania.*

in the public consciousness is not really his face. The only authentic source of his real portrait is the Culture Palace in Marosvásárhely (Figure 6). Being a defining figure of mathematical history, in the future he deserves to be associated with his real facial features.

I present gladly to the reader the next two works of art, which follow this mentality (see Figures 10 and 11).

Furthermore, this shocking statement, referring to his appearance, may equally be applied to the "well-known" facts about his professional activity ("mind-face").

János Bolyai's Real "*Mind-Face*" as a Mathematician (Based on E. Kiss: Mathematical Gems from the Bolyai Chests [16])

In his life János Bolyai's only published work was "The absolute true science of space", better known as the "Appendix". This was enough to make him world famous, but it also reduced his intellectual creation to this single piece of work.

When János Bolyai died the military governor seized all his manuscripts and had them put in chests and transported to the castle so that they could be examined for military secrets. Thus were his papers preserved for posterity, approximately 14,000 pages of manuscripts. The task facing researchers has not been easy. There are few dates, no numbered pages, pages missing, notes on envelopes and theater programs, idiosyncratic mathematical notations, and newly invented words.

However, János Bolyai didn't just leave us with the "Appendix" but with a heritage, consisting of 14,000 pages of letters to his father and manuscripts which are now kept in chests in the Teleki-Bolyai Library in Marosvásárhely. In these chests one can find mathematical theories—treasures in Bolyai's words—that have been hidden from the public for nearly 100 years. These pages convince us that János Bolyai, who was known purely as a geometer, was actually a universal mathematical genius who worked on many branches of mathematics, at times preceding significant inventions of other big names by decades.

The task Elemér Kiss took on, deciphering the contents of the "Bolyai chests", led to extraordinary results. The expression "deciphering" describes the tedious act of many decades by which it has been possible to reconstruct the contents of these materials. The contents, the grammar, the mathematical symbols, which differed significantly from those of present times, were often unreadable. Today we know that the results of this hard work have left us with *a brand new "mind-face" of János Bolyai*.

Elemér Kiss's book was published in 1999 in Hungarian and in English, followed by an extended second edition in 2005 by Typotex and Akadémia Publishers [16].

Figure 10. Reconstructed portrait drawing with India ink, made by Attila Zsigmond (a painter who lived in Marosvásárhely in 1927–1999), using Bolyai contemporary texts and other sources. The picture can be found in the Bolyai Museum, Marosvásárhely.

Figure 11. Bolyai Memorial Medal prepared for the Bolyai anniversary (in 2002) by Kinga Széchenyi, based on the relief on the Culture Palace in Marosvásárhely.

The first chapter, "The life of János Bolyai and the science of space", gives a brief account of the journey the scientist took in the creation of a new geometry. In addition, there is a real novelty in Chapter 1.6, considering the discovery of non-Euclidean geometry based on facts from Bolyai's correspondence. The author comes up with a convincing reasoning for the priority of Bolyai in the Bolyai-Gauss-Lobacsevszky relation.

In the second chapter we can read a systematic and comprehensive description of the "Bolyai chests". Parts of this chapter explain the language and symbols used by Bolyai, the result of meticulous research, as some of the original texts resemble complicated riddles.

In Chapter 4.3 we can read that in one of Bolyai's notes, he writes: "*My long nourished expectations and hopes had grown and mounted higher, namely, that I can devise primes based solely on their order in their series, independently or directly …, in other*

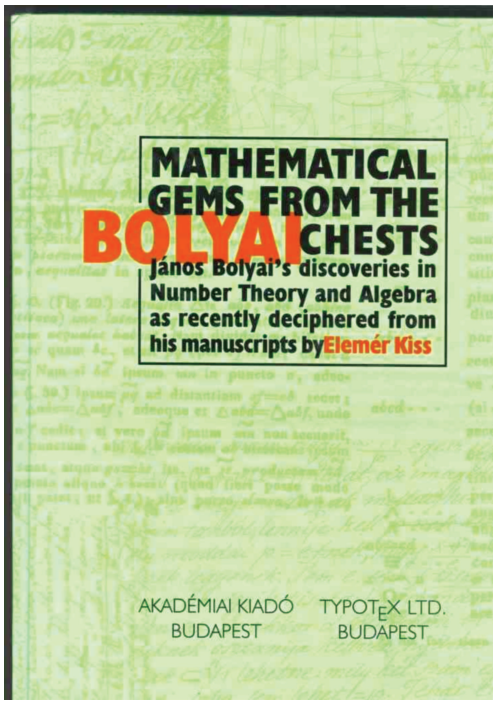


Figure 12. Elemér Kiss's book reveals a brand-new aspect of the mathematical work of János Bolyai.

words, that it is possible to give a formula which will define only primes."

He could find no formula for rational integer primes and neither could anyone else till this day, but his investigations led János Bolyai to an important discovery: he hit upon the first pseudoprime.[10]

Bolyai believed he had discovered the formula of primes in Fermat's Little Theorem.[11] Urged by his father, he attempted to prove the inverse of Fermat's Theorem, but a few attempts convinced him that proof was impossible and the inverse of Fermat's Little Theorem does not hold in general.[12] He did not find the prime formula, but he discovered the first pseudoprime. He communicated the discovery of the smallest pseudoprime (relative to 2), 341, in a letter to his father:

> "*...the most immediate and proper main question, namely that it may be the case that* $2^{\frac{m-1}{2}} \equiv 1 \pmod{m}$, *even though* m *is not a prime (which can of course be proven by even one example, such as the following which I happened to stumble on by chance, but not without theoretical considerations):* $2^{340} \equiv 1 \pmod{341}$ *is divisible by* $341 = 11 \cdot 31$, *which is infinitely easy to ascertain from* $2^{10} = 1024$, *which gives a remainder of* 1 *when divided by* 341, *therefore the remainder of* $2^{10^{17}} = 2^{170} = 2^{\frac{341-1}{2}}$ *and* $2^{341-1} \equiv 1 \pmod{341}$ *alike, thus neither the Fermat theorem nor the nice conjecture with regard to* $2^{\frac{m-1}{2}}$ *is valid (neither in the general case, nor in the particular one when* $a = 2$*), which is only to be regretted, since they could have supplied an excellent and very comfortable new means of identification (criterion) of primes ...*"

From this letter, especially interesting is the fragment: "*but not without theoretical considerations*". What could those earlier notes include? János Bolyai examined the question under what conditions the congruence

$$a^{pq-1} \equiv 1 \pmod{pq} \tag{1}$$

is satisfied, where p and q are primes, and a is an integer not divisible by either p or q. His reasoning was as follows, according to Fermat's Little Theorem: $a^{p-1} \equiv 1 \pmod{p}$ and $a^{q-1} \equiv 1 \pmod{q}$. By raising both sides of the first congruence to the

[10] *Various composite numbers m for which the expression $a^{m-1} \equiv 1 \pmod{m}$ is valid. The fact that the number of pseudoprimes is infinite has been known since 1904 [5]. There are composite numbers m which satisfy this congruence for each a, whenever a is a relative prime to m. These numbers are called* Carmichael numbers *in honor of their discoverer [1]. One of the most recent results of number theory is the proof that Carmichael numbers exist beyond all boundaries (based on a 1956 idea of the magnificent Hungarian mathematician Paul Erdös (1913–1996)). J. Chernick proved a theorem in 1939 that can be used to construct a subset of Carmichael numbers. The number $(6k + 1)(12k + 1)(18k + 1)$ is a Carmichael number if its three factors are all prime. In 1994 it was shown by W. R. Alford, Andrew Granville, and Carl Pomerance that there really do exist infinitely many Carmichael numbers. Specifically, they showed that for sufficiently large n, there are at least $n^{2/7}$ Carmichael numbers between 1 and n. The research on the pseudoprime numbers was completed in the twentieth century. and its more important application is in cryptography [7]. I would like to add at this point that Carmichael numbers have practical applications, namely to attack RSA cryptosystems [21].*

[11] *This theorem states that if p is a prime and a is an integer not divisible by p, then the difference $a^{p-1} - 1$ is divisible by p; a usual shorthand for this is: $a^{p-1} \equiv 1 \pmod{p}$.*

[12] *The inverse of Fermat's Little Theorem is: If $a^{p-1} \equiv 1 \pmod{p}$ holds, it does not necessarily follow that p is a prime.*

power of $q-1$ and those of the second one to the power of $p-1$, we obtain:

$$\begin{aligned} & a^{(p-1)(q-1)} \equiv 1 \pmod{p} \quad \text{and} \\ & a^{(p-1)(q-1)} \equiv 1 \pmod{q} \\ \Rightarrow\ & a^{(p-1)(q-1)} \equiv 1 \pmod{pq}. \end{aligned} \tag{2}$$

Next Bolyai observes that if the congruence $a^{p+q-2} \equiv 1 \pmod{pq} = a^{p-1} \cdot a^{q-1} \equiv \pmod{pq}$ were true, then by multiplying the two expressions obtained earlier, one could arrive at the desired congruence (1).

The following step must be finding the conditions that ensure the validity of the latter congruence. Since $a^{p-1} \equiv 1 \pmod{p}$ and $a^{q-1} \equiv 1 \pmod{q}$, continues Bolyai, there must exist integers h and k such that $a^{p-1} = 1 + hp$ and $a^{q-1} = 1 + kq$. In other words the condition of the validity of (1) is that

$$hp + kq = (a^{p-1} - 1) + (a^{q-1} - 1) \equiv 0 \pmod{pq}. \tag{3}$$

It is satisfied if p is a divisor of k and q is a divisor of h, according to Bolyai, this means that $a^{pq-1} \equiv 1 \pmod{pq}$ is true of primes p and q for which $\frac{a^{p-1}-1}{pq}$ and $\frac{a^{q+1}-1}{pq}$ are integers, in which case

$$\frac{a^{p-1}-1}{q} \quad \text{and} \quad \frac{a^{q-1}-1}{p} \text{ are also integers.} \tag{4}$$

In the simple case when $a = 2$ Bolyai substitutes some primes satisfying (4) and arrives at $p = 11$ and $q = 31$. This is how János Bolyai discovered the smallest pseudoprime.

Although he emphasized in his letter quoted above that "*even one example*" suffices, various counterexamples emerge from the remaining manuscripts. He constructed more congruences:

$$\begin{aligned} & 2^{340} \equiv 1 \pmod{341}, \qquad 4^{14} \equiv 1 \pmod{15}, \\ & 2^{2^{32}} \equiv 1 \pmod{2^{32}+1}. \end{aligned} \tag{5}$$

Bolyai says that if in the congruence (1) is $a = 2$, then the congruence

$$2^{pq-1} \equiv 1 \pmod{pq} \text{ follows.} \tag{6}$$

This corresponds exactly to the theorem of James Hopwood Jeans (1877–1940), which he published in 1898 [15], decades after the death of János Bolyai. This is the case with the Jeans theorem as well. Bolyai's discovery, like many others apart from the "Appendix", was not communicated even to his father. This is why one of Bolyai's beautiful theorems does not bear the name of János Bolyai but that of its rediscoverer.

Bolyai aimed to extend his method (6) to the case in which n is a multiple of three prime numbers: "*…but it will be considerably more difficult with three factors.*" Such congruences were constructed by R. D. Carmichael in [1], [2]. Bolyai's attempt suggests the following idea of generalizing Jeans's theorem: Let $p_1, p_2, \ldots, p_n$ be primes $n \geq 1$ and let a be an integer not divisible by either of these primes.

$$\begin{aligned} & a^{p_1 p_2 \cdots p_{n-1}{}^{-1}} \equiv 1 \pmod{p_n} \\ & a^{p_1 p_2 \cdots p_{n-2} p_n{}^{-1}} \equiv 1 \pmod{p_{n-1}} \\ & \cdot \\ & \cdot \\ & \cdot \\ & a^{p_2 p_3 \cdots p_{n-1} p_n{}^{-1}} \equiv 1 \pmod{p_1} \end{aligned} \quad \left.\right\} \text{ If}$$

$$\text{then } a^{p_1 p_2 \cdots p_n{}^{-1}} \equiv 1 \pmod{p_1 p_2 \cdots p_n}. \tag{7}$$

Chapter 4.6 reveals that János Bolyai was also captivated by Fermat numbers.[13] In one of the letters written to his father, he alludes to his approach to Fermat numbers in two places: "*By the way, my previous demonstration of* numerus perfectus[14] *and that of concerning* $2^{2^m}+1$ *are good and nice …*.

"*I intended to show that any number of the form* $2^p - 1$ *is a prime number if* p *is prime, at the same time when I took pains over* $2^{2^m} + 1$, *since as my writings show, I thought that* $2^p - 1$ *was always a prime for any prime* p. *…*"

This chapter represents a special value where Bolyai's theorem on Fermat numbers is introduced. According to this "*Fermat numbers are always of the form of* $6k-1$, *and therefore are never divisible by* 3." He proves the proposition as follows:

$2^{2m-1} + 1 = (2+1)(\ldots)$; consequently, $2^{2m-1} + 1 = 3n$, and so $2^{2m-1} = 3n - 1$, thus $2^{2m} = 6n - 2$, that is, 2 raised to an even power, is of the form $6n-2$. Then $2^{2m}+1$ and thus $2^{2^m}+1$ is of the form $6n-1$, with $m, n \geq 0$ being natural numbers.

The international significance of this theorem and the weight of Elemér Kiss's research have been supported by the publication of [18], in which Theorem 3.12 was called the "Bolyai Theorem".

This is the first highly reputable source in which János Bolyai's name is mentioned in the field of number theory as opposed to geometry, which is a real milestone on the way to revealing the real "mind-face" of János Bolyai.

In Chapter 4.7, Kiss pointed out that János Bolyai was able to prove the converse of Wilson's Theorem,[15] but he was unaware of the earlier proof

[13] *Numbers of the form* $F_n = 2^{2^n} + 1$ *where* n *is a natural number. Fermat firmly believed that all such numbers were primes, even though he had only calculated* $F_0 = 3$, $F_1 = 5$, $F_2 = 17$, $F_3 = 257$, $F_4 = 65637$. *His conjecture was disproven when Euler in 1732 showed that the next Fermat number* $F_5 = 641x6700417$ *is not a prime. By the early 1980s* F_n *was known to be composite for all* $5 \leq n \leq 32$.

[14] *Perfect number.*

[15] *In 1770 Edward Waring (1736–1798) announced the following theorem by his former student John Wilson (1741–1793): if* p *is prime, then* $(p-1)! \equiv -1 \pmod{p}$, *that is,* $(p-1)! + 1$ *is divisible by* p. *The theorem*

of Lagrange. Gauss discusses Wilson's theorem in *Disquisitiones Arithmeticae*, but on its converse he keeps silent. János Bolyai acquired the bulk of their number theoretic knowledge from the work of Gauss; thus Bolyai was unaware of the proof of the inverse to Wilson's theorem.

The inverse to the theorem was important for János Bolyai, who was interested in the prime or composite nature of various large numbers and who also searched for the formula of primes. He notes that "*I have proven the inverse of the very beautiful and significant Theorem of Wilson.*" For the reader's delight I present Bolyai's proof:

Suppose that

$$(p-1)! \equiv -1 \bmod p. \tag{8}$$

Let q be a prime divisor of p, namely $p = q \cdot p_1$, then

$$(p-1)! \equiv -1 \bmod q, \tag{9}$$

and according to Wilson's theorem

$$(q-1)! \equiv -1 \bmod q. \tag{10}$$

It follows from (9) and (10) that

$$(q-1)! \equiv (p-1)! \bmod q \Rightarrow 1 \equiv \frac{(p-1)!}{(q-1)!} \bmod q. \tag{11}$$

Assume now $q < p$, then q is a divisor of $(p-1)!$ but not of $(q-1)!$. Hence

$$q < p \Rightarrow \frac{(p-1)!}{(q-1)!} \equiv 0 \bmod q. \tag{12}$$

The congruences (11) and (12) are contradictory; consequently the assumption $q < p$ is false. Thus $p = q$ is a prime.

From Chapter 4.8 we may find out that János Bolyai obtained results on the general construction of magic squares[16] of small orders.

Bolyai wrote on the sheet containing the magic square that $a = 3b$ (see Figure 13); consequently $b = 5$ is true.

At the end of his note Bolyai invites the reader to generalize his 3x3 magic square to *nxn* squares:

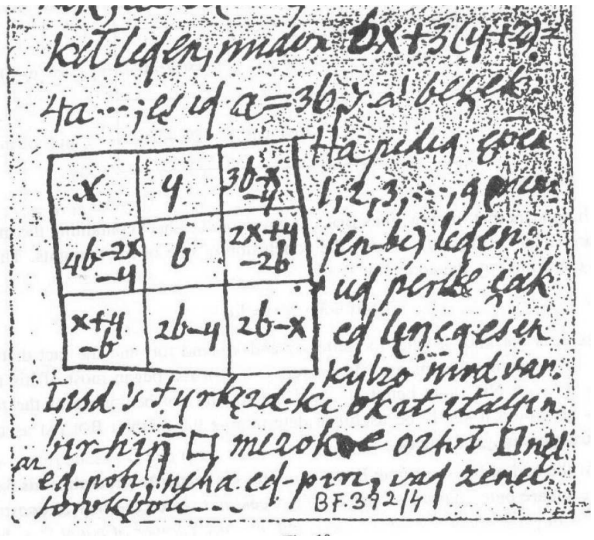


Figure 13. János Bolyai's general construction of a 3x3 magic square.

x	y	$3b-x-y$	$a=15$
$4b-2x-y$	b	$2x+y-2b$	$a=15$
$x+y-b$	$2b-y$	$2b-x$	$a=15$
$a=15$	$a=15$	$a=15$	$a=15$

8	3	4
1	5	9
6	7	2

Figure 14. Concrete solution of János Bolyai's 3x3 magic square.

"*Seek and search the way to construct general magical squares from a* □[17] *divided into any number of equal* □ *− s, be it arithmetical, geometrical or harmonic progression…*" I would like to add that Bolyai's ideas were reinvented by Cayley [3] and Chernick [4], and a survey on the general construction of magic squares can be found in an encyclopedic book [6].

Chapter 5 talks about a few results of Bolyai's work that have never been seen before: about complex integers,[18] into the research of which Bolyai invested huge amounts of energy. These studies, which Bolyai called the "*theory of primes*" or "*imaginary number theory*", dealt with the arithmetic of complex integers.

The theory of divisibility of complex integers was founded and developed by Gauss [12], [13]. He proved the theorem corresponding to the fundamental theorem of number theory inside Gaussian integers and discussed congruences involving complex numbers. János Bolyai elaborated the arithmetic of complex integers independently of Gauss and approximately at the same time.

was published by E. Waring, but he acknowledged that it had first been formulated by J. Wilson without a proof. The theorem was first proved by Joseph Louis Lagrange (1736–1813) in 1771, and he proved the inverse to Wilson's theorem as well: if n is a divisor of $(n-1)!+1$, *then n is prime.*

[16] *A magic square of order n is an arrangement of* n^2 *numbers, usually distinct integers, in a square, such that the n numbers in all rows, all columns, and both diagonals sum to the same constant. A normal magic square contains the integers from* 1 *to* n^2. *The constant sum in every row, column, and diagonal is called the magic constant or magic sum, a. The magic constant of a normal magic square depends only on n and has the value* $a = \frac{n(n^2+1)}{2}$.

[17] *This is the original symbol on Bolyai's sheet (see Figure 13).*

[18] *The* complex *or* Gaussian integer *is a complex number whose real and imaginary parts are both integers. Formally, Gaussian integers are the set* $\mathbb{Z}[i] = \{a+bi \mid a,b \in \mathbb{Z}\}$, $i = \sqrt{-1}$.

The beginnings of Bolyai's investigation of complex numbers can be dated exactly, because in a letter to his father he pinpoints the date: "*I sought the theory of imaginary quantities in their proper place and fortunately found it in 1831*." Based on his statements it can be asserted that János Bolyai saw his own theory clearly at the beginning of the 1830s, even in the years prior to the publication of the "Appendix".

In his manuscripts it can be deciphered that he clearly identified primes in the ring of complex integers. He asserted that complex primes are either

(13) *the numbers* $1+i$, $1-i$, $-1+i$, $-1-i$,
(14) *rational primes of the form* $4m+3$,
(15) *complex factors of rational primes of the form* $4m+1$.

Bolyai merely enumerates the numbers (13) as "*perfect primes*", and he notes that $2=(1+i)(1-i)$, but he clearly indicates that $1+i$ cannot be written as the product of two complex integers.

About numbers (14) Bolyai presents various proofs that they are "*absolute primes*". One of his proofs: "*If a prime p is of the form $4m+3$, then $p=t^2+u^2$ is impossible, because if both t and u are even or odd at the same time, then the sum of their squares would yield an even number and such a number is not a prime. If one of t and u is even and the other is odd, then the sum of their squares is a number of the form $4m+1$. Then p is an absolute prime.*"

Bolyai showed that the complex integer $m+ni$ has no divisor different from its associates provided that $p=m^2+n^2$ is a prime. He relates this property of numbers (15) to Fermat's Christmas theorem, and he writes: "*Every prime p of the form $4m+1$ is the product of two imaginary primes, since all such numbers are the sum of two full squares*." For example: $13=(2+3i)(2-3i)$.

János Bolyai also discussed unique factorization of complex integers, and he proved the following theorem: "*Every number of the form $a+bi$ can be uniquely (up to the order of the factors) decomposed into a product of finitely many primes*."

He not only elaborated the theory of complex numbers, but its applications were also of importance to him. He skillfully applied his conclusions on complex integers in proofs of various number theoretic theorems.

Chapter 6, "The theory of algebraic equations", reveals Bolyai's struggles in connection with the solvability of algebraic equations of fifth and higher order. His unpublished collection contains many notes pertaining to this subject. It has been summed up by Elemér Kiss at the end of this chapter: "*János Bolyai thought long about this important problem without knowing that it had been resolved before.*"

This is why the connection between Bolyai and the theory of algebraic equations is especially interesting. János Bolyai frequently mentions the two-volume *Vorlesungen über höhere Mathematik* by Andreas von Ettingshausen (1796–1878), which was published in Vienna in 1827 (see [11]). In this book the author devoted an entire chapter to the impossibility of solving equations of a degree higher than four and cited Paolo Ruffini's (1765–1822) proof of 1799[19] [22], [23]. Bolyai cites Joseph Louis Lagrange's (1736–1813) book [19], which addresses the fundamental problem of why the methods used for solving equations of a degree equal to or lower than four are inapplicable in equations of higher degree.[20] On his reading Bolyai writes: "*…to give a proof of this impossibility for degree 5 and for higher degrees as well: this proof being given by Ruffini (as the deserved Ettingshausen writes) wittily enough, but with a great many mistakes, in short, only in his fancies*."

This led him to conclude that the theorem was not valid and consequently at first, he searched for the solution of equations of degree higher than four with great enthusiasm, and he wrote in 1844: "*By refuting the demonstration of impossibility (by Ruffini) …it will be proven* eo ipso *(self-evidently) in a new way*."

János Bolyai thought long about this important problem without knowing that it had been resolved before. On the other hand, the world didn't know about this nineteenth-century Hungarian scientist who (perhaps late and only for its own sake) had put an end to a centuries-long debate.

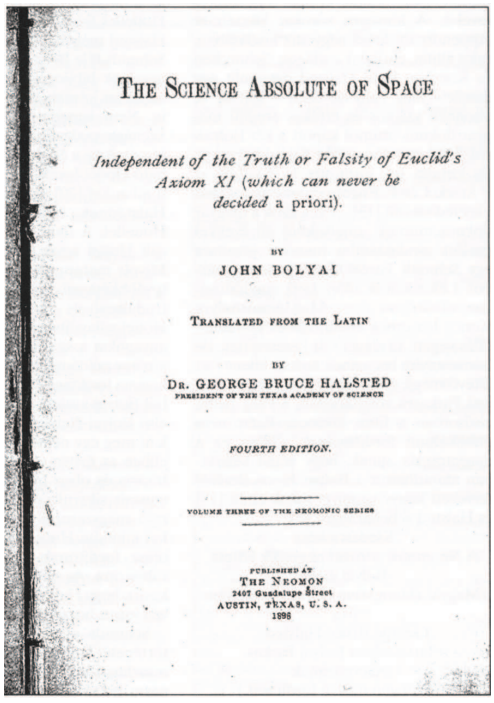
The above facts suggest the isolation Bolyai worked in all his life and the enormous creative power through which he was able to "*create a new, different world out of nothing*", not exclusively in the field of geometry.

Acknowledgment

It is hard to overestimate the value of the work of Elemér Kiss in the process of revealing János Bolyai's real face after 150 years of silence. What makes it even more meaningful is the fact that János Bolyai's face has been unknown so far, as the famous image that has been circulated around the world is certainly not his. To put an end to this misconception, and also to publicize essays and research in related areas, "The Real Face of János Bolyai" has been created at: `http://www.titoktan.hu/Bolyai_a.htm`.

[19] *The 1826 article by Niels Henrik Abel (1802–1829) could not have been included in this work published in 1827. The Abel-Ruffini theorem states that there is no general solution in radicals to polynomial equations of degree five or higher.*

[20] *This observation not only impelled Ruffini and Abel to continue research in this direction but also led to Galois's conception of group theory.*



THE SCIENCE ABSOLUTE OF SPACE

Independent of the Truth or Falsity of Euclid's Axiom XI (which can never be decided a priori).

BY

JOHN BOLYAI

TRANSLATED FROM THE LATIN

BY

DR. GEORGE BRUCE HALSTED

PRESIDENT OF THE TEXAS ACADEMY OF SCIENCE

FOURTH EDITION.

VOLUME THREE OF THE NEOMONIC SERIES

PUBLISHED AT
THE NEOMON
2407 Guadalupe Street
AUSTIN, TEXAS, U. S. A.
1896

George Bruce Halsted (1853–1922), American mathematician, translated the "Appendix" by János Bolyai into English in 1896.

At this point it is necessary to remember the American mathematician George Bruce Halsted (1853–1922), who in 1896—before any other foreign Bolyai researcher—visited Marosvásárhely and translated the main work of János Bolyai: the "Appendix" [14]. With his activity he contributed significantly to the international appreciation of the two Bolyais.

I would like to sincerely thank the referees who supported the publication of this essay, for continuing the tradition initiated by G. B. Halsted. By doing so they make a significant contribution to the introduction of János Bolyai's real face to the world.

This essay could not have been written without our personal discussions with Professor Elemér Kiss, the written accounts of Professor András Prékopa, and Róbert Oláh-Gál's support with the face animation.

I would like to say a special thank you to Ildikó Rákóczi, the director of the János Bolyai Mathematical Society, for making it possible for me to photograph and publish pictures of key importance for the purposes of this project.

I would also like to express my gratitude to my daughter Eszter and Damien Bove for taking care of the language aspect of this essay.

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What Do the NAEP Math Tests Really Measure?

David Klein

The National Assessment of Educational Progress (NAEP)—often called the nation's report card—includes math tests administered to representative populations of fourth- and eighth-grade students in each state.[1] Widely cited by education researchers, the scores are used to track the progress (or lack thereof) of U.S. mathematics education, and they have appreciable influence on national education policies. Until recently, the past two decades have seen fourth- and eighth-grade NAEP math scores increase, albeit slowly. The National Council of Teachers of Mathematics claimed credit for the trend, pointing to its standards documents and policies,[2] but scores were flat from 2007 to 2009. That prompted U.S. Education Secretary Arne Duncan to call for reforms to "accelerate achievement". David Driscoll, chair of the National Assessment Governing Board of NAEP, argued that the lack of improvement demonstrated the need for better training of elementary school math teachers [1]. But what do the math NAEP tests actually measure?

Most problems from the NAEP exams are reused and are therefore kept secret. However, some items each year are retired and made available to the public. The National Center for Educational Statistics suggests that these released items can be used to "supplement classroom instruction" and "provide additional insight into the content of the assessment" [2]. Two of the algebra problems administered in 2009 are displayed in Figures 1 and 2.

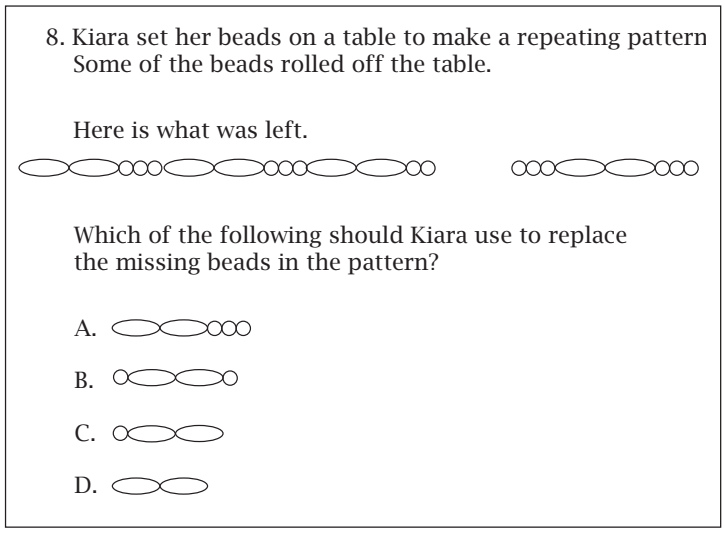

Figure 1. Grade 4 NAEP, 2009, Content Classification: Algebra.

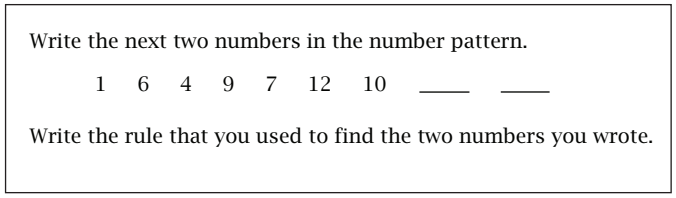

Figure 2. Grade 8 NAEP, 2009, Content Classification: Algebra.

The obvious lack of mathematical content in these items is unfortunately not limited to them. Algebra problems constitute 15% of the fourth-grade test and 30% of the eighth-grade test [3]. In

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[1] *The occasionally administered twelfth-grade math test is not discussed here, nor are the long-term trend tests.*

[2] *See the NCTM webpages at* www.nctm.org/news/release.aspx?id=766 *and* www.nctm.org/news/content.aspx?id=12500.

its 2008 report, the National Mathematics Panel (NMP) found that, "At Grade 4, most of the NAEP algebra items relate to patterns or sequences" [4] (pg. 59). The Task Group on Assessment for the NMP reported [5] (pp. 8-9) that

> While the inclusion of patterns in textbooks or as state curriculum expectations may reflect a view of what constitutes algebra, patterns are not emphasized in the curricula of high-achieving countries.… The prominence given to patterns at the preschool through Grade 8 level is not supported by comparative analysis of curricula or by mathematical considerations.… the Task Group strongly recommends that "algebra" problems involving patterns be greatly reduced in these tests.

Not explicitly pointed out in the NMP reports is that the geometry problems are as devoid of mathematical content as the algebra problems. Examples are shown in Figures 3 and 4.

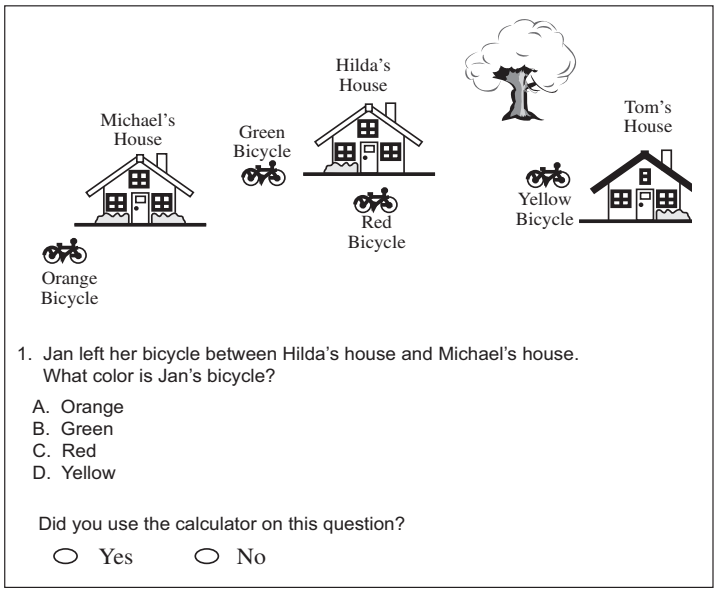

Figure 3. Grade 4 NAEP, 2007, Content Classification: Geometry.

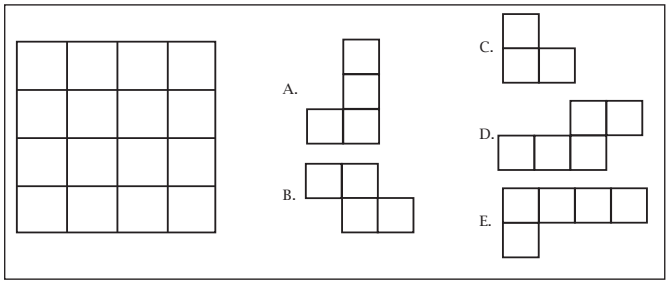

Figure 4: Grade 8 NAEP, 2009, Content Classification: Geometry. The problem says: "Identical puzzle pieces have been put together to form the large square shown [to the left]. Which of the following [shapes to the right] could be the shape of each puzzle piece?"

Overall, the prerequisites for the released NAEP math questions in all categories for fourth and eighth grades are minimal. Some questions test insignificant vocabulary only. Calculators are permitted on a substantial portion of the tests. The NMP Task Group on Assessment identified as "one of its greatest concerns" that "fractions (defined here as fractions, decimals, and related percent) are underrepresented on NAEP." Perhaps most importantly, many of the questions appear to be IQ items rather than math problems, in the sense that their solutions rely on almost no education or knowledge of mathematical techniques. This is especially the case for those questions that require students to complete a pattern or to fill in geometric shapes with other geometric shapes, like puzzles.

Indeed, NAEP scores have been used by psychologists for the purpose of estimating IQ, state by state [6]. That may be a more plausible use for these tests than their stated purpose, to measure mathematics achievement. In fact, a congressionally mandated report, more recent than the Task Group Assessment, concluded that "intended uses of NAEP assessment scores were not clearly defined." The report called for additional research into alignment between NAEP exams and state assessments based on academic content standards [7].

While it is true that some NAEP test questions do include rudimentary mathematical content, many others are as deficient as those displayed in Figures 1–4. What then do marginal differences in NAEP math scores between states really measure? Do they measure relative effectiveness of states' mathematics education programs, as is usually assumed, or do they measure differences in average IQ (whatever that might mean) of the residents? If it is primarily the latter, one would expect NAEP scores to show little if any increase even if school math instruction improved significantly.

The NAEP exam is widely regarded as the yardstick of mathematics achievement at the fourth- and eighth-grade levels in the United States. Diane Ravitch described one of its uses as follows [8].

> NAEP monitors trends; if the state says its scores are rising but its scores on NAEP are flat, then the state reports are very likely inflated. In a choice between the state's self-reported scores and an audit test, the public should trust the audit test.

In the case of some states, the public should trust neither. Regardless of flaws in state assessments, to the extent that the NAEP is an IQ test, it is measuring something different from what state tests are designed to assess. Achievement is not the same as ability.

Until such time as a reliable national mathematics achievement test comes into existence, the plethora of education research articles that base their findings on NAEP math scores should be considered with reservations. More reliable, for the time being, are state-administered K–12 mathematics assessments directly tied to the content of credible state standards, as in the case of California.

Acknowledgement

The author thanks Elizabeth Carson, Tom Loveless, Richard Phelps, Hung-Hsi Wu, and Ze'ev Wurman for helpful comments and suggestions.

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Book Review

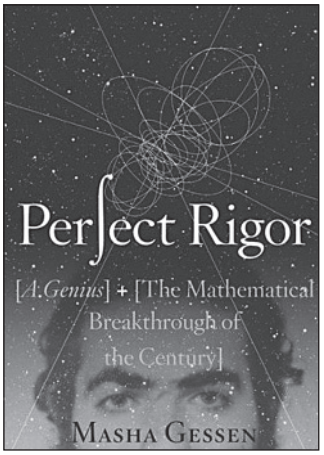
Perfect Rigor: A Genius and the Mathematical Breakthrough of the Century

Reviewed by Donal O'Shea

Perfect Rigor: A Genius and the Mathematical Breakthrough of the Century
Masha Gessen
Houghton Mifflin Harcourt, 2009
US$26.00, 256 pages
ISBN-13: 978-0151014064

Gregory Perelman's proof of the Poincaré conjecture in 2002 and 2003 ranks as the greatest scientific achievement of the last decade. It is a great mathematical and a great human story and has been the subject of several books and will undoubtedly inspire others. The latest such book, Masha Gessen's *Perfect Rigor*, focuses largely on Perelman and the media storm that surrounded him.

The story of a lone individual dropping out of sight for nearly a decade and posting to the Internet a solution to one of the best known mathematical problems of all time would predictably interest the media. Stir in Perelman's eccentricity, a widely circulated *New Yorker* article alleging an unscrupulous attempt to wrest priority from him, the Clay Mathematical Institute's million-dollar prize for the solution, the rejection of a Fields Medal, and Perelman's refusal to talk to the press or to publish in a standard refereed journal, and you have the makings of a category five media hurricane. A journalist, Gessen brings exceptional credentials to the job. Russian-born, she emigrated with her family as a teenager to the United States and returned to Moscow to live in the early 1990s. She



writes in both English and Russian and has made a name for herself for her courage and outspokenness. Unhappily, Gessen was unable to interview Perelman, as he refused all contact with her. She did, however, manage to talk with many in and out of the Russian mathematical establishment. The result is an exceedingly lively book about the schooling and society that gave rise to Perelman.

Before turning to Gessen's book, let me remind readers briefly of the mathematical story. In 1895 Poincaré wrote an extraordinary foundational paper on topology that introduced the fundamental group, generalized the notions of homology and Betti numbers to all dimensions, and focused on differentiable manifolds as objects of particular study. Although this paper and the five "complements" to it that appeared between 1899 and 1904 compose a small percentage of Poincaré's total work (measured by number or page length), they established algebraic, differential, and combinatorial topology as fields in their own right. So deeply embedded are the results of these papers into mathematical consciousness that we no longer have any awareness of the extent to which they have shaped our thinking. In fact, these papers firmly established the utility of topological concepts in analysis and geometry and thereby set the course of much of twentieth-century mathematics.

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They also gave us the first famous mathematics problem that belonged wholly to the twentieth century. In the second complement, which appeared in 1900, Poincaré announced that a compact n-dimensional manifold without boundary with the same Betti numbers as the n-dimensional sphere was necessarily homeomorphic to it. Four years later, he discovered, and in the fifth complement described, a marvelous counterexample: a three-dimensional manifold with the same homology groups as a three-sphere, but with finite fundamental group. In the very last paragraph of the fifth and final complement, however, Poincaré restates his announcement of 1900, asking what has become known as "the Poincaré conjecture". Namely, he asked whether a simply-connected, compact three-dimensional manifold (without boundary) is necessarily homeomorphic to a three-dimensional sphere.

Higher-dimensional analogues of the Poincaré conjecture were proved in dimensions greater than four by Smale in 1960 and in dimension four by Michael Freedman in 1982. Both men received Fields Medals, and their work opened new areas and touched off further advances. But the original three-dimensional conjecture, arguably the most natural question one could ask of compact three-manifolds, resisted all attempts at resolution. Its subtlety and hidden difficulty became famous as false proofs and would-be counterexamples accumulated over the century. In fact, until Bill Thurston formulated and amassed significant evidence in the late 1970s for his celebrated geometrization conjecture, no one really had any idea whether or not the Poincaré conjecture might be true. Thurston's conjecture implied the Poincaré conjecture and provided a conjectural framework indicating why it might be true. But a proof seemed completely out of reach. After some initial promise, various differential geometric approaches pioneered by Yau, Anderson, Hamilton, and others seemed hopelessly stalled. Perelman changed all that. With a mix of sheer power and dazzling geometric insight, he understood and exploited the geometry of Hamilton's Ricci flow, allowing him to prove the full geometrization conjecture. The unselfish labor of mathematicians all over the world in verifying and explaining Perelman's work shows the mathematics at its best.

Gessen set herself the tasks of trying to find out what it was about Perelman's mind that enabled him to settle the Poincaré and geometrization conjectures and, having done so, why he reportedly decided to abandon mathematics. She begins by sketching how mathematics assumed its unique role in Soviet society, beginning with the strength of the Moscow mathematical community in the early twentieth century, the arrest of Dimitri Egorov, the denunciation of Nikolai Luzin, and the conjectural, somewhat casual, decision of Joseph Stalin to head off a show trial and to partially rehabilitate Luzin. The exceedingly effective lesson underscored the dependence of the mathematical community on the goodwill of the state and severed relations between the mathematical community in Russia and the rest of the world. It did, however, leave the community's scientific strength intact, and the usefulness of mathematicians in developing the former Soviet Union's nuclear and space programs resulted in substantial state investment in mathematics and the privileging of mathematicians. Gessen recounts the charmed life of Kolmogorov, born of wealth and fabulously talented, whose influence stemmed not just from his own extraordinary mathematical prowess but also his wide interests, his ideals of a classical liberal education, and his interest in education. Kolmogorov set up a system of schools for gifted children that had a wide influence.

Gessen has a sharp eye for irony and points out that the existence of a strong mathematical school in Stalinist and Soviet Russia is nearly miraculous, since the values of the mathematical community are antithetical to either. She details the unspoken but ubiquitous anti-Semitism of the Soviet mathematical establishment and the rigid quotas on Jews admitted to elite postsecondary educational institutions (two per year to Mathmech, none-to-one in Steklov). This resulted in a strong mathematical culture outside the establishment, peopled by very talented individuals working for the sheer love of mathematics, but occupying positions unequal to their ability and accomplishment. She describes how a system of after-hour mathematics clubs in which schoolchildren would be coached in solving mathematics problems fed the two mathematics cultures, one establishment and privileged, the other not. As in other places in the book, she is able to draw on her own experience, contrasting the teaching she received in elementary school, where her teacher made her pretend to read as poorly as the other kids, with the math club in which the coach elicited from her how she might proceed to solve a particular problem and then exhorted her to do it. "Apparently, this was a place where I was expected to think for myself," she writes. "A wave of embarrassment covered me; I hunched over my piece of paper, sketched out a solution in a couple of minutes. And felt a wave of relief so total that I think I became a math junkie on the spot."

She found, and interviewed extensively, Sergei Rukshin, the idiosyncratic self-made coach who ran the mathematics club that Perelman joined and who was a decisive influence on the younger Perelman. She describes the closeness between coach and student and Rukshin's coup in getting the ablest members of his club admitted as a bloc to the storied Leningrad school 239. She interviewed high school mathematics teacher Valery Ryzhik, who inherited the bloc and who recognized Perelman's

genius. She describes the careful machinations by which Rukshin arranged to have Perelman, a Jew, become a member of the team representing the Soviet Union at the International Mathematics Olympiad in Budapest in 1982.

Gessen diligently tracks down nearly anyone known to have had any contact with Perelman. The closest that Gessen gets to Perelman, however, is through Rukshin, and this is to the adolescent. Ryzhik is clear that he never managed to form a close bond with Perelman. She interviews Perelman's undergraduate geometry teacher and thesis adviser, Zalgaller, now in Israel, who says that he had nothing to teach Perelman but who saw his contribution as directing unsolved problems to Perelman and seeing that Perelman's solutions were published. The precise role that Alexander Danilovich Alexandrov, the former president of Leningrad University who had returned to the classroom, played in Perelman's intellectual development is even less clear, although there can be no doubt that he must have exerted a decisive influence. Paradoxically, the nearer in time Gessen gets to the adult Perelman, the further he seems to recede. Perelman's Russian postgraduate collaborators, Burago and Gromov, and those he met in the United States tell Gessen little.

Writing about someone who refuses to be interviewed may, as Gessen allows, be easier than writing about a cooperating subject, but it also imposes an obligation to exercise caution, as it is harder to check facts and hypotheses. It is difficult to escape the disquieting impression that Gessen's narrative strays a little too far in places from the actual evidence at hand. In the book's penultimate chapter, entitled "The Madness", Gessen writes, "The more Perelman talked about his disappointment with the mathematical establishment, and the more his acquaintances decorated his stories with demonizing details, the more Perelman's sense of betrayal deepened. His world, which had begun narrowing in his first university year and then broadened slightly both times he had traveled to the United States, was now headed for its final disastrous narrowing." How, if she hasn't talked with Perelman, can she talk about a sense of betrayal? In what ways was Perelman's world narrowing in university? He clearly was undergoing tremendous mathematical growth. Likewise, the notion that Perelman was disastrously disappointed with Hamilton seems to be extrapolated solely from a quote from the *New Yorker* article. Gessen is far too good a journalist to misquote a primary source, but no fair-minded reader can fail to note the distressing number of places in which she impugns her sources' testimony. She breathlessly recounts, for example, secondhand reports of the alleged screaming match Perelman had with the accountant at Steklov. However, the accountant, whom Gessen interviewed, denied that there was yelling. Gessen's dismissal of the eyewitness account ("though over her years at the Steklov, she [the accountant] may have grown accustomed to extreme and unexpected expressions of human emotion") seems a stretch, at best.

Gessen argues that the people who surrounded Perelman sheltered him from ordinary reality, allowing him to mistakenly believe that the world is as he thinks it should be. This elaborate narrative is totally conjectural—Gessen has no evidence about what Perelman believes. Undaunted, she goes on to diagnose Perelman with a full-blown case of Asperger's syndrome. I simply don't know enough to evaluate these claims and am entirely unconvinced. Everyone agrees that Perelman lives simply, so why not make the simpler assumption that he wants privacy and does not want to be encumbered with fame or money? Perelman's recent refusal of the million-dollar Clay Millennium award suggests this, particularly since the Clay Institute made it clear that Perelman would not have to participate in any public ceremony.

Even putting aside the evidentiary questions, I found the second half of the book offensive. I felt uncomfortable reading about a living individual who wishes to remain out of public sight. Publicly diagnosing someone with a serious psychological disorder without consultation seems ethically questionable, not to mention presumptuous. Doing any sort of mathematics requires precision, careful attention to meaning, and concentration. Gessen's account of British psychiatrist Simon Baron-Cohen's autism-spectrum quotient test, and the purported strong correlation between high-functioning autism and mathematical ability in a test population, runs dangerously close to medicalizing precisely these traits. Gessen's presumption does not end with psychiatric expertise. She opines freely on Perelman's work, characterizing it as solving the "very, very complicated olympiad problem" into which she has Hamilton casting Thurston's geometrization conjecture. She cavalierly ranks top mathematicians in descending order from those who open new fields by posing questions no one has thought to ask (such as Poincaré and Thurston) to those who devise ways to answer those questions (such as Hamilton) to the bottom of the top, those poor souls (such as Perelman) who take the last steps in completing proofs. Mathematicians will easily discern the depth of Gessen's mathematical ignorance, but others will not, and it is depressing to see Perelman's inspiring achievement and powerful new ideas reduced to psychobabble: "Speaking of the imaginary four-dimensional space, he referred to things that could and could not occur 'in nature'. In essence, he [Perelman] was able to do in mathematics what he had tried to do in life: grasp at once all the possibilities of nature and annihilate everything that fell outside that realm—castrati

voices, cars, anti-Semitism, and any other uncomfortable singularity."

The incoherence and ugliness of such assessments contrast with the clarity and grace of the laudations read at the recent conference in Paris cosponsored by the Clay Mathematics Institute and the Institut Henri Poincaré celebrating Perelman's proof. Bill Thurston, for example, closes his by remarking that "in our modern society most of us reflexively and relentlessly pursue wealth, consumer goods, and admiration. We have learned from Perelman's mathematics. Perhaps we should also pause to reflect on ourselves and learn from Perelman's attitude toward life." (See `http://www.claymath.org/poincare/laudations.html`.) One cannot expect Gessen to understand the mathematics, but one wishes for some sense of her own limitations, some caution, some generosity, and some openness to difference. Her cheeky self-confidence and willingness to trample on what she does not understand, so typical of popular culture, wears thin. Perelman and his work deserve better. So, too, do the discipline and the profession.

Book Review

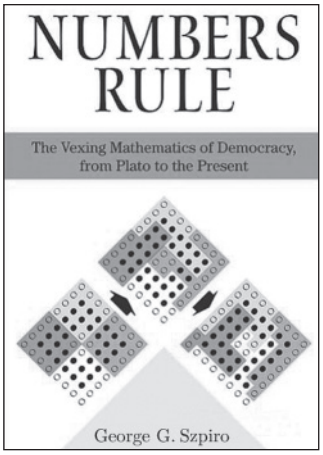
Numbers Rule: The Vexing Mathematics of Democracy, from Plato to the Present

Reviewed by Jonathan K. Hodge

Numbers Rule: The Vexing Mathematics of Democracy, from Plato to the Present
George G. Szpiro
Princeton University Press, 2010
US$26.95, 248 pages
ISBN-13: 978-0691139944

In recent years, the mathematical social sciences—particularly voting and social choice theory—have become a hot topic in both academia and popular culture. Liberal arts mathematics courses now often include sections on fair division and voting theory, and a number of recent textbooks and monographs devote themselves entirely to these topics.

Szpiro's book focuses on one such topic, namely, how mathematics—and mathematicians—have impacted both the theory and practice of democracy. It is an excellent addition to a growing body of literature that aims to convey ideas from the mathematical sciences to general audiences. Moreover, Szpiro's book is unique among other offerings in the mathematical social sciences in that it focuses on the historical development of the field. The narrative is engaging, witty, and easy to read.



As the book's title would suggest, the story begins in Athens, in the fifth century BC. Szpiro describes how the Athenian government was set up so that "everybody who had any sort of interest in running the city could either participate in the Assembly as he pleased, or was selected by lot, as in the Council, the Court, or the civil service" (p. 7). Plato was highly critical of this form of unrestricted democracy. In fact, it was a majority decision (280 of 501 jurors) by a randomly selected jury that had condemned his beloved teacher, Socrates, to death. Plato concluded, as Szpiro puts it, that "regular folks were not fit to rule and to dispense

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justice" (p. 2). He came to despise democracy and was "chastised as the worst anti-democrat by his detractors" (p. 1).

Plato's counterproposal, as conveyed by the Athenian stranger in the unfinished manuscript, *Laws*, involved multistage elections, significant privilege to the wealthy and well educated (who, to Plato, were one and the same), and other suggestions that, in Szpiro's words, "seem pulled out of a hat like a magician's rabbit" (p. 17). Plato's earlier work, *The Republic*, largely ignored elections and votes, which were viewed as superfluous because, as Szpiro summarizes, "the qualities necessary to become philosopher-king…do not often grow together" and "individuals who possess all these qualities are so rare that the state will hardly ever find more than one who fits the job description" (p. 20). In *Laws*, however, Plato dives in head first, setting the stage for centuries of future debate about the merits and implementation of democracy.

What we see in the story of Plato, Socrates, and Athenian democracy is a fundamental tension between competing social values. How is the ideal of full and equal participation in government to be balanced against the fact that majorities can, and sometimes do, endorse erroneous or unjust propositions? How does one ensure that government officials are qualified for the tasks under their charge when they are selected based solely on popular opinion? These are difficult questions, and in many ways they set the tone for the remainder of the book, which Szpiro accurately describes in the preface as "an elucidation and a historical account of the problems and dangers that are inherent in the most cherished instruments of democracies" (p. x).

As the account unfolds, the reader is given the opportunity to turn back the clock and embark on a journey that spans thousands of years and includes both well-known figures and their lesser-known counterparts. For instance, anyone who has studied voting theory is undoubtedly familiar with the work of eighteenth-century French contemporaries Borda and Condorcet. But readers might be surprised to learn that both the Borda count and Condorcet's method of pairwise comparisons were proposed centuries earlier, the former by a German cardinal named Nikolaus von Cusanus and the latter by a Catalan monk named Ramon Llull. In fact, Szpiro notes that "until quite recently most researchers believed that interest in the theory of voting and elections had started toward the end of the eighteenth century, at the time of the French Revolution. But toward the middle of the twentieth century, medievalists were surprised to discover manuscripts in the Vatican library and elsewhere that showed that sophisticated ideas had already been around half a millennium earlier" (p. 33). Szpiro has clearly done his research with this book, and the result is a strikingly thorough and engaging read.

One of the things I like most about the book is that it reveals mathematics to be a decidedly human endeavor, fraught with controversy and able to both expose and help solve real problems. Both the characters and the plot of the story defy the one-dimensional stereotypes that students sometimes associate with mathematicians and the study of mathematics. The historical figures surveyed include economists, lawyers, theologians, military officers, philosophers, artists, politicians, scientists, and yes, mathematicians. The personal and professional lives of each are explicated in detail both within the text and in biographical appendices at the end of each chapter. The effect is to add meaning to the intellectual contributions explored and to place them in the broader context of human experience.

Part of that experience includes spirited debate and a fair dose of name calling. Recall our friends Borda and Condorcet. As it turns out, they weren't friends at all. In fact, Condorcet was a fairly vocal critic of Borda. As Szpiro notes, "Condorcet did not think highly of Borda. In fact he did not even consider him a very capable mathematician… Condorcet wrote that Borda likes to talk a lot and wastes his time tinkering with childish experiments" (p. 89).

But the rift between Borda and Condorcet was nothing compared to that between Edward V. Huntington, a professor of mathematics at Harvard, and Walter F. Willcox, a professor of social science and statistics at Cornell. Their rivalry, which spanned decades in the early 1900s, involved polarizing rhetoric, highly publicized personal attacks, and more than a hint of deception. The substance of Huntington and Willcox's debate was the problem of apportionment—that is, how to allocate the appropriate number of seats to each state in the U.S. House of Representatives. Once again, the difference of opinion between the two professors was ultimately one of competing values. Willcox was a proponent of Webster's method of major fractions, which shows no bias to either large or small states, whereas Huntington supported Hill's method of equal proportions, which minimizes the relative differences in representation between the states. (Incidentally, Huntington could be viewed as the winner in this battle, as the method of equal proportions was adopted in 1941 and is, to this day, the method used to apportion the U.S. House. On the other hand, Michel Balinski and Peyton Young would later provide some vindication for Willcox, stating: "It seems amazing therefore that Hill's method could have been chosen in 1941… and that Webster's method was discarded. A peculiar combination of professional rivalry, scientific error, and political accident seems to have decided the issue" (pp. 195–196).)

The stories of Borda and Condorcet and of Willcox and Huntington serve to illustrate another valuable takeaway from Szpiro's book—namely, it dispels the myth that mathematics is a value-free endeavor, a matter of black and white, of finding the one right answer. If there is anything to be learned from the mathematical study of voting and elections, it is that sometimes there are no universally correct answers. Paradoxes abound, and the correct procedure often depends on the values and beliefs of those using it. Arrow proved this for voting systems, and Balinski and Young did the same for apportionment methods. These examples and many others support Bradley and Schaefer's [1] assertion that as the mathematization of the social sciences continues, "norms, values, and purpose need to become part of the common discourse of researchers." Szpiro notes that even the great mathematician Pierre-Simon de Laplace "did not find it beneath himself to bend the rigorous rules of mathematics somewhat when needed" (p. 97).

In summary, Szpiro's book fills a unique role in an increasingly popular field. Being written for general audiences, it suffers from some oversimplifications (such as stating that "misrepresenting one's preferences brings no advantage" (p. 212) in approval voting; in fact, approval voting is not completely immune to strategic voting, although it is less vulnerable than other nonranked systems) and minor imprecisions in language (for instance, the occasional conflation of the words *plurality* and *majority*). My only other substantive complaint is that the book feels like it ends too soon. The final chapter mentions single transferrable vote and approval voting, but only briefly. In addition, although works by some of today's leading mathematical voting theorists, such as Donald Saari and Alan Taylor, are included in the bibliography, they are not discussed at all within the text. Of course, every author must make choices about what to include and what to omit. Szpiro, in general, has chosen well. The result is a readable, engaging, and intellectually stimulating book that accomplishes its goal of "[introducing] readers to the subject matter in an entertaining way" (p. x).

Reference

[1] W. J. Bradley and K. C. Schaefer, *The Uses and Misuses of Data and Models: The Mathematization of the Human Sciences*, Sage Publications, 1998.

Best Current Practices for Journals

At its meeting August 16–17, 2010, in Bangalore, India, just prior to the 2010 International Congress of Mathematicians, the General Assembly of the International Mathematical Union (IMU) endorsed the following document prepared by the IMU Committee on Electronic Information and Communication. The committee members are John Ball (chair), Olga Caprotti, James Davenport, Michael Doob, Carol Hutchins, Peter Olver, and Ulf Rehmann. The document is available electronically on the IMU website at `http://www.mathunion.org/fileadmin/CEIC/bestpractice/bpfinal.pdf`.

In 2004 the CEIC produced a document listing various recommendations relating to the changing environment of peer-reviewed journals and digital distribution of research in its various stages. Now, in 2010, we wish to return to that document and offer more details on how journals can best serve the mathematical community. Specifically, this document focuses on how a good mathematics journal should be organized and managed.

Journals remain one of the most important tools of mathematical research and communication. A good journal adds value to the manuscripts submitted to it by providing:

Quality control: The peer-review process evaluates and aims, as much as possible, to certify the correctness, importance, novelty, and clarity of a paper.

Improvement in content and presentation: Journal referees, editors, and publishers improve the quality of published manuscripts and provide feedback to their authors.

Dissemination: Journals help to categorize the literature and help authors, readers, librarians, historians, and others to find relevant works.

Archiving: Journals ensure that papers remain accessible. They help establish priority and certify the historical record. In addition, they provide tags such as volume numbers and document identifiers that can be cited and linked to.

On the other hand, a poorly run journal has a detrimental effect on the mathematical literature. The proliferation of poorly run mathematical journals is becoming an increasing burden to the community. Some of these have been created for dubious reasons, such as the hoped-for prestige of the editors or institutions involved, or with no clear purpose beyond financial incentives. Even journals created with the best of intentions may fail to provide the services above because of inadequate planning or stewardship.

In this document, we draw together some best practices for journal management based on the experience of existing journals. Certain fundamental principles apply to all. Primary among these are transparency and integrity.

By *transparency* we mean that all the journal's stakeholders—readers, authors, referees, editors, publishers, etc.—are fully aware of the decision processes that affect them.

Integrity of the publication process is paramount. It includes maintaining an objective review process focused on scientific quality, proper acknowledgment of sources, and a respect for confidentiality where required.

Professionalism is also important. This includes timely handling of manuscripts at each stage of the process and continuity of management, scope, and vision as they evolve.

This document is necessarily based on currently available technology, and, while some practices are universal, others must be reformulated to adapt to new and unanticipated technological developments. The best practices and recommendations presented in the document will be periodically revisited and updated as circumstances require.

Rights and Responsibilities

There are many ways to organize the decision-making processes of a journal. However the editors and publishers decide to implement the details, there are certain basic rights and responsibilities of the authors, referees, editors, and publishers that should be respected in all circumstances.

Authors

Authors who submit a manuscript to a journal have the right to a careful, timely, and unbiased peer review overseen by the journal editors, who often seek the advice of referees. The level of detail of the review can vary greatly, but, following the principle of transparency, authors have a

right to know in advance the processes by which their manuscripts will be handled and a right to be informed of the grounds for the acceptance or rejection of their manuscript, including normally being given access to any referee reports that have been sought. However, manuscripts that are deemed not to adhere to the journal's standards or scope can be quickly returned to the authors with a brief editorial justification.

Authors must abide by high standards of research integrity and good scholarship. It is the responsibility of authors to submit a well-written, mathematically correct article—if necessary seeking advice if it is not written in their native language—to clearly describe any novel and nontrivial content, and to suitably acknowledge the contributions of others, including referees. Submission of a paper to a journal implies that it is not currently under consideration by any other journal and that any substantial overlap with other published or submitted papers is duly acknowledged. In addition authors should be responsive to correspondence with the journal. Multiple authors should communicate fully, speak with one voice, and accept mutual responsibility in their communications with the journal. All authors are expected to have materially contributed to the paper and to be familiar with its contents. The ordering of authors' names is at the discretion of the journal and/or authors, although the standard practice in most mathematical papers is to list authors alphabetically.

Referees

Researchers who benefit from the literature and contribute to it as authors also have an obligation to participate in the peer-review process, in particular by serving as referees in their areas of expertise. When doing so, they have a right to anonymity, unless this is clearly waived by the referee or by the stated policies of the journal. While no one has an obligation to referee any particular paper, the decision to do so or not should be communicated in a timely fashion. Potential referees should disclose any circumstances that might compromise their ability to provide an unbiased review.

Once a referee has agreed to serve, that referee should adhere to the agreed-upon schedule (typically including revisions) and inform the editor of unanticipated delays. Referees must act with integrity. They should familiarize themselves with the expectations of the journal and the review process and do their best to implement them in an unbiased fashion. They should respect confidentiality, neither disclosing the fact that the paper has been submitted nor that they are refereeing it, nor disclosing any nonpublic content to others, nor using for their own purposes results that are not publicly available. Referees wishing to seek the opinions of colleagues on the submitted article should seek permission from the journal editors. Referees are expected to base their written assessment on publicly available works.

We have noticed a trend, perhaps reinforced by manuscript tracking software, for referees to communicate additional opinions to editors that are not meant for transmission to authors. This concerns us, since the principle of transparency implies that authors should be fully informed of the grounds for the decision on their work. Such confidential comments do not relieve the referee of the obligation to make an honest assessment of the qualities of the paper in the report that will be transmitted to the author. We believe that in best practice such comments should be used exceptionally, rather than as a general procedure.

The obligations of a referee are, first, as expert advisor to the editors of the journal; second, through the editors, to the mathematical public, the obligation being the maintenance of standards in the mathematical literature; and, third, to the authors. Although the opinion of referees on the correctness of a paper is normally sought, ultimate responsibility for correctness lies with the authors. Refereeing is also an opportunity to provide positive guidance to the author. Although a referee does not have an obligation to do this, it can be an extremely valuable contribution, particularly in the case of authors in the early stages of their careers.

Editors and Editorial Boards

The editors and editorial boards bear the primary scientific responsibility for guiding a journal. Transparency requires that the journal have a clearly formulated statement of its vision and scope and a detailed description of its submission, peer-review, and publication processes, including the responsibilities of editors and referees. These should be publicly disseminated, and, in particular, all editors should both be aware of and in agreement with them. In many cases, the editorial board will take the primary role in formulating, monitoring, and updating these statements. The editorial board should also be familiar with and take an active interest in the publisher's pricing policies.

A primary responsibility of the editors is to implement the peer-review process, ensuring its integrity and fairness. This is carried out by

- a wise choice of referee or referees, with sufficient expertise but avoiding conflicts of interest;
- communicating with authors, referees, managing editors, and publishers in a timely manner;
- ensuring that the process moves forward by following up on referees and appointing new ones when necessary;
- arriving at decisions on objective grounds, which are communicated to authors, as discussed above.

Editors should ensure that papers are reviewed on purely scientific grounds and that authors are not pressured to cite specific journals, papers, or books for nonscientific reasons. There should be clear and transparent procedures for handling submissions by editors that guarantee that the standards of the journal are maintained.

Some journals use a quick reject procedure in which editors may determine that a paper is unsuitable for the journal without sending it outside for review. In this case, the editor must ensure that his or her own decisions are made fairly and objectively. The decision whether to accept or reject a manuscript is a complex judgment, depending on the submitted manuscript, the extant literature, and the goals and standards of the journal. Different referees and editors may well come to different conclusions. Referees sometimes make mistakes, and it is important that appeals against rejection of an article are fairly handled.

As noted above, authors have the right to be informed of the grounds for the acceptance or rejection of their manuscripts, including normally being given access to all referee reports. There may be exceptional circumstances in which an editor can reasonably decide to exclude part of a report—for example, if it contains libelous or insulting remarks or certain kinds of sensitive information. Nonetheless, it is important that such editorial discretion is not used to suppress inconvenient comments, such as a recommendation to accept the paper when the editor's decision is to reject it.

Editors should be alert to unethical practices such as simultaneous submissions to different journals, plagiarism, and self-plagiarism; be prepared to impose appropriate sanctions (such as refusing to consider further submissions from an offending author for a certain period); and cooperate with publishers in adopting procedures to eradicate such practices.

Publishers

For most journals, the editorial board does not itself oversee the production and business processes. These are usually carried out by a commercial publisher, a professional organization, university, or other institution. The support publishers receive from authors, editors, and referees in the mathematical community carries with it responsibilities. Most important is a commitment to the mathematical literature and its dissemination. Publishers must also adhere to the principles of integrity, transparency, and timeliness. Detailed information concerning the journal, including editorial board members, journal vision and scope, submission and publication procedures, fees, page charges, subscription pricing, etc., must be made publicly available to all concerned parties.

Publishers should ensure that papers are widely accessible, affordable in all parts of the world, and permanently archived in a form that can be readily located, referenced, and (possibly after paying a reasonable fee) accessed. Sales arrangements should be flexible, allowing, for instance, the purchase of individual journals and articles. Alternative modes of financing the publication process, such as through author fees, submission fees, page charges, or combinations of these, create significant ethical challenges. First, the opportunity to publish in a peer-reviewed venue should be available to all, subject to scientific merit, not the ability to pay via research grants, institutional support, or other means. Therefore, there should be methods to opt out of payment when needed. Second, payment in direct return for publication creates a potential conflict of interest with the peer-review process. For this reason, any such journal requires clear, well-defined, effective processes to insulate peer review and editorial decision making from monetary considerations.

Accepted papers should be typeset, copyedited (if appropriate), and published online and/or in print in a timely manner. Publishers should establish and clearly communicate to potential authors their policies concerning copyright and authors' web posting. Publishers should track and publish the date of submission; final revised submission, if applicable; and date of publication (electronic and/or print) of published papers. Publishers should respond to and investigate allegations of plagiarism or other unethical behavior connected with their journals, publish a clear and specific retraction in confirmed cases, and protect the rights of authors by seeking appropriate redress for plagiarism and unauthorized use of their work.

Recommendations

In this section, we append some more general recommendations for successful journal stewardship that are based on observed best practices among existing journals. These are presented to help editors and publishers launch successful new journals, as well as strengthen and improve existing journals. Not all are currently followed by even some of our most successful journals, and we are not presuming to second-guess the stewardship of well-run journals.

The vision and processes of a journal are very important to its success, and we encourage journals to involve their editorial boards in addressing these issues. Communicating this vision to all involved with production of the journal will, in the long run, save a great deal of time and effort, avoid problems and misunderstanding, and contribute greatly to the success of the journal.

The maintenance of a careful, professional system for handling manuscripts throughout submission, refereeing, revision, acceptance or rejection, and publication requires careful thought and effort. A clear procedure for handling mistakes, errata, retractions, counterexamples, and updates

should be established. We have observed a worrying increase in instances of plagiarism, and we encourage journals to consider instituting procedures for detecting, publicizing, and appropriately dealing with plagiarism in submitted articles. Such procedures rely on editorial judgment but may well be supported by automated systems, commercial or otherwise, and we encourage the development of such systems appropriate for use by journals.

The publisher and editorial board should determine the expected standards of exposition, including the languages of publication. In the case in which the author is unable to meet these standards, they should decide how much, if any, editorial support or copyediting the journal will supply. There is clear value to well-written and typeset papers, and editorial efforts by a journal are a significant contribution to the quality of the mathematical literature.

We believe that all the editors should be actively involved in the editorial processes of the journal, or, when this is not the case, that a designation such as "honorary editor" should be used. In any case, editors should be informed of and agree to their responsibilities, the scope of the journal, and the processes used to evaluate submissions. Even the agreement to serve as an honorary editor is a public statement of support for the goals and running of the journal and should be entered into thoughtfully. It is advisable to establish a clear term length for editors and procedures for renewal. Information about the history of a journal, such as the makeup of the editorial boards over time, is an important part of the historical record, and publishers should endeavor to archive such information in a readily accessible form.

It is an editor's responsibility to know the pricing policies of the publisher and to take an active interest in them as regards the journal's goals and the dissemination of scientific knowledge as widely as possible. Some of the very best mathematical journals operate without assessing page charges and with liberal policies for posting of articles in web repositories and on authors' home pages, while maintaining reasonable subscription fees and flexible bundling arrangements. This is a standard to be striven toward. All such policies must be clearly spelled out by the publisher. See also previous CEIC recommendations on open access to the mathematical literature: http://www.mathunion.org/ceic/Publications/Recommendations/6_call.shtml.

While some predict the imminent demise of journals, we hesitate to join that view. We recognize that there are many forces affecting how journals will be run in the future and that innovations in publishing will lead to researchers interacting with content in new ways. We hope with this document to support such evolution. If journals are run well, they will continue to play an important role in furthering mathematical research and communication for many years to come.

This document was prepared by the International Mathematical Union Committee on Electronic Information and Communication (CEIC), which gratefully acknowledges the valuable contributions to its contents and writing by Douglas Arnold. CEIC also expresses its thanks to a number of persons whose comments on an earlier draft led to substantial improvements.

References to Other Sites:

CEIC Best Current Practices: http://www.mathunion.org/ceic/Publications/Recommendations/3_best_practices.shtml.

Association for Computing Machinery (ACM) Rights and Responsibilities: http://www.acm.org/publications/policies/RightsResponsibilities.

Committee on Publication Ethics (COPE): http://publicationethics.org/.

U.S. Government Office of Research Integrity: http://ori.dhhs.gov/.

American Mathematical Society (AMS) Ethical Guidelines: http://www.ams.org/secretary/ethics.html.

Society for Industrial and Applied Mathematics (SIAM) Authorial Integrity in Scientific Publication: http://www.siam.org/journals/plagiarism.php.

Palis Awarded Balzan Prize

Jacob Palis

JACOB PALIS of the Instituto de Matemática Pura e Aplicada (IMPA), Rio de Janeiro, Brazil, has been awarded the International Balzan Prize for his "fundamental contributions to the mathematical theory of dynamical systems". The Balzan Prizes are awarded to scholars, artists, and scientists who have distinguished themselves in their fields on an international level. The cash prize is 750,000 Swiss francs (approximately US$740,000). Palis will receive the prize from the president of the Italian Republic during a ceremony to be held in Rome on November 19, 2010.

The Work of Jacob Palis

The Balzan Foundation provided the following information about the work of Jacob Palis.

The theory of dynamical systems was originated by the great mathematician H. Poincaré as a qualitative study of differential equations. For more than forty years Jacob Palis has made outstanding contributions to this area of mathematics. Soon after finishing his Ph.D. Palis became one of the most important contributors to a program that aimed at describing almost all dynamical systems.

In the 1970s, following in the wake of Smale, Palis was one of the major figures in developing the theory of hyperbolic dynamics and structural stability. At the beginning of the 1980s he initiated, with Newhouse and Takens, what has become one of the most active fields in dynamics: the interplay between homoclinic and heteroclinic bifurcations and chaos. One of his most important contributions was to reveal, in this context, the fundamental role played by fractal dimensions in connection with the frequency of dynamical bifurcations.

Beyond these remarkable achievements, Jacob Palis recently proposed a comprehensive set of conjectures that together form an ambitious program to understand the typical behavior of dynamical systems and, in particular, chaotic systems. This program is currently generating immense scientific activity. Recently, in conjunction with Jean-Christophe Yoccoz, Palis has been studying the formation of "nonuniformly hyperbolic horseshoes" in the unfolding of homoclinic and heteroclinic tangencies.

Not only has Jacob Palis made lasting and influential contributions to mathematics, but also his record as an advisor is impressive, having significantly influenced at least two generations of mathematicians. Thus he is recognized as the father of the Latin American school of mathematics in dynamical systems and one of the most important scientific personalities on the continent.

Biographical Sketch

Jacob Palis was born in Uberaba, Minas Gerais, Brazil, on March 15, 1940, and is a Brazilian citizen. He was educated at the Federal University of Rio de Janeiro and at the University of California at Berkeley, where he earned his M.Sc. in 1966 and his Ph.D. in 1967. In 1973 he held a Guggenheim Foundation postdoctoral fellowship at the University of California at Berkeley. He has been full professor at the Instituto de Matemática Pura e Aplicada (IMPA), Rio de Janeiro, Brazil, since 1971. He is currently president of the Academy of Sciences for the Developing World (TWAS) and president of the Brazilian Academy of Sciences.

Other prizes he has received include the Prize of the Academy of Sciences for the Developing World (TWAS) (1988), the National Prize for Science and Technology of Brazil (1990), the InterAmerican Prize for Science of the Organization of the American States (1995), and the Trieste Science Prize in Mathematics (2006).

He is a member of many professional societies, including the Brazilian Academy of Sciences,

the Indian Academy of Sciences, the Indian National Science Academy, the Chilean Academy of Sciences, the European Academy of Sciences, the Norwegian Academy of Sciences, and the Russian Academy of Sciences. He is a foreign member of the U.S. National Academy of Sciences, the Mexican Academy of Sciences, the French Academy of Sciences, the German Academy of Sciences Leopoldina, and the Accademia Nazionale dei Lincei. In 1994 he was awarded the Brazilian Grand-Croix National Order of Scientific Merit, and in 2005 he received the French Légion d'Honneur. He holds honorary degrees from the State University of Rio de Janeiro, Brazil; the University of Chile; the University of Warwick, United Kingdom; the University of Santiago de Chile; the Universidad de la Habana, Cuba; and the Universidad de Ingenieria, Peru.

His editorial activities include numerous scientific journals: *Ergodic Theory and Dynamical Systems, Nonlinearity*, the *Bulletin of the Brazilian Mathematical Society, Annales de l'Institut Henri Poincaré, Acta Applicandae Mathematicae, Chaos—Nonlinear Science,* the *Chinese Annals of Mathematics, Communications in Contemporary Mathematics, Mathematics Applied in Science and Technology*, and the *Moscow Mathematical Journal*. He has also authored more than eighty papers in major journals.

His research areas in mathematics are global stability of dynamical systems, bifurcations and fractal dimensions, and the global scenario for chaotic systems.

About the Prize

The International Eugenio Balzan Prize Foundation was established in 1956 by Lina Balzan, who had come into a considerable inheritance on the death of her father, Eugenio, and began the foundation to honor his memory. The aim of the International Balzan Prize Foundation is to promote culture, the sciences, and the most meritorious initiatives in the cause of humanity, peace, and brotherhood among peoples throughout the world. Currently, four annual awards are made: two in literature, moral sciences, and the arts; and two in the physical, mathematical, and natural sciences and medicine. The award fields vary each year and can be related to either a specific or an interdisciplinary field; they look to go beyond the traditional subjects, both in the humanities (literature, moral sciences, and the arts) and in the sciences (medicine and the physical, mathematical, and natural sciences). They give priority to innovative research. Half of the amount received by the winner of each of the four prizes must be destined for research work, preferably involving young scholars and researchers.

— From Balzan Foundation announcements

Mathematics People

Zhang Awarded 2010 SASTRA Ramanujan Prize

WEI ZHANG of Harvard University has been awarded the 2010 SASTRA Ramanujan Prize. This annual prize is awarded for outstanding contributions to areas 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 2010 SASTRA Ramanujan Prize citation reads as follows: "Wei Zhang has made far-reaching contributions by himself and in collaboration with others to a broad range of areas in mathematics, including number theory, automorphic forms, *L*-functions, trace formulas, representation theory, and algebraic geometry." We highlight some of his path-breaking contributions: In 1997, Steve Kudla constructed a family of cycles on Shimura varieties and conjectured that their generating functions are actually Siegel modular forms. The proof of this conjecture for Kudla cycles of codimension 1 is a major theorem of the Fields Medalist Borcherds. In his Ph.D. thesis, written under the direction of Shou-Wu Zhang at Columbia University, New York, Wei Zhang established conditionally, among other things, a generalization of the results of Borcherds to higher dimensions, and in that process essentially settled the Kudla conjecture. His thesis, written when he was just a second-year graduate student, also extended earlier fundamental work of Hirzebruch-Zagier and of Gross-Kohnen-Zagier. The thesis opened up major lines of research and led to significant collaboration with Xinyi Yuan and his Ph.D. advisor Shou-Wu Zhang. In the first of a series of joint papers (published in *Compositio Math* in 2009), the results of Wei Zhang's important thesis are generalized to totally real fields. In a paper on heights of CM points in Shimura varieties, Wei Zhang, along with Shou-Wu Zhang and Xinyi Yuan, establish an arithmetic analogue of a theorem of Waldspurger that connects integral periods to special values of *L*-functions. This paper, which goes well beyond all earlier work on formulas of Gross-Zagier type, will appear in the book series *Annals of Mathematical Studies*.

"Yet another outstanding contribution of Wei Zhang is conveyed in his two recent preprints—one on relative trace formulas and the Gross-Prasad conjecture and another on arithmetic fundamental lemmas. In these works he has made decisive progress on certain general conjectures related to the arithmetic intersection of Shimura varieties; in that process he has successfully transposed major techniques due to Jacquet and Rallis into an arithmetic intersection theory setting. With these two preprints and his seminal earlier work, Wei Zhang has emerged as a worldwide leader in his field."

Wei Zhang was born on July 18, 1981, in the People's Republic of China and received his bachelor's degree from Beijing University in 2004. He received his Ph.D. from Columbia University in 2009 under the supervision of Shou-Wu Zhang. He joined Harvard University as a postdoctoral fellow in 2009–2010. He currently holds the Benjamin Peirce Lectureship at Harvard. His research interests are number theory, automorphic forms, and algebraic geometry.

The 2010 SASTRA Ramanujan Prize Committee consisted of Krishnaswami Alladi (chair), Dorian Goldfeld, Christian Krattenthaler, Ken Ono, Wolfgang Schmidt, Jeffrey Vaaler, and Akshay Venkatesh. Previous recipients of the SASTRA Ramanujan Prize are Manjul Bhargava and Kannan Soundararajan (2005), Terence Tao (2006), Ben Green (2007), Akshay Venkatesh (2008), and Kathrin Bringmann (2009).

—From a SASTRA Ramanujan Prize announcement

ICIAM Prizes Awarded

The International Council for Industrial and Applied Mathematics (ICIAM) will award several prizes at its 2011 meeting in Vancouver, British Columbia.

Emmanuel J. Candès of Stanford University has been awarded the Collatz Prize for his "exemplary work in numerical solution of wave propagation problems and compressive sensing, in addition to anisotropic extensions of wavelets." The Collatz Prize recognizes individual scientists under age forty-two worldwide for outstanding research work in industrial and applied mathematics. It carries a cash award of US$1,000.

Alexandre J. Chorin of the University of California, Berkeley, and the Lawrence Berkeley National Laboratory was awarded the Lagrange Prize for his "fundamental and original contributions to applied mathematics, fluid mechanics, statistical mechanics, and turbulence modeling." The Lagrange Prize recognizes mathematicians for career-long contributions to applied mathematics and carries a cash award of US$3,000.

Vladimir Rokhlin of Yale University received the Maxwell Prize "for his research in the area of fast multipole methods. His research has revolutionized the field of numerical electromagnetism for radar and molecular dynamics for chemistry, among others." The Maxwell Prize is awarded for demonstrated originality in applied mathematics and carries a cash award of US$1,000.

James A. Sethian of the University of California, Berkeley, and the Lawrence Berkeley National Laboratory received the Pioneer Prize "for his research on areas such as medical imaging and geophysics, which have been fueled by fundamental methods and algorithms" that he pioneered. The Pioneer Prize was established for pioneering work introducing applied mathematical methods and scientific computing techniques to an industrial problem area or a new scientific field of applications. It carries a cash award of US$1,000.

Edward Lungu of the University of Botswana was awarded the Su Buchin Prize "for the development of mathematical models for problems related to Africa and for his work in developing teaching, research, and organizational structures for applied mathematics in Southern Africa." The Su Buchin Prize provides international recognition of outstanding contributions in applied mathematics made by individuals to emerging economies and in human development, particularly at the economic and cultural levels in developing countries. It carries a cash award of US$1,000.

—From an ICIAM announcement

Young Awarded CMS Doctoral Prize

Benjamin Young has been awarded the 2010 Doctoral Prize of the Canadian Mathematical Society (CMS). In his thesis work, Young proved several outstanding conjectures concerning "box counting". He was able to count the number of ways in which colored boxes can be piled in a corner with various predetermined color schemes. The answers came in the form of generating functions in several variables. Young received his Ph.D. in mathematics from the University of British Columbia and is currently participating in the program of Random Matrix Theory, Interacting Particle Systems and Integrable Systems at the Mathematical Sciences Research Institute (MSRI) in Berkeley, California. He will subsequently attend KTH Royal Institute of Technology in Stockholm for a Wallenberg Postdoctoral Fellowship. The CMS Doctoral Prize recognizes outstanding performance by a doctoral student.

—From a CMS announcement

Australian Mathematical Society Prizes

The Australian Mathematical Society has awarded its two major annual prizes. Kate Smith-Miles of Monash University was awarded the Australian Mathematical Society Medal, and Peter Hall of the University of Melbourne was honored with the George Szekeres Medal. The prize certificate for Smith-Miles reads: "Kate Smith-Miles is internationally known for interdisciplinary applications of mathematics, characterized by their extraordinary breadth, as well as an exceptional attention to rigour. She is especially respected for her influential studies of neural networks, chaotic systems, optimisation problems, and machine learning." The prize certificate for Hall reads: "Peter Hall's research has produced a wide variety of significant and influential results in probability theory and statistics. He has focused particularly on nonparametric statistics, especially resampling methods, extreme value techniques, fractal-based methodologies, and function estimation. His development of a theoretical basis for the bootstrap is arguably his most important contribution. Earlier in his career he did important work in probability, for example, on martingale methods, convergence rates, and percolation. He has provided considerable leadership to the profession through his work for professional societies, both in Australia and abroad, and as an editor. He has also taken up vigorously the cause of improving the lot of the mathematical sciences in Australia."

—From an Australian Mathematical Society announcement

Royal Society of Canada Elections

The Royal Society of Canada has elected three new fellows and one foreign fellow who work in the mathematical sciences. The new fellows are Richard Cleve, University of Waterloo; Ian Goulden, University of Waterloo; and David Thomson, Queen's University. David Cox of Oxford University was elected a foreign fellow.

—From a Royal Society 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 2011. Please refer to the program announcement or contact the program director for more information.

December 15, 2010 (full proposal): Computational Mathematics

January 2, 2011 (letter of intent): Industry/University Cooperative Research Centers Program (I/UCRC)

January 10, 2011 (full proposal): Algorithms for Threat Detection (ATD)

January 13, 2011 (full proposal): Mathematical Biology

January 27, 2011 (full proposal): Scientific Computing Research Environments for the Mathematical Sciences (SCREMS)

February 4, 2011 (full proposal): Mathematical Sciences Research Institutes

February 10, 2011 (full proposal): Interdisciplinary Training for Undergraduates in Biological and Mathematical Sciences (UBM)

March 6, 2011 (full proposal): University/Industry Cooperative Research Centers Program (I/UCRC)

June 3, 2011 (full proposal): Research Experiences for Undergraduates (REU)

June 15, 2011 (full proposal): Workforce Program in the Mathematical Sciences

June 26, 2011 (letter of intent): Industry/University Cooperative Research Centers Program (I/UCRC)

August 24, 2011 (full proposal): Research Experiences for Undergraduates (REU)

September 13, 2011 (full proposal): International Research Fellowship Program

September 26, 2011 (full proposal): Industry/University Cooperative Research Centers Program (I/UCRC)

October 3, 2011 (letter of intent): ADVANCE: Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers

October 3, 2011 (full proposal): Joint DMS/NIGMS Initiative to Support Research at the Interface of the Biological and Mathematical Sciences (DMS/NIGMS)

October 4, 2011 (full proposal): Algebra and Number Theory; Analysis; Combinatorics; 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

NSF Algorithms for Threat Detection

The Division of Mathematical Sciences (DMS) at the National Science Foundation (NSF) has formed a partnership with the Defense Threat Reduction Agency (DTRA) to develop the next generation of mathematical and statistical algorithms for the detection of chemical and biological threats. Proposals are solicited from the mathematical sciences community in two main areas: mathematical and statistical techniques for genomics and mathematical and statistical techniques for the analysis of data from sensor systems. The deadline for full proposals is **January 10, 2011**. For more details, see `http://www.nsf.gov/pubs/2010/nsf10540/nsf10540.htm`.

—From an NSF announcement

National Academies Research Associateship Programs

The Policy and Global Affairs Division of the National Academies is sponsoring the 2011 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 100 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 2011 review is **February 1, 2011**. Materials for the May review are due **May 1, 2011**; for the August review, **August 1, 2011**; and for the November review, **November 1, 2011**. Note that not all sponsors participate in all four reviews. Applicants should refer to the specific information for the laboratory to which they are applying.

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 Mathematical Society provides support each year for a graduate student in the mathematical sciences to participate in the American Association for the Advancement of Science (AAAS) Mass Media Science and Engineering Fellows 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*, *Milwaukee Journal Sentinel, Time* magazine, and WOSU-AM Radio.

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 2011 is **January 15, 2011**. Further information about the fellowship program and application procedures is available online at http://www.aaas.org/programs/education/MassMedia; 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/policy/government/fellow-awards/fellow-awards 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

CAIMS/PIMS Early Career Award

The Canadian Applied and Industrial Mathematics Society (CAIMS) and the Pacific Institute for Mathematical Sciences (PIMS) sponsor the Early Career Award in Applied Mathematics to recognize exceptional research in any branch of applied mathematics, interpreted broadly. The nominee's research should have been conducted primarily in Canada or in affiliation with a Canadian university. The prize is to be awarded every year to a researcher less than ten years past the date of Ph.D. at the time of nomination.

The award consists of a cash prize of C$1,000 and a commemorative plaque presented at the CAIMS Annual Meeting. The recipient will be invited to deliver a plenary lecture at the CAIMS Annual Meeting in the year of the award. A travel allowance will be provided. The deadline for nominations is **January 31, 2011**. For more information see http://www.pims.math.ca/pims-glance/prizes-awards.

—From a PIMS announcement

AMS von Neumann Symposium

The AMS is sponsoring the von Neumann Symposium: Multimodel and Multialgorithm Coupling for Multiscale Problems to be held in Snowbird, Utah, July 4–7, 2011. Plenary talks will be given by Aleksandar Donev, Courant Institute, New York University; Weinan E, Princeton University; Nicolas Hadjiconstantinou, Massachusetts Institute of Technology; George Karniadakis, Brown University; Rupert Klein, Freie Universität, Berlin; Petros Koumoutsakos, ETH Zurich; Tinsley Oden, University of Texas at Austin; and George Oster, University of California, Berkeley. There will also be a series of shorter presentations. The organizers are John B. Bell (chair), Alejandro L. Garcia, and Francis J. Alexander.

Participation in this program is limited. Visit www.math-programs.org to apply for an invitation and to request limited support funds. All requests will be reviewed and considered by the organizing committee. The application deadline is **February 1, 2011**. For more information, see www.ams.org/meetings/amsconf/symposia/symposia-2011.

—AMS announcement

PIMS IGTC Fellowship for 2011–2012

The PIMS International Graduate Training Centre in Mathematical Biology invites applicants for the IGTC fellowship for the 2011–2012 academic year. Fellowships are worth up to C$10,000 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 program. 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 Program and application process can be found at: `http://www.pims.math.ca/scientific/graduate-training-igtc/mathematical-biology`. If you have further questions, please contact the IGTC coordinator, Maryna Yaskina (`igtcmathbio@math.ualberta.ca`) or Program Director Mark Lewis (`mlewis@math.ualberta.ca`).

Application deadline is **February 8, 2011**.

—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 2010 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 are 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 2010, the names of the students receiving Trjitzinsky awards, and brief biographical sketches of the students.

California State University, Bakersfield: VIANEY CAROLINA LEOS BARAJAS. Barajas was born in Mexico and came to the United States when she was one year old. After graduating from high school, she studied for two years in Madrid, Spain. She is president of the math club at California State and is minoring in computer science. She is currently pursuing research in nonparametric regression. She is a tutor in the Math Tutoring Center and is a Louis Stokes Alliance for Minority Participation scholar. She also works for the Migrant Education Program in the Bakersfield City School District. She intends to pursue graduate studies in applied statistics.

University of Cincinnati: LANGSTON W. JOINER. Joiner is pursuing an undergraduate degree in mathematics and performed excellently in his first year at the University of Cincinnati. He plans to pursue a career in actuarial science. He is a volunteer and advocate for people with developmental disabilities in the Cincinnati community and is active in his church, in which he serves as a mentor to the youth group.

Emory University: MICHELLE CHU. Chu is a senior with a GPA of 3.94 who is actively engaged in mathematical research. During the summer of 2010 she conducted research in physical knot theory at the Williams College SMALL Research Experience for Undergraduates (REU); she is currently writing a paper based on her project. She is an active member of the Gamma Phi Beta sorority and currently serves as president of the Reformed University Fellowship at Emory.

Kansas State University: PERLA SALAZAR. Salazar is a first-generation college student who was born in Mexico. She graduated with honors from Dodge City Community College after receiving a presidential scholarship for her studies and then transferred to Kansas State. With help from the Bridges Program of the National Institutes of

Health and from the Developing Scholars Program at Kansas State, she has performed undergraduate research and is currently a McNair Scholar, which will allow her to continue research during the summer. She plans to attend graduate school in mathematics.

University of Oklahoma: DANA C. HAYMON. Haymon is a mathematics major with a minor in history and is a member of the National Society of Scholars. She has a GPA of 3.93 and is a hard and dedicated worker. She is also an experienced musician. She hopes to work in the defense industry and to encourage other young women through her example to enter the field of mathematics

Rochester Institute of Technology: JAMES S. WRATTEN JR. Wratten is a senior majoring in applied mathematics and has a 4.0 GPA. In the spring of 2010 he studied in Hungary under the auspices of the Budapest Seminars in Mathematics program. He has served as a teaching assistant and tutor at Rochester, and he attended the Gene Drive Systems REU program at Texas A&M University during the summer after his freshman year. During the past two summers he has worked and tutored mathematics at two orphanage schools in India. He plans to study for a Ph.D. in mathematics.

York College: BEBI Z. G. RAJENDRA. Rajendra was born in Guyana, the oldest of nine children. She began teaching directly out of high school in order to help support her family. She is now a mother of three studying for a bachelor's degree in mathematics. While still living in Guyana, she completed the Edexcel GCE A-Level mathematics program, which solidified her desire and determination to seek higher education. She intends to pursue a teaching career in mathematics.

—Elaine Kehoe

AMS Hosts Congressional Briefing

On October 12, 2010, the AMS hosted a briefing on Capitol Hill titled "The Gulf Oil Spill: How Can We Protect Our Beaches in the Future?" Andrea Bertozzi, professor of mathematics at UCLA, delivered the address to Congressional representatives. She discussed how scientific modeling and basic research in mathematics is helping in the understanding of the impact of this major environmental problem. Her research examines the dynamics of oil-sand-water mixtures in an effort to provide more efficient cleanup and protection methods for oil spills such as the one that occurred in the Gulf of Mexico this year.

Andrea Bertozzi, UCLA, speaks to Congressional representatives at the AMS Congressional briefing in Washington, DC.

—AMS announcement

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 `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 2010 was Doron Zeilberger of Rutgers University, who delivered a lecture titled "$3x+1$" at the Spring Southeastern Section Meeting at the University of Kentucky in Lexington, Kentucky, on March 27, 2010.

—AMS announcement

From the AMS Public Awareness Office

The AMS hosted a hands-on exhibit, George Hart's "Sculpture Barn Raising", at the USA Science and Engineering Festival (USASEF), held in Washington, DC, October 23–24. Visitors of all ages stopped by to help build the modular equilateral triangles. The completed sculpture allows one to see a variety of patterns of tunnels from various directions. After the festival the sculpture was delivered to Towson University to be put on permanent display. Hart describes the sculpture in detail at `http://www.georgehart.com/DC`, and this work and others by Hart may be sent as e-postcards from Mathematical Imagery at `http://www.ams.org/mathimagery`. The USASEF included hundreds of exhibitors—the MAA, SIAM, other scientific societies, companies, government agencies, and laboratories—and drew thousands of visitors. Read more about USASEF at `http://www.usasciencefestival.org/`.

AMS booth at the USA Science and Engineering Fair.

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

My Summer at *The Oregonian*

Each year the AMS sponsors a fellow to participate in the Mass Media Fellowship program of the American Association for the Advancement of Science (AAAS). This program places science and mathematics graduate students in summer internships at media outlets. In the piece below, the 2010 Fellow, Benjamin Pittman-Polletta of the University of Arizona, Tuscon, describes his experiences during his fellowship at The Oregonian. *For information about applying for the fellowship, see the "Mathematics Opportunities" section in this issue of the* Notices *or visit the website* `http://www.ams.org/programs/ams-fellowships`. *The application deadline is* **January 15, 2011**.

When I got the news that the AAAS wanted to ship me to Portland, Oregon, to write for *The Oregonian*, a world-class paper covering the Pacific Northwest, I was more than a little hesitant. Preparing writing samples for my application over a grueling and sleepless weekend was a vivid reminder of just how difficult writing can be. At the end of a six-year quest for a Ph.D., I wanted a break and time to look for a job. I was wary of traveling out of my comfort zone and across the country for a ten-week crash course in a new profession.

But part of me thought that a dose of contact with the world outside mathematics would be a balm for my dissertation-weary soul. As a liaison between journalism and science, I looked forward to learning not only about the culture of journalism but also what it feels like to be on the outside of science peering in. And while I knew there would be hard work, I hoped that the reward of making an immediate impact on other people would be worth it.

Because *The Oregonian* is primarily a local paper, only one of my stories was about an article appearing in a peer-reviewed journal. This was a blessing, because I learned that there are many ways to get science into the news even without a study or a researcher in sight.

For example, my most mathematical article was about the weather. It started with me wondering, "What is the hottest day of the year?" and ended with an article about Oregon weather. Published on August 8, historically the hottest day of the year in Portland, it contains some basic probability and statistics even if it only alludes to the differential equation that answers my question.[1]

And while I was lucky enough to cover an evolutionary biology conference, Evolution 2010, I did not interview any conference participants about their research. Instead, I wrote a blog post about the kickoff talk and then published a number of short interviews with participants about the hottest trends in evolutionary biology.

Writing for a local paper also gave me the time and space to write a number of articles about big, complex issues. My first story, inspired by a research paper upgrading estimates of American food waste to 40 percent of our food supply, touched on the obesity epidemic, agricultural policy, and American eating and consumption habits, in addition to food waste and food rescue in Portland.

Putting together all the pieces of this story was a challenge. One of the hurdles I had to jump was my own reluctance to draw a conclusion or state an opinion—evidence, I think, of my mathematical training: there is a taboo in mathematical culture against interpreting results too broadly. I was tempted at many points to say, "It's complicated!"—to throw up my hands, lay out the evidence, and let readers draw their own conclusions.

But complications have a hard time holding readers' attention. The responsibility of the journalist is to pick out the best-quality, most relevant information and deliver it to the reader in the most streamlined package possible. And this has to happen after researching a topic for as short a time as a week or a day!

This is in sharp contrast to the painstaking, time-consuming way scientists build expertise and draw conclusions. Many scientists I interviewed seemed genuinely afraid of talking about subjects "outside (their) area of expertise." As a researcher, I understand the importance of consulting the main expert—and not just anyone in your field—on a topic. But as a journalist representing laypeople, I found this academic turf minding to be alienating and confusing. There I was talking to evolutionary biologists at Evolution 2010 about evolutionary biology, and they were telling me that they weren't the experts!

One of the ways journalists make up for the short amount of time they have to develop each article is to start with a strong idea of where the article is going before they ever start reporting or writing. Decisions about the arc of a story and the larger themes that will run through it happen before the first phone call or trip is made. This is a technique that can also be fruitfully applied in mathematical research, provided you are flexible about how your "story" ends up.

Another piece of advice I have used in both journalism and research is the advice I was given about interviewing: play dumb. Even if you know what your source is talking about, don't show it. You will be sure to get the facts right, and your source may even explain things in a way your readers can understand. Then you can quote her and make her sound good, something she will appreciate far more than being impressed by your knowledge of her field. It makes perfect sense, but it is another way that journalists and scientists differ. I spent far too much time in graduate school playing smart and feeling dumb rather than the other way around.

Not surprisingly, the different pressures scientists and journalists feel can result in miscommunications and frustrations when they interact. Hoping to write an article about one of the talks at Evolution 2010, I attempted to interview a woman who spoke about predicting flu virus evolution. When I asked her a question after her presentation, she told me impatiently that I would have to take her freshman biology class if I was going to understand the answer. Before she stormed out, she shared

[1] *In fact, the "easy" answer to the question is August 4. A simplified equation for the temperature T of a body being heated by a source of sinusoidally oscillating intensity is $dT/dt=T(t)-\sin(t)$. The solution to this equation is $T(t)=\cos(2t)$, which has a peak 1/8 of a cycle behind the peak heat intensity. Thus, three in the afternoon should be the hottest time of day, and August 4 should be the hottest day of the year.*

the opinion that journalists want easy answers even when there are none and are not above distorting the truth to get them.

In my experience, journalists are very careful about getting right the details that are important to them. Fact checking takes on a new urgency when the facts are about a real person and destined for the morning paper. And journalists, like mathematicians, are expert at leaving just enough detail out of a statement to make it correct. For the most part, their sources and even their readers are appreciative of their efforts.

This was really my favorite part of the summer: the tangible sense I got that I was making a real difference in peoples' lives, whether by sharing their stories and their passions, by shedding light on new problems, or even occasionally by making a point or driving home a message. My article on food waste was basically about the dysfunctional food production and distribution system, and it started an online conversation about food purchasing and storage habits. My interviews from Evolution 2010 highlighted the fact that evolution has become a predictive science, providing overwhelming evidence of the theory's explanatory power. And one of my stories was not about math or science at all. Instead, it was about the product stewardship movement, which attempts to hold manufacturers responsible for helping to dispose of their products at the end of those products' useful life.

We live in a time when accurate and rational voices are sorely needed. One of the best reasons for mathematicians and scientists to reach out to the larger community is to bring whatever expertise we have in whatever capacity possible to bear on the problems facing our community and our country.

If the job market for mathematicians is bad, that for journalists is worse. The newspaper industry is in peril and, consequently, in flux. *The Oregonian* recently nixed its science section, and the number of dedicated science journalists at the paper and at large is dwindling. If this trend continues, the responsibility for putting science and math in the media will fall increasingly on the shoulders of mathematicians and scientists. This will require us to become less afraid of being wrong or appearing stupid—less afraid of leaving our comfort zone—and more afraid of the unchecked spread of misinformation, because there are always people willing to discard the facts or pretend to expertise if it serves their interests.

—Benjamin Pittman-Polletta

Deaths of AMS Members

EMIL R. BRANDLI, of Zurich, Switzerland, died on January 30, 2010. Born on October 24, 1916, he was a member of the Society for 39 years.

A. JOHN COLEMAN, of Ontario, Canada, died on September 30, 2010. Born on May 20, 1918, he was a member of the Society for 68 years.

HERBERT B. ENDERTON, professor at the University of California Los Angeles, died on October 20, 2010. Born on April 15, 1936, he was a member of the Society for 49 years.

JOE W. JENKINS, from the National Science Foundation in Arlington, VA, died on October 21, 2010. Born on October 17, 1941, he was a member of the Society for 44 years.

NIGEL KALTON, of Columbia, Missouri, died on August 31, 2010. Born on June 20, 1946, he was a member of the Society for 32 years.

RICHARD MICHAEL KANE, University of Western Ontario, died on October 1, 2010. Born on June 27, 1944, he was a member of the Society for 19 years.

ROBERT J. LEVIT, of Oakland, California, died on May 13, 2010. Born on August 17, 1916, he was a member of the Society for 69 years.

WILLIAM S. MAHAVIER, professor emeritus, Emory University, died on October 8, 2010. Born on July 30, 1930, he was a member of the Society for 55 years.

RICHARD J. MAHER, professor, Loyola University, died on September 14, 2010. Born on July 13, 1943, he was a member of the Society for 39 years.

J. E. MARSDEN, California Institute of Technology, Pasadena, California, died on September 21, 2010. Born on August 17, 1942, he was a member of the Society for 39 years.

G. C. MILOSLAVSKY, of Staten Island, New York, died on July 1, 2010. Born on November 1, 1911, he was a member of the Society for 62 years.

REINHARD M. OLIVIER, University of Bonn, Germany, died on September 13, 2010. Born on October 3, 1933, he was a member of the Society for 40 years.

JOHN RAUSEN, of New York, New York, died on October 31, 2010. Born on February 3, 1923, he was a member of the Society for 61 years.

CONSTANCE REID, of San Francisco, California, died on October 13, 2010. Born on January 3, 1918, she was a member of the Society for 10 years.

JOEL E. SCHNEIDER, of New York, New York, died on September 12, 2004. Born on April 8, 1943, he was a member of the Society for 38 years.

MICHAEL S. SKAFF, of Michigan, died on June 18, 2010. Born on June 21, 1936, he was a member of the Society for 50 years.

S. LEIF SVENSSON, of Sweden, died on February 13, 2010. Born on December 18, 1943, he was a member of the Society for 17 years.

JOSEPH J. TRIOLO, of Pennsylvania, died on January 20, 2010. Born on December 4, 1942, he was a member of the Society for 16 years.

RONSON J. WARNE, of Birmingham, Alabama, died on September 12, 2010. Born on June 14, 1930, he was a member of the Society for 51 years.

DAVID A. WOODWARD, of Fair Oaks, California, died on July 7, 2010. Born on November 23, 1932, he was a member of the Society for 50 years.

DAVID M. YOUNG, of Texas, died on December 21, 2008. Born on October 20, 1923, he was a member of the Society for 59 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, 2010: Applications for Fields Institute Postdoctoral Fellowships. See www.fields.utoronto.ca/proposals/postdoc.html.

December 15, 2010: Abstracts for contributed papers for ICIAM. See the website http://www.iciam2011.com/.

December 15, 2010: Applications for PIMS Postdoctoral Fellowships. See http://www.pims.math.ca/scientific/postdoctoral.

December 16, 2010: Applications for Mathematical Biosciences Institute (MBI) Early Career Awards and Postdoctoral Fellowships. See http://mbi.osu.edu.

December 17, 2010: Applications for Department of Defense (DoD) National Defense Science and Engineering Graduate (NDSEG) Fellowships. See http://ndseg.asee.org/.

January 10, 2011: Full proposals for NSF Algorithms for Threat Detection program. See "Mathematics Opportunities" in this issue.

January 10, 2011: Applications for American Association of University Women (AAUW) Selected Professions Fellowships. 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: 319/337-1716, ext. 60; email: aauw@act.org.

January 15, 2011: Applications for Jefferson Fellows (JSF) program. See http://sites.nationalacademies.org/PGA/Jefferson/PGA_046612, , email jsf@nas.edu, or telephone 202-334-2643.

January 15, 2011: Applications for AMS-AAAS Mass Media Summer Fellowships. See "Mathematics Opportunities" in this issue.

January 21, 2011: Applications for Math for America Foundation (MfA) Fellowship Program. See http://www.mathforamerica.org/.

January 27, 2011: Proposals for NSF Computing Equipment and Instrumentation Programs (SCREMS). See http://www.nsf.gov/pubs/2007/nsf07502/nsf07502.htm.

Where to Find It

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

AMS Bylaws—*November 2009, p. 1320*

AMS Email Addresses—*February 2010, p. 268*

AMS Ethical Guidelines—*June/July 2006, p. 701*

AMS Officers 2008 and 2009 Updates—*May 2010, p. 670*

AMS Officers and Committee Members—*October 2010, p. 1152*

Conference Board of the Mathematical Sciences—*September 2010, p. 1009*

IMU Executive Committee—*December 2010, page 1488*

Information for *Notices* Authors—*June/July 2009, p. 749*

Mathematics Research Institutes Contact Information—*August 2009, p. 854*

National Science Board—*January 2011, p. 77*

New Journals for 2008—*June/July 2009, p. 751*

NRC Board on Mathematical Sciences and Their Applications—*March 2010, p. 423*

NRC Mathematical Sciences Education Board—*April 2010, p. 541*

NSF Mathematical and Physical Sciences Advisory Committee—*February 2010, p. 272*

Program Officers for Federal Funding Agencies—*October 2010, p. 1148 (DoD, DoE); December 2007, p. 1359 (NSF); December 2010, page 1488 (NSF Mathematics Education)*

Program Officers for NSF Division of Mathematical Sciences—*November 2010, p. 1328*

January 31, 2011: Nominations for CAIMS/PIMS Early Career Award. See "Mathematics Opportunities" in this issue.

February 1, 2011: Applications for February review for National Academies Research Associateship Programs. See "Mathematics Opportunities" in this issue.

February 1, 2011: Applications for AWM Mentoring Travel Grants. See http://www.awm-math.org/travelgrants.html#standard.

February 1, 2011: Applications for AWM Travel Grants. See http://www.awm-math.org/travelgrants.html#standard.

February 1, 2011: Applications for AMS von Neumann Symposium. See "Mathematics Opportunities" in this issue.

February 4, 2011: Full proposals for NSF Mathematical Sciences Research Institutes. See http://www.nsf.gov/pubs/2010/nsf10592/nsf10592.htm?WT.mc_id=USNSF_25&WT.mc_ev=click.

February 15, 2011: Applications for AMS Congressional Fellowship. See http://www.ams.org/programs/ams-fellowships/ams-aaas/ams-aaas-congressional-fellowship or contact the AMS Washington Office at 202-588-1100, email: amsdc@ams.org.

February 21, 2011: Applications for EDGE for Women Summer Program. See http://www.edgeforwomenorg/?page_id=5.

February 27, 2011: Entries for Association for Women in Mathematics (AWM) Essay Contest. See http://www.awm-math.org/biographies/contest.html.

May 1, 2011: Applications for May review for National Academies Research Associateship Programs. See "Mathematics Opportunities" in this issue.

May 1, 2011: Applications for National Academies Christine Mirzayan Graduate Fellowship Program for fall 2011. See http://sites.nationalacademies.org/PGA/policyfellows/index.htm.

May 1, 2011: Applications for AWM Travel Grants. See http://www.awm-math.org/travelgrants.html#standard.

August 1, 2011: Applications for August review for National Academies Research Associateship Programs. See "Mathematics Opportunities" in this issue.

October 1, 2011: Applications for AWM Travel Grants. See http://www.awm-math.org/travelgrants.html#standard.

October 1, 2011: Nominations for the 2012 Emanuel and Carol Parzen Prize. Contact Thomas Wehrly, Department of Statistics, 3143 TAMU, Texas A&M University, College Station, Texas 77843-3143.

November 1, 2011: Applications for November review for National Academies Research Associateship Programs. 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

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 (Chair)
President Emeritus
Texas A&M University

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

France A. Cordova
President
Purdue University

Patricia D. Galloway (Vice Chair)
Chief Executive Officer
Pegasus Global Holding, Inc.

José-Marie Griffiths
Vice President for Academic Affairs
Bryant University

Esin Gulari (Vice Chair)
Dean of Engineering and Science
Clemson University

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

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

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.

Apocalypse When?: Calculating How Long the Human Race Will Survive, by Willard Wells. Springer Praxis, June 2009. ISBN-13:978-03870-983-64.

**The Best Writing on Mathematics: 2010,* edited by Mircea Pitici. Princeton University Press, December 2010. ISBN-13: 978-06911-484-10.

Bright Boys: The Making of Information Technology, by Tom Green. A K Peters, April 2010. ISBN-13: 978-1-56881-476-6.

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: 978-0-691-13493-2. (Reviewed June/July 2010.)

The Cult of Statistical Significance: How the Standard Error Costs Us Jobs, Justice, and Lives, by Stephen T. Ziliak and Deirdre N. McCloskey, University of Michigan Press, February 2008. ISBN-13: 978-04720-500-79. (Reviewed October 2010.)

Duel at Dawn: Heroes, Martyrs, and the Rise of Modern Mathematics, by Amir Alexander. Harvard University Press, April 2010. ISBN-13: 978-06740-466-10. (Reviewed November 2010.)

Euler's Gem: The Polyhedron Formula and the Birth of Topology, by David S. Richeson. Princeton University Press, September 2008. ISBN-13: 97-80691-1267-77. (Reviewed December 2010.)

Here's Looking at Euclid: A Surprising Excursion through the Astonishing World of Math, by Alex Bellos. Free Press, June 2010. ISBN-13: 978-14165-882-52.

The Housekeeper and the Professor, by Yoko Ogawa. Picador, February 2009. ISBN-13: 978-03124-278-01. (Reviewed May 2010.)

How to Read Historical Mathematics, by Benjamin Wardhaugh. Princeton University Press, March 2010. ISBN-13: 978-06911-401-48.

Isaac Newton on Mathematical Certainty and Method, by Niccolò Guicciardini. MIT Press, October 2009. ISBN-13: 978-02620-131-78.

Logicomix: An Epic Search for Truth, by Apostolos Doxiadis and Christos Papadimitriou. Bloomsbury USA, September 2009. ISBN-13: 978-15969-145-20. (Reviewed December 2010.)

**The Math Book: From Pythagoras to the 57th Dimension, 250 Milestones in the History of Mathematics*, by Clifford A. Pickover. Sterling, September 2009. ISBN-13: 978-14027-579-69.

Mathematicians: An Outer View of the Inner World, by Mariana Cook. Princeton University Press, June 2009. ISBN-13: 978-0-691-13951-7. (Reviewed August 2010.)

Mathematicians Fleeing from Nazi Germany: Individual Fates and Global Impact, by Reinhard Siegmund-Schultze. Princeton University Press, July 2009. ISBN-13: 978-0-691-14041-4. (Reviewed November 2010.)

Mathematics in Ancient Iraq: A Social History, by Eleanor Robson. Princeton University Press, August 2008. ISBN-13: 978-06910-918-22. (Reviewed March 2010.)

Mathematics in India, by Kim Plofker. Princeton University Press, January 2009. ISBN-13: 978-06911-206-76. (Reviewed March 2010.)

A Motif of Mathematics: History and Application of the Mediant and the Farey Sequence, by Scott B. Guthery. Docent Press, September 2010. ISBN-13 978-4538-105-76.

Mrs. Perkins's Electric Quilt: And Other Intriguing Stories of Mathematical Physics, Paul J. Nahin, Princeton University Press, August 2009. ISBN-13: 978-06911-354-03.

Naming Infinity: A True Story of Religious Mysticism and Mathematical Creativity, by Loren Graham and Jean-Michel Kantor. Belknap Press of Harvard University Press, March 2009. ISBN-13: 978-06740-329-34.

Nonsense on Stilts: How to Tell Science from Bunk, by Massimo Pigliucci. University of Chicago Press, May 2010. ISBN-13: 978-02266-678-67.

Numbers Rule: The Vexing Mathematics of Democracy, from Plato to the Present, by George G. Szpiro. Princeton University Press, April 2010. ISBN-13: 978-06911-399-44. (Reviewed in this issue.)

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. Emblem Editions, April 2010. ISBN-13: 978-07710-169-74.

Perfect Rigor: A Genius and the Mathematical Breakthrough of the Century, by Masha Gessen. Houghton Mifflin Harcourt, November 2009. ISBN-13: 978-01510-140-64. (Reviewed in this issue.)

Pioneering Women in American Mathematics: The Pre-1940 Ph.D.'s, by Judy Green and Jeanne LaDuke. AMS, December 2008. ISBN-13:978-08218-4376-5.

Plato's Ghost: The Modernist Transformation of Mathematics, by Jeremy Gray. Princeton University Press, September 2008. ISBN-13: 978-06911-361-03. (Reviewed February 2010.)

Probabilities: The Little Numbers That Rule Our Lives, by Peter Olofsson. Wiley, March 2010. ISBN-13: 978-04706-244-56.

Proofs from THE BOOK, by Martin Aigner and Günter Ziegler. Expanded fourth edition, Springer, October 2009. ISBN-13: 978-3-642-00855-9. (Previous edition reviewed August 1999.)

Pythagoras' Revenge: A Mathematical Mystery, by Arturo Sangalli. Princeton University Press, May 2009. ISBN-13: 978-06910-495-57. (Reviewed May 2010.)

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

Roger Boscovich, by Radoslav Dimitric (Serbian). Helios Publishing Company, September 2006. ISBN-13: 978-09788-256-21.

The Shape of Inner Space: String Theory and the Geometry of the Universe's Hidden Dimensions, by Shing-Tung Yau (with Steve Nadis). Basic Books, September 2010. ISBN-13: 978-04650-202-32.

The Solitude of Prime Numbers, by Paolo Giordano. Pamela Dorman Books, March 2010. ISBN-13: 978-06700-214-82. (Reviewed September 2010.)

Solving Mathematical Problems: A Personal Perspective, by Terence Tao. Oxford University Press, September 2006. ISBN-13: 978-0-199-20560-8. (Reviewed February 2010.)

The Strangest Man, by Graham Farmelo. Basic Books, August 2009. ISBN-13: 978-04650-182-77.

Street-Fighting Mathematics: The Art of Educated Guessing and Opportunistic Problem Solving, by Sanjoy Mahajan. MIT Press, March 2010. ISBN-13: 978-0-262-51429-3.

Survival Guide for Outsiders: How to Protect Yourself from Politicians, Experts, and Other Insiders, by Sherman Stein. BookSurge Publishing, February 2010. ISBN-13: 978-14392-532-74.

Symmetry in Chaos: A Search for Pattern in Mathematics, Art, and Nature, by Michael Field and Martin Golubitsky. Society for Industrial and Applied Mathematics, second revised edition, May 2009. ISBN-13: 978-08987-167-26.

Teaching Statistics Using Baseball, by James Albert. Mathematical Association of America, July 2003. ISBN-13: 978-08838-572-74. (Reviewed April 2010.)

What's Luck Got to Do with It? The History, Mathematics and Psychology of The Gambler's Illusion, by Joseph Mazur. Princeton University Press, July 2010. ISBN: 978-0-691-13890-9.

AMERICAN MATHEMATICAL SOCIETY

Mathematical Reviews/MathSciNet Associate Editor

Applications are invited for a full-time position as an Associate Editor of Mathematical Reviews/MathSciNet, to commence as soon as possible after June 1, 2011. The Mathematical Reviews (MR) division of the American Mathematical Society (AMS) is located in Ann Arbor, Michigan, in a beautiful, historic building not far from the campus of the University of Michigan. The editors are employees of the AMS; they also enjoy many privileges at the University. At present, the AMS employs over seventy people including sixteen mathematical editors at Mathematical Reviews/MathSciNet. MR's mission is to develop and maintain the MR Database, from which all MR-related products are produced: MathSciNet and the journals *Mathematical Reviews* and *Current Mathematical Publications*.

An Associate Editor is responsible for a broad area of the mathematical sciences. Editors select articles and books for coverage, classify these items, determine the type of coverage, assign selected items for review to reviewers, and edit the reviews when they are returned.

An individual is sought who has mathematical breadth, with an interest in current developments, and is willing to learn new topics in pure and applied mathematics; the ability to write well in the English language is essential, and the ability to read mathematics in the principal foreign languages is an advantage. Evidence of written scholarship in mathematics is expected. The applicant should normally have several years of relevant academic (or equivalent) experience beyond the Ph.D.

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

Applications (including curriculum vitae; bibliography; and the names, addresses, phone numbers, and email addresses of at least three references) should be sent to

Dr. Graeme Fairweather
Executive Editor
Mathematical Reviews
P. O. Box 8604
Ann Arbor, MI 48107-8604

email: gxf@ams.org
Tel: (734) 996-5257
Fax: (734) 996-2916
URL: www.ams.org/mr-database

Applications received by March 18, 2011 will receive full consideration.

The American Mathematical Society is an Affirmative Action/Equal Opportunity Employer.

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American Mathematical Society
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Mathematics Calendar

Please submit conference information for the Mathematics Calendar through the Mathematics Calendar submission form at `http://www.ams.org/cgi-bin/mathcal-submit.pl`. The most comprehensive and up-to-date Mathematics Calendar information is available on the AMS website at `http://www.ams.org/mathcal/`.

January 2011

* 10–14 **ERC School on Geometric Measure Theory and Analysis in Metric Spaces**, Centro di Ricerca Matematica "Ennio De Giorgi" Palazzo Puteano, Piazza dei Cavalieri 3 56100, Pisa, Italy.
Description: The school consists of five courses organized for Ph.D. students and post-docs interested in geometric measure theory and analysis in metric spaces. Special emphasis will be put on the theory of currents, isoperimetric and filling problems, and regularity theory.
Funded: The school is funded by the ERC Advanced Grant GeMeThnES, geometric measure theory in non-Euclidean spaces.
Lecturers: Dimitri Burago (Pennsylvania State University), Robert Hardt (Rice University), Stephen Keith: TBA, Emanuele Spadaro (Hausdorff Center for Mathematics, Bonn), Robert Young (IHES, Paris).
Support: Financial support will be made available for a restricted number of participants (10–15 students) upon selection. For the selection procedure please link to: `http://www.crm.sns.it/hpp/events/event.html?id=181;sez=financial`.
Information: `http://www.crm.sns.it/hpp/events/event.html?id=181`.

* 10–14 **Nonlinear PDEs in Valparaiso**, Universidad Técnica Federico Santa María, Valparaíso, Chile.
Description: This workshop will be an opportunity to meet young and senior researchers sharing their latest results in the field of the fully nonlinear elliptic and parabolic partial differential and integral equations.
Plenary Speakers: Henri Berestycki, Luis Caffarelli, Halil Mete Soner, Louis Nirenberg, Panagiotis Souganidis, Neil Trudinger.
Organizers: Patricio Felmer, Alexander Quaas, Boyan Sirakov.
Information: `http://npdeval.dim.uchile.cl/`.

* 25–29 **International Conference "Groups and Semigroups: Interactions and Computations"**, University of Lisbon, Portugal.
Description: The aim of this conference is to deepen the existing interactions between group theory and semigroup theory. The main themes of the conference include, not exclusively: the application of permutation group theory in the theory of transformation semigroups; computational techniques in group theory and semigroup theory; and combinatorial methods in group theory and semigroup theory.
Information: `http://caul.cii.fc.ul.pt/GSConf2011`.

February 2011

* 1–5 **Centennial Congress of the Spanish Royal Mathematical Society, RSME 2011**, Palacio de Congresos, Ávila, Spain.
Plenary speakers: Antonio Córdoba (Universidad Autónoma de Madrid), Edward Frenkel (University of California at Berkeley), Francisco Gancedo, Rubio de Francia Prize 2009 (University of Chicago), Carlos Kenig (University of Chicago), Jean Francois Le Gall (Université Paris-Sud 11), Marc Noy (Universitat Politècnica de Catalunya), Joaquim Ortega Cerd'a (Universtitat de Barcelona), Álvaro Pelayo, Rubio de

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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/`.

Francia Prize 2010 (Washington University in St. Louis), Antonio Ros (Universidad de Granada), Mike Shub (University of Toronto), Cédric Villani, Fields Medal 2010 (Ecole Normale Supérieure de Lyon, Institut Henri Poincaré). In addition, there will be 16 special sessions whose titles are available at the Congress website and a poster session.
Information: For more information and on-line registration please check the web: http://campus.usal.es/rsme2011.

* 21–25 **NCTS(Taiwan)-CPT(France) Joint Workshop on Symplectic Geometry and Quantum Symmetries in Mathematical Physics**, National Center for Theoretical Sciences, National Tsing-Hua University, Hsin-Chu, Taiwan.
Description: The aim of this workshop is to bring together mathematicians and mathematical physicists with various backgrounds to discuss prospective advances in the areas covered by the title. Another purpose is to foster interactions between several groups of French and Taiwanese scientists working in those fields. Interested researchers from all countries are invited to attend. We hope to attract Ph.D. students, postdoctoral students, and young scholars.
Information: http://math.cts.nthu.edu.tw/Mathematics/2011Taiwan-FranceWorkshop.htm.

* 24–25 **IAMCS Workshop in Large-Scale Inverse Problems and Uncertainty Quantification**, Texas A&M University, College Station, Texas.
Description: The ability to solve large-scale inverse problems and to quantify uncertainty is an essential precondition towards the goal of accurate predictions in many data-intensive applications. Challenges in this area are numerous due to multiple scales and uncertainties in physical processes. The workshop will focus on: efficient data assimilation techniques, robust and accurate model reduction techniques, constructing and assessing the statistical accuracy of emulators, and implementation of these methods on today's computer architectures. Interested participants should contact: email: inverseuq@gmail.com.
Information: http://isc.tamu.edu/event/inverseuq.

* 24–26 **IMPACT-Workshop in honour of Peter Imkeller's 60th birthday**, Humboldt University, Berlin, Germany.
Description: This workshop honors Peter Imkeller's remarkable work in the field of Stochastic Analysis, on the occasion of his 60th birthday.
Topics: Random dynamical systems, Malliavin calculus, backward stochastic differential equations and stochastic finance, among others.
Information: For the program, registration and further information please visit the workshop's webpage: http://www.math.hu-berlin.de/~heinc/impact/.

* 26–27 **Southern California Geometric Analysis Seminar**, University of California San Diego, La Jolla, California.
Description: The Southern California Geometric Analysis Seminar is an annual conference in geometric analysis organized jointly by UC Irvine and UC San Diego. Some travel funds are available. Graduate students, junior faculty members without support, and members of underrepresented groups are especially encouraged to apply. Priority will be given to those who request support before January 15th, 2011. Please register on the website.
Information: http://www.math.ucsd.edu/~scgas/.

March 2011

* 14–18 **Workshop 4: Insect Self-organization and Swarming**, Mathematical Biosciences Institute, The Ohio State University, Columbus, Ohio.
Description: Collective insect behavior is interesting from the point of view of evolution because understanding the non-linear dynamics provides insights into self-organization in natural systems which in turn serves as an inspiration for computer algorithms and robots. Many of the emergent collective phenomena involve synchronization where large numbers of individuals move in the same direction or co-ordinate their activities. Lastly, mass movement of insects such as grasshoppers and crickets involve large-scale interactions with the environment, whereby feedback between individuals within a group and their environment determine collective patterns.
Information: http://www.mbi.osu.edu/2010/ws4description.html.

* 17–18 **Finitely presented solvable groups**, The City College of New York, New York, New York.
Description: The conference will explore the structure and geometry of finitely presented solvable groups. Gromov's work on finitely generated groups of polynomial growth has led to research exploring the extent to which the asymptotic properties of a finitely generated solvable group determine its algebraic structure. This conference is designed to join two rather different points of view, the geometric and the combinatorial, to suggest interesting new directions for research.
Information: http://www.sci.ccny.cuny.edu/~cleary/fpsolconf.html.

* 22–26 **Current Topic Workshop: New Developments in Dynamical Systems Arising from the Biosciences**, Mathematical Biosciences Institute, The Ohio State University, Columbus, Ohio.
Description: The biosciences provide rich grounds for mathematical problems, and many questions require the development of new mathematical theory and algorithms. With this workshop we give particular attention to new ideas and developments in dynamical systems. We have chosen four themes to showcase how the biosciences inspired recent progress: systems with delays, systems with multiple scales, dynamics of networks, and stochastic bifurcation theory. The meeting will highlight and discuss new directions of fundamental research in each of the themes, how they are connected, and how they contribute to the understanding of specific questions in bioscience applications.
Information: http://www.mbi.osu.edu/2010/ddsdescription.html.

* 25–27 **The Seventh International Conference on Number Theory and Smarandache Notions**, Weinan Teachers University, Weinan, Shaanxi, People's Republic of China.
Description: The theme of the conference will include all branches of number theory and Smarandache Notions.
Information: email: wpzhang@nwu.edu.cn.

* 29–30 **International Workshop on Mathematical and Physical Foundations of Discrete Time Quantum Walk**, Oh-Okayama Campus, Tokyo Institute of Technology, Meguro, Tokyo, Japan.
Description: What is probability and stochastic process in quantum mechanics? To study the foundations of the stochastic process in quantum mechanics, the discrete time quantum walk (DTQW), which is a quantum analogue of the random walk, may be useful. This has recently been the hot research field, especially in quantum information science, and been experimentally realized. This workshop will bring together the theoretical researchers in the DTQW. While this workshop is focused on the theoretical side, we also welcome experimentalists. We take the advantage of special opportunities to invite founders of DTQW. The organizers strongly encourage young researchers to actively join us to this workshop.
Information: http://www.th.phys.titech.ac.jp/~shikano/dtqw/.

April 2011

* 1–3 **Underrepresented Students in Topology and Algebra Research Symposium (USTARS): Research symposium for underrepresented graduate students in algebra and topology**, University of Iowa, Iowa City, Iowa.
Description: The Underrepresented Students in Topology and Algebra Research Symposium (USTARS) is a graduate student conference proposed by a group of underrepresented students in the University of Iowa Mathematics Department and will be largely run and organized by graduate students. The symposium will be structured so that speakers give 20-minute parallel research talks with one distinguished graduate student and one invited faculty member, Prof. Emille Davie

Lawrence, giving 1-hour presentations on Saturday and a mentoring brunch on Sunday. The broader impact of this event is that graduate students who attend USTARS will be better equipped to find academic positions and continue the cycle of research and collaboration.
Information: http://www.mathalliance.org/ustars.asp.

* 11–16 **The Fifth de Brun Workshop: Groups, Combinatorics, Computing**, National University of Ireland, Galway, Ireland.
Description: The primary aim of the workshop is to bring together experts in group theory and combinatorics, to discuss computational and algorithmic aspects that have recently emerged at the interface of both subjects. Three short lecture courses will be delivered by leading experts. There will also be contributed research talks. The workshop will be beneficial and suitable both for early-stage researchers (including Ph.D. students), as well as those who are more established.
Information: http://larmor.nuigalway.ie/~detinko/DeBrun5.shtml.

* 12–14 **International Conference on Mathematical and Computational Biology 2011(ICMCB2011)**, Malacca, Malaysia.
Description: The International conference on Mathematical and Computational Biology provides the opportunity to bring together researchers and students from all over the world to share their experiences and explore the challenges of applying mathematics to biological problems.
Scope: Bioinformatics, biometrics, cancer modelling, computational biology, computational ecology, epidemiology, genetics and evolution, mathematical biology, mathematical ecology, neural networks, population dynamics, stochastic modelling & other topics relevant to this area.
Information: http://einspem.upm.edu.my/icmcb2011.

May 2011

* 10–13 **Second Buea International Conference on the Mathematical Sciences**, University of Buea, Cameroon.
Description: The University of Buea, Cameroon, will be organizing its Second International Conference on the Mathematical Sciences, with the aim of bringing together academicians and professionals with cross-disciplinary interests related to mathematical sciences, to demonstrate the vital role that mathematics plays in society, and to bridge as well as nurture understanding and collaboration between global and Cameroon regional mathematical scientists and practitioners. The conference will be in conjunction a two-week CIMPA summer school on analysis and its applications to other sciences.
Information: http://www.bueaconference.com.

* 14–15 **Methodological Aspects of Teaching Mathematics**, Faculty of Education in Jagodina, Jagodina, Serbia.
Description: The general aim of the Conference is to contribute to the development, promotion and improvement of teaching mathematics in primary school, as well as to the development of teacher competencies necessary for modern primary education. The Conference will be held in the form of plenary and thematic sessions: multidisciplinary approach in methodology and teaching mathematics, innovative programs in teaching mathematics, teaching mathematics in inclusive settings, pedagogical and psychological aspects of teaching mthematics, individual talks in sessions will be allocated 20 minutes.
Information: http://matm2011.blogspot.com.

* 16–20 **IMA Hot Topics Workshop: Strain Induced Shape Formation: Analysis, Geometry and Materials Science**, Institute for Mathematics and its Applications (IMA), University of Minnesota, Minneapolis, Minnesota.
Description: This workshop is devoted to analytical aspects of morphogenesis (shape formation), arising as a consequence of the inelastic effects associated with growth, swelling, shrinkage or plasticity. Such effects result in a local and heterogeneous incompatibility of strains and naturally lead to the non-trivial shapes, seen even in the absence of any external forces, in a variety of science and technology situations. A large body of experimental data, as well as numerous formal derivations, present in physics and mechanics literature, suggest various approaches to coupling between residual strain and the ultimate shape of an object. On the other hand, the rigorous results are sparse, and call for a more detailed analysis. During the workshop, we hope to stimulate discussions and enhance further interactions between applied mathematicians, physicists, analysts and geometers, who pursue research around problems in strain-induced morphogenesis.
Information: http://www.ima.umn.edu/2010-2011/SW5.16-20.11/.

* 29–June 4 **Function spaces—Approximation, Inequalities and Lineability**, Paseky nad Jizerou, Czech Republic.
Invited speakers and titles: Richard M. Aron (Kent State University) (title to be announced); David Cruz-Uribe, SFO (Trinity College): Recent advances in the theory of weights: Extrapolation and sharp one- and two-weight norm inequalities; Michael Lacey (Georgia Institute of Technology): Two-weight inequalities in harmonic analysis: First results and outstanding challenges; Andrei K. Lerner (Bar-Ilan University): The local sharp maximal function and some applications.
Organizers: Jaroslav Lukes and Lubos Pick (Charles University, Prague, Czech Republic).
Deadlines: For a reduced fee or support, February 1, 2011; email: pasejune@karlin.mff.cuni.cz.
Information: http://www.karlin.mff.cuni.cz/katedry/kma/ss/jun11/.

* 30–June 2 **Discrete Groups and Geometric Structures, with Applications IV**, This workshop will be held at Hotel Royal Astrid in Oostende, Belgium.
Description: The workshop will focus on research topics related to discrete groups and geometric structures, e.g., crystallographic groups and their generalisations, discrete subgroups of Lie groups, mapping class groups, affine structures and the Auslander conjecture, etc... A special part of the program will be dedicated to the memory and mathematics of Fritz Grunewald, who was involved in the organisation of all previous editions of this workshop.
Invited speakers: Martin Bridson (Oxford), William Goldman (Maryland), Ursula Hamenstaedt (Bonn), Alex Lubotzky (Jerusalem), Ludovic Marquis (Rennes), Alan Reid (Austin), Alain Valette (Neuchatel), Anna Wienhard (Princeton).
Information: http://www.kuleuven-kortrijk.be/workshop.

* 30–June 3 **International Conference on Asymptotics and Special Functions**, City University of Hong Kong, Hong Kong.
Description: Special functions is a very classic subject which together with their asymptotics has many connections to various areas of pure and applied mathematics. Since the 1980s, special functions, orthogonal polynomials and their asymptotics have seen tremendous developments. Many new areas evolved such as the combinatorial theory of orthogonal polynomials, special functions on root systems, several variable and matrix valued special functions, uniform asymptotics, and the application of Riemann-Hilbert techniques to orthogonal polynomials. The conference will bring together researchers with diverse backgrounds whose research interests overlap with special functions and orthogonal polynomials and their asymptotics. The speakers will report on the state of the art in these areas and we expect the presence of such talent in one place will lead to significant developments. The program will also contain some symbolic algebra presentations.
Information: http://www6.cityu.edu.hk/rcms/ICASF2011/index.html.

* 31–June 3 **Nonlinear Modeling and Analysis International Conference: 4th Chaotic Modeling and Simulation International Conference (CHAOS2011)**, Agios Nikolaos, Crete, Greece.
Topics: The general topics and the special sessions proposed for the conference include but are not limited to: chaos and nonlinear dynamics, stochastic chaos, chemical chaos, data analysis and chaos,

hydrodynamics, turbulence and plasmas, optics and chaos, chaotic oscillations and circuits, chaos in climate dynamics, geophysical flows, biology and chaos, neurophysiology and chaos, Hamiltonian systems, chaos in astronomy and astrophysics, chaos and solitons, micro- and nano-electro-mechanical systems, neural networks and chaos, ecology and Economy.
Publications: Include: 1. The book of abstracts in electronic and in paper form. 2. Electronic Proceedings in CD and in the Web in a permanent website. 3. A book including selected papers presented in the conference.
Information: For more information and Abstract/Paper submission and Special Session Proposals please visit the conference website at: http://www.cmsim.org.

June 2011

* 8–11 **2011 International Symposium on Symbolic and Algebraic Computation (ISSAC 2011)**, San Jose Convention Center, 150 West San Carlos St., San Jose, California.
Description: The International Symposium on Symbolic and Algebraic Computation (ISSAC) is the premier conference for research in symbolic computation and computer algebra. ISSAC 2011 is the 36th meeting in the series, started in 1966 and held annually since 1981, in North America, Europe, and Asia. The conference presents a range of invited speakers, tutorials, poster sessions, software demonstrations and vendor exhibits with a centerpiece of contributed research papers.
Information: http://www.issac-conference.org/2011.

* 12–17 **Geometric and nonlinear analysis, meeting in Lorraine**, Université Henri Poincaré, Nancy, France.
Description: This meeting is dedicated to cover large sectors of nonlinear and geometric analysis.
Scientific committee: Emmanuel Hebey, Oussama Hijazi, Fang-Hua Lin, Frank Pacard, Richard M. Schoen and Michael Struwe.
Organizers: Dong Ye (Metz) and Frédéric Robert (Nancy).
Information: http://www.iecn.u-nancy.fr/~frobert/.

* 13–16 **FPP6: Foundations of Probability and Physics-6**, Linnaeus University, Vaxjo, Sweden.
Description: This is the 12th conference arranged at Vaxjo which is devoted to quantum foundations and quantum information, especially the clarification of fundamental questions in probabilistic foundations, interplay of classical and quantum probability and statistics.
Organization committee: V. Belavkin (University of Nottingham, United Kingdom), M. D'Ariano (University of Pavia, Italy), S.-M. Fei (Capital Normal University, China), B. Hiesmayr (University of Vienna, Austria), G. Jaeger (Boston University, USA), A. Khrennikov (Linnaeus University, Växjö, Sweden), J-A. Larsson (Linköping University, Sweden), M. Ozawa (Nagoya University, Japan), S. Stenholm (Stockholm University, Sweden), J. Tollaksen (Chapman University, USA).
Information: http://www.lnu.se/fpp6.

* 20–24 **Permutation Patterns 2011**, California Polytechnic State University, San Luis Obispo, California.
Description: The invited speakers for this, the ninth annual, session are Herbert Wilf from the University of Pennsylvania and Igor Pak from the University of California at Los Angeles. Researchers wishing to present a talk on or related to permutation patterns should submit an abstract to Robert Brignall, email: r.brignall@open.ac.uk, by April 1, 2011. Details on lodging, travel, and registration will be available by January 1, 2011 through the link below.
Information: http://math.calpoly.edu/PP2011/index.html.

* 20–25 **3rd Conference of the Euro-American Consortium for Promoting the Application of Mathematics in Technical and Natural Sciences**, Resort of Albena, Bulgaria.
Description: The conference will be scheduled in plenary and keynote lectures followed by special and contributed sessions. The accents of the conference will be on applied analysis, applied physics, biomathematics, continuum mechanics, mathematical physics, numerical methods, scientific computing, solitons and transport processes which can be complemented by some specific topics in contributed special sessions. You are welcomed to announce and organize special sessions that should be within the general topic of the conference. If you are interested in attending AMiTaNS'11 please prepare a short abstract within 300 words clearly stating the goal, tools, and and fill out the online application form.
Deadline: The deadline for submissions is March 31, 2011.
Information: http://2011.eac4amitans.org.

* 20–July 1 (NEW DATE) **Polyhedral Geometry and Algebraic Combinatorics**, University of Wyoming, Laramie, Wyoming.
Description: This program will expose participants to recent developments in polyhedral geometry and algebraic combinatorics. Topics include the theory of valuations on cones, combinatorial reciprocity theorems, and computational polyhedral geometry. No specialized prior knowledge will be assumed. The program will begin with a tutorial phase to provide a solid background to all participants.
Aim: To prepare participants to pursue open problems in the subject. Anyone interested in the theory or applications of polyhedral geometry and algebraic combinatorics will be interested in this conference.
Speakers: Matthias Back (San Francisco State Univ.); Jess De Loera (Univ. of California, Davis); Victor Reiner (Univ. of Minnesota).
Sponsors: Rocky Mountain Mathematics Consortium. NSF and IMA Funding possible.
Deadline: For applications/abstracts of talks: April 1, 2011.
Information: Tyrrell McAllister, email: tmcallis@uwyo.edu; A. Duane Porter, email: adporter@uwyo.edu; http://math.uwyo.edu/rmmc/2011.

July 2011

* 5–7 **The 4th Congress of the Turkic World Mathematical Society (TWMS)**, Baku, Azerbaijan.
Description: The aim of the Congress is to provide a forum where scientists and mathematicians from academia and industry can meet to share ideas of latest research work in all branches of pure and applied mathematics.
Information: http://www.twmsc2011.com/.

* 19–22 **The SUMMER 9th International Conference on Computing, Communications and Control Technologies: CCCT 2011**, Orlando, Florida.
Goal: To bring together researchers representing various fields related to the numerical modeling of objects and visualization for science, engineering and medicine. This is a sincere effort to make a contribution to: Achieving better solutions for more realistic computational models; establish a bridge between clinicians and researchers from diverse fields; set the major lines of development for the near future.
Topics: Mathematics and computer graphics, biomechanics, statistics, computational biology, medical imaging, image acquisition, image segmentation, objects tracking, objects matching, computational vision, scientific visualization.
Organizer: Dr. Mohammad Siddique, Fayetteville State University, North Carolina.
Information: For submission: msiddiqu@uncfsu.edu; http://www.iiis2011.org/imeti/Invitedsession/InvitedSessionPre.asp?vc=35.

* 28–30 **International Conference on Special Functions & their Applications (ICSFA 2011)**, Department of Mathematics & Statistics, J. N. Vyas University, Jodhpur (Rajasthan) 342 005, India.
Description: The organizers extend a coordial invitation to those who are interested to participate and call for papers for presentation.
Information: For further details contact: Dr. R. K. Yadav, rkmdyadav@gmail.com, Organizing Secretary, CSFA 2011; http://www.ssfaindia.webs.com/conf.htm.

August 2011

* 8–13 **Toposym 2011: 11th Prague Topological Symposium**, Prague, Czech Republic.
Description: It will be organized under the auspices of: The Centre for Theoretic Study, Mathematical Institute of Czechoslovak Academy of Sciences and Faculty of Mathematics and Physics of Charles University.
Information: http://www.toposym.cz/.

* 22–24 **The 3rd International Conference on Control and Optimization with Industrial Applications: COIA 2011**, Bilkent University, Ankara, Turkey.
Description: The conference will provide a forum where engineers, scientists and mathematicians from academia, industry and government organizations can meet to share ideas on recent advances in all disciplines of science and engineering involving control and optimization. Latest industrial applications of the control and optimization theory will be presented in thematic special sessions. Selected papers will be published in *Applied and Computational Mathematics* (ISSN 1683-3511) indexed in Scopus and in Science Citation Index Expanded. Detailed instructions for paper submission will be posted on the conference web site: http://www.ee.bilkent.edu.tr/~coia2011.
Important Dates: Extended Abstract Submission: February 15, 2011. Author Notification: April 30, 2011. Early Registration and Submission of the Final Extended Abstract: May 31, 2011.
Information: Please contact the secretariat: coia2011@ee.bilkent.edu.tr; http://www.ee.bilkent.edu.tr/~coia2011.

* 22–27 **10th International Symposium on Generalized Convexity and Monotonicity (GCM10)**, Babes-Bolyai University, Cluj-Napoca, Romania.
Description: The GCM10 symposium aims to continue the series of nine conferences organized in the area of generalized convexity and monotonicity during the last three decades: 1980 (Vancouver, Canada), 1986 (Canton, U.S.A.), 1988 (Pisa, Italy), 1992 (Pécs, Hungary), 1996 (Luminy-Marseille, France), 1999 (Karlovassi-Samos, Greece), 2002 (Hanoi, Vietnam), 2005 (Varese, Italy), and 2008 (Kaohsiung, Taiwan). As all recent editions, this one is organized by the Working Group on Generalized Convexity; http://www.genconv.org—a scientific community with more than 450 members from 52 countries. Its theme covers generalized convexity and monotonicity, variational analysis, and their applications in optimization, control, economics, statistics, finance, engineering and related areas.
Information: http://www.cs.ubbcluj.ro/gcm10.

* 29–September 2 **European Conference on Combinatorics, Graph Theory and Applications 2011**, Alfred Renyi, Institute of Mathematics, Budapest, Hungary.
Description: In the tradition of EuroComb01 (Barcelona), EuroComb03 (Prague), EuroComb05 (Berlin), EuroComb07 (Seville) and EuroComb09 (Bordeaux), this conference will cover the full range of combinatorics and graph theory including applications in other areas of mathematics, computer science and engineering. Topics include, but are not limited to: enumerative combinatorics, designs and configurations, graph theory, extremal combinatorics, algebraic combinatorics, topological combinatorics, ordered sets, combinatorial number theory, combinatorial geometry, random methods.
Information: http://www.renyi.hu/conferences/ec11.

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.

February 2012

* 27–March 2 **IMA Workshop: Network Links: Connecting Social, Communication and Biological Network Analysis**, Institute for Mathematics and its Applications (IMA), University of Minnesota, Minneapolis, Minnesota.
Description: Networks occur in a large variety of disciplines, e.g., social networks, communication networks, gene regulatory networks, disease transmission networks, financial networks, power networks, etc. Common problems are how to model, map and measure the network, how to understand and adjust to network evolution and dynamics, and how network structure affects information flow and robustness/resilience of networks. These problems have often been studied in each discipline individually. In this workshop, we bring together researchers and methodologies of network analysis from three disciplines, to build on the similarities and contrasts among their approaches.
Information: http://www.ima.umn.edu/2011-2012/W2.27-3.2.12/.

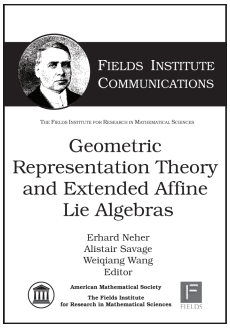
March 2012

* 26–30 (NEW DATE) **IMA Workshop: Machine Learning: Theory and Computation**, Institute for Mathematics and its Applications (IMA), University of Minnesota, Minneapolis, Minnesota.
Topics: Topics to be discussed at the workshop include the interplay between machine learning (kernel learning, graphical models, online learning, active learning) with (a) statistical modeling and learning theory, (b) theoretical computer science, (c) numerical optimization, (d) topological methods, (e) tensor methods, and (f) sparse methods.
Information: http://www.ima.umn.edu/2011-2012/W3.26-30.12/.

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



Geometric Representation Theory and Extended Affine Lie Algebras

Erhard Neher and **Alistair Savage**, *University of Ottawa, ON, Canada*, and **Weiqiang Wang**, *University of Virginia, Charlottesville, VA*, Editors

Lie theory has connections to many other disciplines such as geometry, number theory, mathematical physics, and algebraic combinatorics. The interaction between algebra, geometry and combinatorics has proven to be extremely powerful in shedding new light on each of these areas.

This book presents the lectures given at the Fields Institute Summer School on Geometric Representation Theory and Extended Affine Lie Algebras held at the University of Ottawa in 2009. It provides a systematic account by experts of some of the exciting developments in Lie algebras and representation theory in the last two decades. It includes topics such as geometric realizations of irreducible representations in three different approaches, combinatorics and geometry of canonical and crystal bases, finite W-algebras arising as the quantization of the transversal slice to a nilpotent orbit, structure theory of extended affine Lie algebras, and representation theory of affine Lie algebras at level zero.

This book will be of interest to mathematicians working in Lie algebras and to graduate students interested in learning the basic ideas of some very active research directions. The extensive references in the book will be helpful to guide non-experts to the original sources.

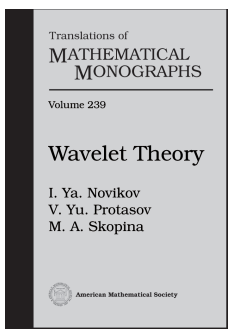
Titles in this series are co-published with the Fields Institute for Research in Mathematical Sciences (Toronto, Ontario, Canada).

Contents: J. Kamnitzer, Geometric constructions of the irreducible representations of GL_n; **S.-J. Kang**, Introduction to crystal bases; **A. Savage**, Geometric realizations of crystals; **W. Wang**, Nilpotent orbits and finite W-algebras; **E. Neher**, Extended affine Lie algebras—An introduction to their structure theory; **V. Chari**, Representations of affine and toroidal Lie algebras; Bibliography; Index.

Fields Institute Communications, Volume 59

February 2011, 213 pages, Hardcover, ISBN: 978-0-8218-5237-8, LC 2010043432, 2010 *Mathematics Subject Classification:* 16G20, 17B10, 17B35, 17B37, 17B50, 17B65, 17B67, **AMS members US$79.20**, List US$99, Order code FIC/59

Analysis



Wavelet Theory

I. Ya. Novikov, *Voronezh State University, Russia*, **V. Yu. Protasov**, *Moscow State University, Russia*, and **M. A. Skopina**, *St. Petersburg University, Russia*

Wavelet theory lies on the crossroad of pure and computational mathematics, with connections to audio and video signal processing, data compression, and information transmission.

The present book is devoted to a systematic exposition of modern wavelet theory. It details the construction of orthogonal and biorthogonal systems of wavelets and studies their structural and approximation properties, starting with basic theory and ending with special topics and problems. The book also presents some applications of wavelets. Historical commentary is supplied for each chapter in the book, and most chapters contain exercises.

The book is intended for professional mathematicians and graduate students working in functional analysis and approximation theory. It is also useful for engineers applying wavelet theory in their work. Prerequisites for reading the book consist of graduate courses in real and functional analysis.

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

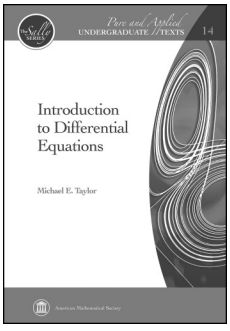
Contents: Wavelets on the line; Multivariate wavelets; Compactly supported refinable functions; Wavelets with compact support; Fractal properties of wavelets; Factorization of refinement equations; Smoothness of compactly supported wavelets;

Nonstationary wavelets; Periodic wavelets; Approximation by periodic wavelets; Remarkable properties of wavelet bases; Auxiliary facts of the theory of functions and functional analysis; Historical comments; Bibliography; Index.

Translations of Mathematical Monographs, Volume 239

April 2011, approximately 508 pages, Hardcover, ISBN: 978-0-8218-4984-2, LC 2010035110, 2010 *Mathematics Subject Classification:* 42C40, **AMS members US$104.80**, List US$131, Order code MMONO/239

Differential Equations



Introduction to Differential Equations

Michael E. Taylor, *University of North Carolina, Chapel Hill, NC*

The mathematical formulations of problems in physics, economics, biology, and other sciences are usually embodied in differential equations. The analysis of the resulting equations then provides new insight into the original problems. This book describes the tools for performing that analysis.

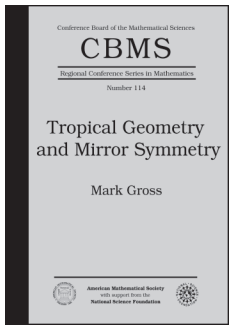
The first chapter treats single differential equations, emphasizing linear and nonlinear first order equations, linear second order equations, and a class of nonlinear second order equations arising from Newton's laws. The first order linear theory starts with a self-contained presentation of the exponential and trigonometric functions, which plays a central role in the subsequent development of this chapter. Chapter 2 provides a mini-course on linear algebra, giving detailed treatments of linear transformations, determinants and invertibility, eigenvalues and eigenvectors, and generalized eigenvectors. This treatment is more detailed than that in most differential equations texts and provides a solid foundation for the next two chapters. Chapter 3 studies linear systems of differential equations. It starts with the matrix exponential, melding material from Chapters 1 and 2, and uses this exponential as a key tool in the linear theory. Chapter 4 deals with nonlinear systems of differential equations. This uses all the material developed in the first three chapters and moves it to a deeper level. The chapter includes theoretical studies, such as the fundamental existence and uniqueness theorem, but also has numerous examples, arising from Newtonian physics, mathematical biology, electrical circuits, and geometrical problems. These studies bring in variational methods, a fertile source of nonlinear systems of differential equations. The reader who works through this book will be well prepared for advanced studies in dynamical systems, mathematical physics, and partial differential equations.

Contents: Single differential equations; Linear algebra; Linear systems of differential equations; Nonlinear systems of differential equations; Bibliography; Index.

Pure and Applied Undergraduate Texts, Volume 14

March 2011, approximately 415 pages, Hardcover, ISBN: 978-0-8218-5271-2, LC 2010037816, 2010 *Mathematics Subject Classification:* 34-01, **AMS members US$58.40**, List US$73, Order code AMSTEXT/14

Geometry and Topology



Tropical Geometry and Mirror Symmetry

Mark Gross, *University of California, San Diego, CA*

Tropical geometry provides an explanation for the remarkable power of mirror symmetry to connect complex and symplectic geometry. The main theme of this book is the interplay between tropical geometry and mirror symmetry, culminating in a description of the recent work of Gross and Siebert using log geometry to understand how the tropical world relates the A- and B-models in mirror symmetry.

The text starts with a detailed introduction to the notions of tropical curves and manifolds, and then gives a thorough description of both sides of mirror symmetry for projective space, bringing together material which so far can only be found scattered throughout the literature. Next follows an introduction to the log geometry of Fontaine-Illusie and Kato, as needed for Nishinou and Siebert's proof of Mikhalkin's tropical curve counting formulas. This latter proof is given in the fourth chapter. The fifth chapter considers the mirror, B-model side, giving recent results of the author showing how tropical geometry can be used to evaluate the oscillatory integrals appearing. The final chapter surveys reconstruction results of the author and Siebert for "integral tropical manifolds." A complete version of the argument is given in two dimensions.

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

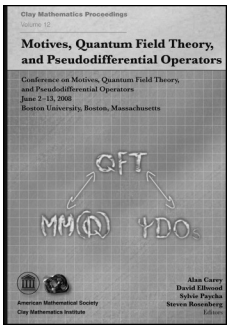
A co-publication of the AMS and CBMS.

Contents: *The three worlds:* The tropics; The A- and B-models; Log geometry; *Example:* $\mathbb{P}^2$*:* Mikhalkin's curve counting formula; Period integrals; *The Gross-Siebert program:* The program and two-dimensional results; Bibliography; Index of symbols; General index.

CBMS Regional Conference Series in Mathematics, Number 114

February 2011, 317 pages, Softcover, ISBN: 978-0-8218-5232-3, LC 2010043384, 2010 *Mathematics Subject Classification:* 14T05, 14M25, 14N35, 14J32, 14J33, 52B20, **AMS members US$45.60**, **All Individuals US$45.60**, List US$57, Order code CBMS/114

Mathematical Physics



Motives, Quantum Field Theory, and Pseudodifferential Operators

Alan Carey, *Australian National University, Canberra, Australia*, **David Ellwood**, *Clay Mathematics Institute, Cambridge, MA*, **Sylvie Paycha**, *Université Blaise Pascal, Aubiere, France*, and **Steven Rosenberg**, *Boston University, MA*, Editors

This volume contains articles related to the conference "Motives, Quantum Field Theory, and Pseudodifferntial Operators" held at Boston University in June 2008, with partial support from the Clay Mathematics Institute, Boston University, and the National Science Foundation. There are deep but only partially understood connections between the three conference fields, so this book is intended both to explain the known connections and to offer directions for further research.

In keeping with the organization of the conference, this book contains introductory lectures on each of the conference themes and research articles on current topics in these fields. The introductory lectures are suitable for graduate students and new Ph.D.'s in both mathematics and theoretical physics, as well as for senior researchers, since few mathematicians are expert in any two of the conference areas.

Among the topics discussed in the introductory lectures are the appearance of multiple zeta values both as periods of motives and in Feynman integral calculations in perturbative QFT, the use of Hopf algebra techniques for renormalization in QFT, and regularized traces of pseudodifferential operators. The motivic interpretation of multiple zeta values points to a fundamental link between motives and QFT, and there are strong parallels between regularized traces and Feynman integral techniques.

The research articles cover a range of topics in areas related to the conference themes, including geometric, Hopf algebraic, analytic, motivic and computational aspects of quantum field theory and mirror symmetry. There is no unifying theory of the conference areas at present, so the research articles present the current state of the art pointing towards such a unification.

This item will also be of interest to those working in differential equations and algebra and algebraic geometry.

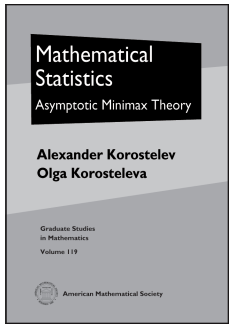
Titles in this series are co-published with the Clay Mathematics Institute (Cambridge, MA).

Contents: *Introductory articles:* **Y. André**, An introduction to motivic zeta functions of motives; **D. Kreimer**, Algebra for quantum fields; **M. Lesch**, Pseudodifferential operators and regularized traces; **D. Manchon**, Renormalization in connected graded Hopf algebras: An introduction; *Research articles:* **P. Albin** and **R. Melrose**, Fredholm realizations of elliptic symbols on manifolds with boundary II: Fibered boundary; **J. Bergström** and **F. Brown**, Inversion of series and the cohomology of the moduli spaces $\mathcal{M}^{\delta}_{0,n}$; **P. Bouwknegt**, **K. C. Hannabuss**, and **V. Mathai**, C*-algebras in tensor categories; **J. Blümlein**, Structural relations of harmonic sums and Mellin transforms at weight $w = 6$; **L. Foissy**, Hopf subalgebras of rooted trees from Dyson-Schwinger equations; **J. Mickelsson**, From gauge anomalies to Gerbes and Gerbal actions; **R. Ponge**, A microlocal approach to Fefferman's program in conformal and CR geometry; **M. Roth** and **N. Yui**, Mirror symmetry for elliptic curves: The A-model (fermionic) counting; **C. Schneider**, A symbolic summation approach to find optimal nested sum representations; **S. Scott**, Logarithmic structures and TQFT; **W. D. van Suijlekom**, Renormalization Hopf algebras for gauge theories and BRST-symmetries.

Clay Mathematics Proceedings, Volume 12

January 2011, 349 pages, Softcover, ISBN: 978-0-8218-5199-9, LC 2010040806, 2010 *Mathematics Subject Classification:* 14-02, 14F42, 16T05, 33F10, 58-02, 58J42, 81-02, 81T15, 81T18, 81Q30, **AMS members US$71.20**, List US$89, Order code CMIP/12

Probability and Statistics



Mathematical Statistics

Asymptotic Minimax Theory

Alexander Korostelev, *Wayne State University, Detroit, MI*, and **Olga Korosteleva**, *California State University, Long Beach, CA*

This book is designed to bridge the gap between traditional textbooks in statistics and more advanced books that include the sophisticated nonparametric techniques. It covers topics in parametric and nonparametric large-sample estimation theory. The exposition is based on a collection of relatively simple statistical models. It gives a thorough mathematical analysis for each of them with all the rigorous proofs and explanations. The book also includes a number of helpful exercises.

Prerequisites for the book include senior undergraduate/beginning graduate-level courses in probability and statistics.

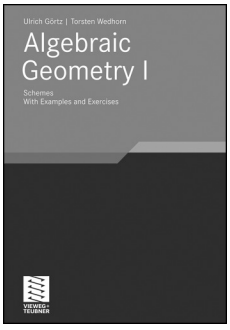
Contents: *Parametric models:* The Fisher efficiency; The Bayes and minimax estimators; Asymptotic minimaxity; Some irregular statistical experiments; Change-point problem; Sequential estimators; Linear parametric regression; *Nonparametric regression:* Estimation in nonparametric regression; Local polynomial approximation of regression function; Estimation of regression in global norms; Estimation by splines; Asymptotic optimality in global norms; *Estimation in nonparametric models:* Estimation of functionals; Dimension and structure in nonparametric regression; Adaptive estimation; Testing of nonparametric hypotheses; Bibliography; Index of notation; Index.

Graduate Studies in Mathematics, Volume 119

February 2011, approximately 243 pages, Hardcover, ISBN: 978-0-8218-5283-5, LC 2010037408, 2010 *Mathematics Subject Classification:* 62F12, 62G08; 62F10, 62G05, 62G10, 62G20, **AMS members US$50.40**, List US$63, Order code GSM/119

New AMS-Distributed Publications

Algebra and Algebraic Geometry



Algebraic Geometry I

Schemes. With Examples and Exercises

Ulrich Görtz, *University of Bonn, Germany*, and **Torsten Wedhorn**, *University of Paderborn, Germany*

This book introduces the reader to modern algebraic geometry. It presents Grothendieck's technically demanding language of schemes that is the basis of the most important developments in the last fifty years within this area. A systematic treatment and motivation of the theory is emphasized, using concrete examples to illustrate its usefulness. The two example classes of Hilbert modular surfaces and determinantal varieties are used methodically to discuss the covered techniques. For the reader the further development of the theory yields a better understanding of these fascinating objects.

The text is complemented by many exercises that serve to enhance comprehension, treat additional examples, or give an outlook on further results. This book, the first of two volumes, serves as an introductory volume on schemes. The second volume concerns the cohomology of schemes.

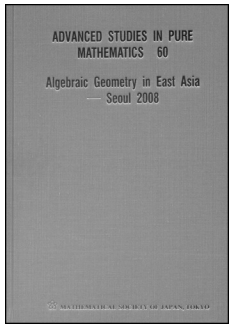
Volume I requires only basic knowledge in abstract algebra and topology. Essential facts from commutative algebra are assembled in an appendix.

A publication of Vieweg Verlag. The AMS is exclusive distributor in North America. Vieweg Verlag Publications are available worldwide from the AMS outside of Germany, Switzerland, Austria, and Japan.

Contents: Prevarieties; Spectrum of a ring; Schemes; Fiber products; Schemes over fields; Local properties of schemes; Quasi-coherent modules; Representable functors; Separated morphisms; Finiteness conditions; Vector bundles; Affine and proper morphisms; Projective morphisms; Flat morphisms and dimension; One-dimensional schemes; Examples.

Vieweg Advanced Lectures in Mathematics

June 2010, 615 pages, Softcover, ISBN: 978-3-8348-0676-5, **AMS members US$81.90**, List US$91, Order code VWALM/12



Algebraic Geometry in East Asia (Seoul, 2008)

JongHae Keum, *Korea Institute for Advanced Study, Seoul, Korea*, **Shigeyuki Kondō**, *Nagoya University, Japan*, and **Kazuhiro Konno** and **Keiji Oguiso**, *Osaka University, Japan*, Editors

The international conference "Algebraic Geometry in East Asia, III" was held at the Korea Institute for Advanced Study in Seoul, Korea in November 2008. The 21 invited lectures (including four lectures by Europeans and Americans) were presented at the conference.

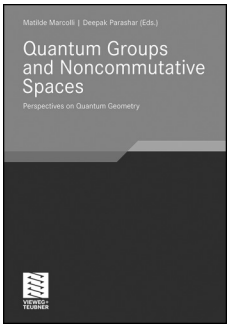
This volume consists of three survey articles and 10 research articles. The papers explore a wide variety of topics, including algebraic surfaces, Fano varieties, variety of general type, bundles, Cremona groups, Mordell–Weil groups, fundamental group scheme, and quantum rings.

Published for the Mathematical Society of Japan by Kinokuniya, Tokyo, and distributed worldwide, except in Japan, by the AMS.

Contents: *Survey Articles:* **I. V. Dolgachev**, Finite subgroups of the plane Cremona group; **M. Schütt** and **T. Shioda**, Elliptic surfaces; **X. Sun**, Frobenius morphism and semi-stable bundles; *Research Articles:* **J.-X. Cai**, Automorphisms of an irregular surface with low slope acting trivially in cohomology; **J. -C. Chen**, On Fano varieties with large pseudo-index; **M. Chen**, On pluricanonical systems of algebraic varieties of general type; **H. Esnault** and **P. H. Hai**, Two small remarks on Nori fundamental group scheme; **J. Keum**, Projective surfaces with many nodes; **Y. Lee**, Complex structure on the rational blowdown of sections in $E(4)$; **H. -W. Lin**, Quantum invariance under $\mathbb{P}^1$ flops of type $(k+2,k)$; **N. Nakayama**, Separable endomorphisms of surfaces in positive characteristic; **K. Oguiso**, The third smallest Salem number in automorphisms of K3 surfaces; **I. Shimada**, Topology of curves on a surface and lattice-theoretic invariants of coverings of the surface.

Advanced Studies in Pure Mathematics, Volume 60

September 2010, 382 pages, Hardcover, ISBN: 978-4-931469-63-1, 2010 *Mathematics Subject Classification:* 14-06; 14E07, 14J27, 06B05, 11G05, 11G07, 11G50, 14J20, 14J50, 14E30, 14E05, 14E25, 14L15, 14J17, 14J29, 14J10, 53D05, 14N35, 53D45, 14J26, 14J28, 14H50, 14E20, 14J60, **AMS members US$53.60**, List US$67, Order code ASPM/60



Quantum Groups and Noncommutative Spaces

Perspectives on Quantum Geometry

Matilde Marcolli, *California Institute of Technology, Pasadena, CA*, and **Deepak Parashar**, *University of Cambridge, UK*, Editors

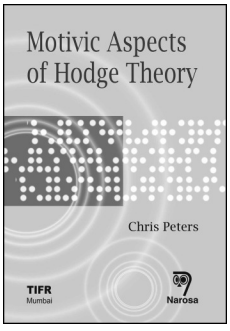
This book aims to present different methods and perspectives in the theory of quantum groups and to provide a bridge between the algebraic, representation-theoretic, analytic, and differential-geometric approaches. It also covers recent developments in noncommutative geometry which have close relations to quantization and quantum group symmetries. The volume includes surveys by experts. The surveys originated from an activity at the Max Planck Institute for Mathematics in Bonn.

A publication of Vieweg Verlag. The AMS is exclusive distributor in North America. Vieweg Verlag Publications are available worldwide from the AMS outside of Germany, Switzerland, Austria, and Japan.

Contents: Contributions by Tomasz Brzezinski, Branimir Cacic, Rita Fioresi, Rita Fioresi and Fabio Gavarini, Debashish Goswami, Christian Kassel, Avijit Mukherjee, Alfons Van Daele, Robert Wisbauer, and Alessandro Zampini.

Vieweg Aspects of Mathematics, Volume 40

September 2010, 240 pages, Hardcover, ISBN: 978-3-8348-1442-5, 2010 *Mathematics Subject Classification:* 17B37, 58B32, 20G42, 16T05, 19D55, 81T75, **AMS members US$67.50**, List US$75, Order code VWAM/40



Motivic Aspects of Hodge Theory

Chris Peters, *Université Grenoble I, St. Martin d'Heres, France*

These notes are based on a series of lectures given at the Tata Institute of Fundamental Research, Mumbai, in 2007, on the theme of Hodge theoretic motives associated to various geometric objects. Starting with the topological setting, the notes go on to Hodge theory and mixed Hodge theory on the cohomology of varieties. Degenerations, limiting mixed Hodge structures and the relation to singularities are addressed next. The original proof of Bittner's theorem on the Grothendieck group of varieties, with some applications, is presented as an appendix to one of the chapters.

The situation of relative varieties is addressed next using the machinery of mixed Hodge modules. Chern classes for singular varieties are explained in the motivic setting using Bittner's approach, and their full functorial meaning is made apparent using mixed Hodge modules.

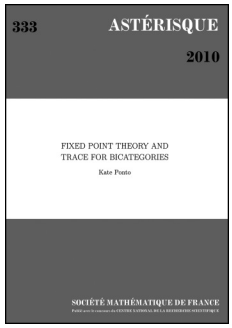
An appendix explains the treatment of Hodge characteristic in relation with motivic integration and string theory. Throughout these notes, emphasis is placed on explaining concepts and giving examples.

A publication of the Tata Institute of Fundamental Research. Distributed worldwide except in India, Bangladesh, Bhutan, Maldavis, Nepal, Pakistan, and Sri Lanka.

Contents: Motives and topology; The Hodge characteristic makes its appearance; The Hodge characteristic: examples; Hodge theory revisited; Mixed Hodge theory; Motivic Hodge theory; Motivic aspects of degenerations; Motivic nearby fibre: examples; Motivic aspects of degenerations: Applications; Motives in the relative setting: Topological aspects; Variations of Hodge structure; Hodge modules; Motives in the relative setting: Mixed Hodge modules; The motivic Chern class transformation; Bibliography; Index.

Tata Institute of Fundamental Research

April 2010, 141 pages, Softcover, ISBN: 978-81-8487-012-1, 2010 *Mathematics Subject Classification:* 14C30, 14D07, 32S35, 32S20, 32S60; 34M50, 32C38, 19E15, **AMS members US$32**, List US$40, Order code TIFR/15



Fixed Point Theory and Trace for Bicategories

Kate Ponto, *University of Notre Dame, IN*

The Lefschetz fixed point theorem follows easily from the identification of the Lefschetz number with the fixed point index. This identification is a consequence of the functoriality of the trace in symmetric monoidal categories. There are refinements of the Lefschetz number and the fixed point index that give a converse to the Lefschetz fixed point theorem. An important part of this theorem is the identification of these different invariants.

The author defines a generalization of the trace in symmetric monoidal categories to a trace in bicategories with shadows. She shows the invariants used in the converse of the Lefschetz fixed point theorem are examples of this trace and that the functoriality of the trace provides some of the necessary identifications. The methods used here do not use simplicial techniques and so generalize readily to other contexts.

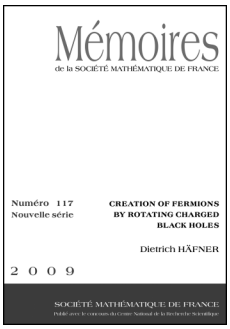
A publication of the Société Mathématique de France, Marseilles (SMF), distributed by the AMS in the U.S., Canada, and Mexico. Orders from other countries should be sent to the SMF. Members of the SMF receive a 30% discount from list.

Contents: A review of fixed point theory; The converse to the Lefschetz fixed point theorem; Topological duality and fixed point theory; Why bicategories?; Duality for parametrized modules; Classical fixed point theory; Duality for fiberwise parametrized modules; Fiberwise fixed point theory; A review of bicategory theory; Index; Index of notation; Bibliography.

Astérisque, Number 333

August 2010, 102 pages, Softcover, ISBN: 978-2-85629-293-8, **Individual member US$40.50**, List US$45, Order code AST/333

Differential Equations



Creation of Fermions by Rotating Charged Black Holes

Dietrich Häfner, *Université Bordeaux 1, Talence, France*

This work is devoted to the mathematical study of the Hawking effect for fermions in the setting of the collapse of a rotating charged star. The author shows that an observer who is located far away from the star and at rest with respect to the Boyer–Lindquist coordinates observes the emergence of a thermal state when his proper time goes to infinity.

The author first introduces a model of the collapse of the star. He supposes that the space-time outside the star is given by the Kerr–Newman metric. The assumptions on the asymptotic behavior of the surface of the star are inspired by the asymptotic behavior of certain timelike geodesics in the Kerr–Newman metric. The Dirac equation is then written using coordinates and a Newman–Penrose tetrad, which are adapted to the collapse. This coordinate system and tetrad are based on the so-called simple null geodesics. The quantization of Dirac fields in a globally hyperbolic space-time is described.

The author formulates and proves a theorem about the Hawking effect in this setting. The proof of the theorem contains a minimal velocity estimate for Dirac fields that is slightly stronger than the usual ones and an existence and uniqueness result for solutions of a characteristic Cauchy problem for Dirac fields in the Kerr–Newman space-time. In an appendix the author constructs explicitly a Penrose compactification of block *I* of the Kerr–Newman space-time based on simple null geodesics.

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

A publication of the Société Mathématique de France, Marseilles (SMF), distributed by the AMS in the U.S., Canada, and Mexico. Orders from other countries should be sent to the SMF. Members of the SMF receive a 30% discount from list.

Contents: Introduction; Strategy of the proof and organization of the article; The model of the collapsing star; Classical Dirac fields; Dirac quantum fields; Additional scattering results; The characteristic Cauchy problem; Reductions; Comparison of the dynamics; Propagation of singularities; Proof of the main theorem; Bibliography.

Mémoires de la Société Mathématique de France, Number 117

October 2010, 158 pages, Softcover, ISBN: 978-2-85629-284-6, 2010 *Mathematics Subject Classification:* 35P25, 35Q75, 58J45, 83C47, 83C57, 83C60, **Individual member US$37.80**, List US$42, Order code SMFMEM/117

AMERICAN MATHEMATICAL SOCIETY

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Contact: Membership and Programs Department, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294 USA; telephone: 800-321-4267, ext. 4139 (U.S. and Canada) or 401-455-4139 (worldwide); email: bookdonations@ams.org

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CALIFORNIA

UNIVERSITY OF CALIFORNIA, IRVINE
Department of Mathematics
Irvine, CA 92697-3875
Job #5096–Assistant Professor-level positions in mathematics

The Department of Mathematics at the University of California, Irvine, is seeking outstanding candidates to fill one or more (pending budgetary considerations) tenure-track positions to start July 1, 2011. The positions may be upgraded to a tenured position for extraordinarily strong candidates. Applicants must hold a Ph.D. and should have demonstrated excellence in research and teaching. We encourage applications from any area in pure and applied mathematics. The level of appointment will be commensurate with qualifications and experience. Applications are welcome at any time. The review process starts December 1, 2010, and will continue until positions are filled.

Completed applications must be submitted electronically and must contain:

(1) AMS cover sheet
(2) Curriculum Vitae
(3) Cover letter
(4) Research statement
(5) Teaching statement
(6) Selected reprints and/or preprints
(7) Three reference letters sent electronically through: `http://www.mathjobs.org`, or emailed to: `recruit@math.uci.edu`. Reference Job #5096 in subject line of all correspondence.

Instructions for the electronic application process can be found at: `http://www.mathjobs.org`.

Indicate your area of mathematical specialization in field labeled "Area of Specialization" for example: "Applied & Computational Mathematics".

UCI is an Equal Opportunity Employer committed to excellence through diversity and strongly encourages applications from all qualified applicants, including women and minorities.

000011

INDIANA

INDIANA UNIVERSITY PURDUE UNIVERSITY INDIANAPOLIS
Tenure-Track Positions in Mathematics and Statistics

The IUPUI Department of Mathematical Sciences invites applications for several tenure-track faculty positions in pure math, applied math and statistics to begin August 1, 2011. A Ph.D. (or completion by date of appointment) in mathematics, statistics, or a related field, as well as a demonstrated potential for excellence in research and in teaching are required. Rank and salary will be commensurate with qualifications. For more detailed information, as well as minimum qualifications, see: `http://www.math.iupui.edu/employment/`. Apply online at: `mathjobs.org`. A complete application must includ e: letter of interest, curriculum vitae, statements of research and teaching philosophy, and three letters of recommendation. Screening of completed applications will begin on November 30, 2010, and will continue until all approved positions are filled. IUPUI is an EEO/AA Employer, M/F/D.

000012

KANSAS

KANSAS STATE UNIVERSITY
Department of Mathematics

Applications are invited for a Visiting Assistant Professorship commencing August 7, 2011. These will be annual appointments with the possibility of two subsequent one-year appointments

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 2010 rate is $3.25 per word. 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 2011 issue–November 29, 2010; March 2011 issue–December 28, 2010; April 2011 issue–January 30, 2011; May 2011 issue–February 28 2011; June/July 2011 issue–April 28, 2011; August 2011 issue–May 27, 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.

depending on performance, funding, and need of services. A Ph.D. in mathematics or a Ph.D. dissertation accepted with only formalities to be completed is required by the time of appointment. The department seeks candidates whose research interests mesh well with current faculty. The department has research groups in algebra, analysis, differential equations, geometry/topology, and number theory. Successful candidates are expected to participate in the department's programs integrating undergraduate and graduate research, including mentoring undergraduate students during summer programs. The successful candidate should have strong research credentials as well as strong accomplishments or promise in teaching, 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 or potential. All application materials must be submitted electronically via: http://www.mathjobs.org. Screening of applications begins December 1, 2010, and continues until positions are 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.

000002

KANSAS STATE UNIVERSITY
Department of Mathematics

Applications are invited for a tenure-track assistant professor position to commence August 7, 2011, 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 mathematics and its applications. 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, 2010, 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.

000003

KANSAS STATE UNIVERSITY
Department of Mathematics

Applications are invited for a tenure-track assistant professor position to commence August 7, 2011, with salary commensurate with qualifications. A Ph.D. in mathematics is required. The department seeks candidates whose research interests are in geometry. 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 8, 2010, 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.

000004

UNIVERSITY OF KANSAS
Department of Mathematics
Assistant Professor

Applications are invited for a tenure-track assistant professor position in Fourier analysis or differential equations/dynamical systems expected to begin as early as August 18, 2011. Ph.D. or ABD in math or a related field is expected by the start date of the appointment; commitment to excellence in teaching in mathematics; and commitment to excellence in research. Apply online at: http://jobs.ku.edu, search for position 00002070. Review of applications will begin on November 15, 2010, and continues as long as needed to identify a qualified pool. EO/AA Employer.

000005

UNIVERSITY OF KANSAS
Department of Mathematics

Applications are invited for the Robert D. Adams Visiting Assistant Professor positions expected to begin as early as August 18, 2011. These are term positions, initially for one academic year and renewable for a second year with the expectation that one additional one-year appointment is possible. Preference will be given to candidates in differential equations/dynamical systems, numerical analysis and commutative algebra/algebraic geometry. Ph.D. or ABD in math or a related field is expected by the start date of the appointment; commitment to excellence in teaching in mathematics; and commitment to excellence in research. Apply online at: http://jobs.ku.edu, search for position 00002891. Review of applications will begin on November 15, 2010, and continues as long as needed to identify a qualified pool. EO/AA Employer.

000006

MASSACHUSETTS

UNIVERSITY OF MASSACHUSETTS
AMHERST
Department of Mathematics and Statistics

The Department of Mathematics and Statistics (http://www.math.umass.edu) invites applications for three-year visiting assistant professor/lecturer positions (non-tenure-track) to start September 1, 2011. Candidates should have completed the Ph.D. by the beginning of the appointment. Exceptional promise in research and a commitment to outstanding teaching at all levels of the curriculum are expected. The search will encompass the following areas: algebra and number theory, algebraic geometry, analysis and partial differential equations, applied and computational mathematics, differential geometry and topology, mathematical physics, probability, representation theory and Lie theory, and statistics. Applications should be submitted electronically through the AMS website: http://MathJobs.org. Alternatively, applicants may send a curriculum vitae and research and teaching statements, and arrange to have three letters of recommendation sent, to: Search Committee, Department of Mathematics and Statistics, Lederle Graduate Research Center, 710 North Pleasant St., Amherst, MA 01003-9305. Review of applications will begin January 18, 2011. Applications will continue to be accepted until all positions are filled. The department is committed to the development of a diverse faculty, student body, and workplace; women and members of minority groups are encouraged to apply. The University of Massachusetts is an Affirmative Action/Equal Opportunity Employer.

000013

MICHIGAN

WAYNE STATE UNIVERSITY
Department of Mathematics

Tenure-track position for fall 2011 in algebra, but exceptional candidates from any area of mathematics are welcome to apply. Applications should include a signed, detailed vita, description of current

research interests, and four letters of recommendation, one of which should address teaching.

There is also a possibility of a visiting position for the 2011-2012 academic year.

The position is posted at: http://jobs.wayne.edu. Applicants must apply online through this website. For further information, please consult the department's website, http://www.math.wayne.edu.

Wayne State University is an Equal Opportunity/Affirmative Action Employer.

000001

MINNESOTA

UNIVERSITY OF MINNESOTA
School of Mathematics

The School of Mathematics of the University of Minnesota is seeking outstanding candidates for 2-4 tenured or tenure-track faculty positions starting fall semester 2011. Candidates should have a Ph.D. or equivalent degree in mathematics or a closely related field and excellent records in both research and teaching.

For full consideration, applications and all supporting materials must be submitted electronically through: http://www.mathjobs.org by January 1, 2011. Applications received after the deadline will be considered as positions remain.

Applicants must include the following: Cover letter, Curriculum vitae, at least 4 letters of recommendation, one of which should address teaching ability, and a research and teaching statement. Reference letter writers should be asked to submit their letters on line through: http://mathjobs.org. If they are unable to do so, they may send their letters to the above mentioned address. In addition to your MathJobs application, the University of Minnesota requires all applicants to register at the website: http://employment.umn.edu. At this site you should first click on the link "Search Positions". Enter Requisition Number 169056 for tenure-track positions and 169055 for tenured positions. When the job listing appears click the "View" link in the Position Title field and then the button "Apply for this Posting". At this point you will be prompted to "Fill out a new Application".

In your application, you should enter your name and optional demographic information. It is not necessary to fill out your complete contact information or to submit your other application material to this site.

The University of Minnesota is an Equal Opportunity Employer/Educator.

000015

NEW JERSEY

RUTGERS UNIVERSITY-CAMDEN
Department of Mathematical Sciences

The Department of Mathematical Sciences at Rutgers University-Camden invites applications for a tenure-track position at the assistant professor level. Candidates with strong background in analysis and an established research record are encouraged to apply. The department is particularly interested in applicants whose research activities are related to the current faculty research areas such as differential equations, dynamical systems, stochastic processes, and geometric control theory. The appointee should have a good potential to interact with our Center for Computational and Integrative Biology and its newly established Ph.D. program. Appointment is effective July 1, 2011. Application material, which must include a current vita, a statement of research plan, and at least three letters of recommendation should be sent to: Search Committee, Department of Mathematical Sciences, Rutgers University, Camden, NJ 08102. Rutgers University is an Equal Opportunity Employer. Qualified women and minority group members are urged to apply.

000116

OHIO

CASE WESTERN RESERVE UNIVERSITY
Department of Mathematics

The Department of Mathematics at Case Western Reserve University anticipates at least one new tenure-track position (rank open, junior preferred). Applications are encouraged from any area of applied, computational, or interdisciplinary mathematics. Preference will be given to candidates whose research areas will augment and broaden one or more of the applied research groups active in the department, which include imaging, life sciences, probability and its applications, and scientific computing. Demonstrated excellence in teaching and a strong research record is required for consideration at the rank of associate professor. A strong record in mentoring and leadership is required for consideration at the rank of professor. All candidates should hold a Ph.D. in mathematics or a related field by the time of appointment, have demonstrated teaching experience, and a publication record appropriate to rank. The normal teaching load is two courses per semester.

Candidates should submit a letter of application, curriculum vitae, a statement of teaching philosophy and experience, evidence of teaching excellence, and a statement of current and future research plans. In addition, they should arrange for three letters of recommendation to be submitted directly by writers. All application materials should be submitted electronically through the AMS website mathjobs.org or mailed to:

Faculty Search
Department of Mathematics
Case Western Reserve University
10900 Euclid Avenue
Cleveland, OH 44106-7058

More detailed information regarding the department may be found on our website: http://www.cwru.edu/artsci/math/.

In employment, as in education, Case Western Reserve University is committed to Equal Opportunity and Diversity. Women, veterans, members of underrepresented minority groups, and individuals with disabilities are encouraged to apply. Case Western Reserve University is supportive of the needs of dual career couples and is an Equal Opportunity /Affirmative Action Employer. Application will be reviewed upon arrival. Applications received by December 15, 2010, will be given full consideration.

Case Western Reserve University is located in the University Circle cultural district of Cleveland Ohio, home of the internationally famous Cleveland Orchestra, the Cleveland Museum of Art, the Cleveland Institute of Music, and the Cleveland Institute of Art. Within a five-mile radius of campus are the nation's second largest theater district, multiple professional sports teams, a wide range of musical, artistic, and culinary venues, and numerous, diverse communities in which to live.

Items to be submitted with the application:

- AMS Cover Sheet
- Curriculum Vitae
- Publication List
- Research Statement
- Teaching Statement
- 3 Reference Letters (submitted directly by writers)

000008

CASE WESTERN RESERVE UNIVERSITY
Department of Mathematics

The Department of Mathematics at Case Western Reserve University anticipates at least one new tenure-track position (rank open, junior preferred). Applications are encouraged in all areas of mathematics; applicants whose areas of research will augment and broaden the department's strengths are particularly encouraged. Currently active areas of research in the department include algebra, analysis, geometry and probability. Demonstrated excellence in teaching and a strong research record is required for consideration at the rank of associate professor. A strong record in mentoring and leadership is required for consideration at the rank of professor. All candidates should hold a Ph.D. in mathematics by the time of appointment, have demonstrated teaching experience, and a publication record

appropriate to rank. The normal teaching load is two courses per semester.

Candidates should submit a letter of application, curriculum vitae, a statement of teaching philosophy and experience, evidence of teaching excellence, and a statement of current and future research plans. In addition, they should arrange for three letters of recommendation to be submitted directly by writers. All application materials should be submitted electronically through the AMS website mathjobs.org or mailed to:

Faculty Search
Department of Mathematics
Case Western Reserve University
10900 Euclid Avenue
Cleveland, OH 44106-7058

More detailed information regarding the department may be found on the website: http://www.cwru.edu/artsci/math/.

In employment, as in education, Case Western Reserve University is committed to Equal Opportunity and Diversity. Women, veterans, members of underrepresented minority groups, and individuals with disabilities are encouraged to apply. Case Western Reserve University is supportive of the needs of dual career couples and is an Equal Opportunity /Affirmative Action Employer. Applications will be reviewed upon arrival. Applications received by December 15, 2010, will be given full consideration.

Case Western Reserve University is located in the University Circle cultural district of Cleveland Ohio, home of the internationally famous Cleveland Orchestra, the Cleveland Museum of Art, the Cleveland Institute of Music, and the Cleveland Institute of Art. Within a five-mile radius of campus are the nation's second largest theater district, multiple professional sports teams, a wide range of musical, artistic, and culinary venues, and numerous, diverse communities in which to live.

Items to be submitted with the application:

· AMS Cover Sheet
· Curriculum Vitae
· Publication List
· Research Statement
· Teaching Statement
· 3 Reference Letters (submitted directly by writers)

000009

OKLAHOMA

UNIVERSITY OF CENTRAL OKLAHOMA
John T. Beresford Endowed Chair in Mathematics & Statistics

The University of Central Oklahoma invites applications for a tenure-track assistant professor in pure or applied mathematics starting August 8, 2011: the John T. Beresford Endowed Chair in Mathematics & Statistics. Duties include teaching day/evening classes, graduate/undergraduate courses, scholarly activities, and service. In particular, the successful applicant will be expected to engage in teaching and research in an area of mathematics that supports the computer science discipline. Representatives from the Personnel Committee will be attending the Joint Meetings in January. Applicants must be eligible to work in the United States. To apply, submit materials online to: http://jobs.uco.edu. UCO is AA/EOE. UCO strongly promotes diversity.

000007

CHINA

EAST CHINA NORMAL UNIVERSITY
Center for Partial Differential Equations
Applicants for Postdoctoral Positions

The successful candidates are expected to be young researchers with Ph.D. degrees in mathematics or related areas, with a strong research record in at least one of the following areas: analysis/computation/modeling. More information about the positions as well as the introduction of the Center are available at: http://postdoctor.ecnu.edu.cn/details.aspx?id=31.

000111

CYPRUS

UNIVERSITY OF CYPRUS
Department of Mathematics and Statistics

The Department invites applications for one position in algebra or geometry at the rank of lecturer or assistant professor. The language of instruction at the department is Greek. The deadline for applications is February 14, 2011. For more information, see: http://www.ucy.ac.cy/goto/mathstatistics/en-US/HOME.aspx,.

000014

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 2011-2012 post-doctoral positions.

There is also the Institute of Mathematics Research Scholar position for young Ph.D. with exceptional research potential. This recently established position has the duration of 4-5 years.

Application for regular (resp. postdoctoral and Research Scholar) positions completed by Jan. 15, 2011 (resp. May 31, 2011) will be given full considerations.

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
6F, Astronomy-Mathematics Building
No.1, Sec. 4, Roosevelt Rd.
Taipei 10617, 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.

000016

NATIONAL TSING HUA UNIVERSITY
Department of Mathematics

The Department of Mathematics at National Tsing Hua University of Taiwan invites applications for all levels of faculty positions in pure and applied mathematics. Applications received by January 1, 2011, are given full consideration, but all applications are considered until positions are filled. Send signed cover letter, CV, research statement, three letters of recommendation, copies of publications to: Chairman, Department of Mathematics, National Tsing Hua University, 101 Kuang Fu Road, Hsinchu 300, Taiwan. For more information, visit our webpage: http://www.math.nthu.edu.tw.

000120

Call for Conference Proposals 2012 MRC Conferences

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.

The American Mathematical Society (AMS) invites individuals and groups of individuals to serve as organizers of summer conferences of the Mathematics Research Communities (MRC) program to be held in Snowbird, Utah, in the summer of 2012. The MRC program is funded by a grant from the National Science Foundation.

About the Mathematics Research Communities program

Mathematics Research Communities, a program of the American Mathematical Society, nurtures early-career mathematicians—those who are close to finishing their doctorate 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 a one-week summer conference for each topic, Special Sessions at the national meeting, discussion networks by research topic, 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 United States 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 www.ams.org/amsmtgs/mrc.html.

The dates for the MRC conferences in summer 2012 are June 10–16, June 17–23, and June 24–30. The program pays for air transportation for all participants and organizers, up to US$630 in 2012, transportation by van from the Salt Lake City airport to the resort and back, as well as room and board for the stay at Snowbird. Each organizer receives an honorarium of US$3,000. Additionally, each organizing committee has the option of choosing a graduate student to assist with work before and during the conference, for an honorarium of US$3,000. Young mathematicians should apply to be participants in the MRC program by March 1, 2012. The organizers of each summer conference choose among these applicants during the month of March, 2012, 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 Submit a Proposal

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 five (5) pages long.

(3) Organization of the week of the summer conference.

Preparation and submission guidelines are available at `http://www.ams.org/programs/research-communities/Guidlines_for_2012_MRC_proposals_v1.pdf`. The current MRC Advisory Board members are listed at `http://www.ams.org/programs/research-communities/mrc-contact`.

Send inquiries and proposals to:

Mathematics Research Communities
American Mathematical Society
by email: `mrc2012@ams.org`
by mail: 201 Charles Street, Providence, RI 02904
by fax: 401-455-4004

Dates for 2012 MRCs

June 10–16, June 17–23, June 24–30

Deadlines for 2012 MRCs

Intent to submit proposal: **March 1, 2011**
Proposals: **April 1, 2011**

All individuals who submit proposals will be notified of the decisions before Monday, August 1, 2011.

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 `www.snowbird.com`.

— Ellen J. Maycock Associate Executive Director
Meetings and Professional Services

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 223 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 223. 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.

Pucón, Chile

December 15–18, 2010

Wednesday – Saturday

Meeting #1066

First Joint International Meeting between the AMS and the Sociedad de Matematica de Chile.
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: August 2010
Program first available on AMS website: Not applicable
Program issue of electronic *Notices*: Not applicable
Issue of *Abstracts*: Not applicable

Deadlines

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

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/internmtgs.html`.

AMS Invited Addresses

Ricardo Baeza, Universidad de Talca, Chile, *p-cohomological dimension of fields of characteristic p*.

Igor Dolgachev, University of Michigan, *Cremona groups and their subgroups*.

Andres Navas, Universidad de Santiago de Chile, *Probabilistic, dynamical and topological aspects of orderable groups*.

Rodolfo Rodriguez, Universidad de Concepcion, *Numerical approximation of the spectrum of the curl operator*.

Gunther Uhlmann, University of Washington, *Inside-out: Inverse problems*.

S. R. Srinivasa Varadhan, New York University, *Large deviations*.

AMS Special Sessions

Algebra and Model Theory, **Thomas Scanlon**, University of California, Berkeley, **Xavier Vidaux**, Universidad de Concepcion, **Charles Steinhorn**, Vassar College, and **Alf Onshuus**, Universidad de los Andes, Columbia.

Algebraic Modeling of Knotted Objects, **Vaughan F. R. Jones**, University of California, Berkeley, **Jesús Juyumaya**, Universidad de Valparaìso, **Louis H. Kauffman**, University of Illinois at Chicago, and **Sofia Lambropoulou**, National Technical University of Athens.

Applications of Differential and Difference Equations in Biology and Ecology, **J. Robert Buchanan**, Millersville University, **Fernando Córdova**, Universidad Católica de Maule, and **Jorge Velasco Hernandez**, Institute Nacional de Petroleo.

Arithmetic of Quadratic Forms and Integral Lattices, **Maria Ines Icaza**, Universidad de Talca, Chile, **Wai Kiu Chan**, Wesleyan University, and **Ricardo Baeza**, Universidad de Talca, Chile.

Automorphic Forms and Dirichlet Series, **Yves Martin**, Universidad de Chile, and **Solomon Friedberg**, Boston College.

Complex Algebraic Geometry, **Giancarlo Urzua** and **Eduardo Cattani**, University of Massachusetts.

Foliations and Dynamics, **Andrés Navas**, Universidad de Santiago de Chile, and **Steve Hurder**, University of Illinois at Chicago.

Group Actions: Probability and Dynamics, **Andrés Navas**, Universidad de Santiago de Chile, and **Rostislav Grigorchuk**, University of Texas.

Inverse Problems and PDE Control, **Matias Courdurier**, Pontificia Universidad Católica de Chile, **Axel Osses**, Universidad de Chile, and **Gunther Uhlmann**, University of Washington.

Non-Associative Algebras, **Alicia Labra**, Universidad de Chile, and **Kevin McCrimmon**, University of Virginia.

Probability and Mathematical Physics, **Hui-Hsiung Kuo**, Louisiana State University, and **Rolando Rebolledo**, Pontificia Universidad Católica de Chile.

Representation Theory, **Jorge Soto Andrade**, Universidad de Chile, and **Philip Kutzko**, University of Iowa.

Spectral Theory and Mathematical Physics, **Bruno Nachtergaele**, University of California, Davis, and **Rafael Tiedra**, Pontificia Universidad Católica de Chile.

New Orleans, Louisiana

New Orleans Marriott and Sheraton New Orleans Hotel

January 6–9, 2011

Thursday – Sunday

Meeting #1067

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

Statesboro, Georgia

Georgia Southern University

March 12–13, 2011

Saturday – Sunday

Meeting #1068

Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: January 2011
Program first available on AMS website: January 27, 2011
Program issue of electronic *Notices*: March 2011
Issue of *Abstracts*: Volume 32, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: January 20, 2011

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Jason A. Behrstock, Lehman College (CUNY), *The quasi-isometric classification of 3-manifold groups.*

Gordana Matic, University of Georgia, *Title to be announced.*

Jeremy T. Tyson, University of Illinois at Urbana-Champaign, *Sobolev mappings into metric spaces.*

Brett D. Wick, Georgia Institute of Technology, *The Corona Problem.*

Special Sessions

Advances in Biomedical Mathematics (Code: SS 4A), **Yangbo Ye**, University of Iowa, and **Jiehua Zhu**, Georgia Southern University.

Advances in Optimization (Code: SS 20A), **Goran Lesaja**, Georgia Southern University.

Algebraic Geometry (Code: SS 18A), **Jing Zhang**, State University of New York at Albany, **Roya Beheshti Zavareh**, Washington University in St Louis, and **Qi Zhang**, University of Missouri at Columbia.

Algebraic and Geometric Combinatorics (Code: SS 13A), **Drew Armstrong**, University of Miami, and **Benjamin Braun**, University of Kentucky.

Applied Combinatorics (Code: SS 2A), **Hua Wang**, Georgia Southern University, **Miklos Bona**, University of Florida, and **Laszlo Szekely**, University of South Carolina.

Categorical Topology (Code: SS 9A), **Frederic Mynard**, Georgia Southern University, and **Gavin Seal**, EPFL, Lausanne.

Control Systems and Signal Processing (Code: SS 14A), **Zhiqiang Gao**, Cleveland State University, **Frank Goforth**, Georgia Southern University, **Thomas Yang**, Embry-Riddle Aeronautical University, and **Yan Wu**, Georgia Southern University.

Dynamic Equations on Time Scales with Applications (Code: SS 17A), **Billur Kaymakcalan**, Georgia Southern University, and **Bonita Lawrence**, Marshall University.

Fractals and Tilings (Code: SS 3A), **Ka-Sing Lau**, The Chinese University of Hong Kong, **Sze-Man Ngai**, Georgia Southern University, and **Yang Wang**, Michigan State University.

Geometric Group Theory (Code: SS 7A), **Xiangdong Xie**, Georgia Southern University, **Jason A. Behrstock**, Lehman College, CUNY, and **Denis Osin**, Vanderbilt University.

Geometric Mapping Theory in Euclidean and Non-Euclidean Spaces (Code: SS 11A), **Jeremy Tyson**, University of Illinois at Urbana-Champaign, **David A. Herron**, University of Cincinnati, and **Xiagdong Xie**, Georgia Southern University.

Harmonic Analysis and Applications (Code: SS 5A), **Dmitriy Bilyk**, University of South Carolina, **Laura De Carli**, Florida International University, **Alex Stokolos**, Georgia Southern University, and **Brett Wick**, Georgia Institute of Technology.

Harmonic Analysis and Partial Differential Equations (Code: SS 1A), **Paul A. Hagelstein**, Baylor University, **Alexander Stokolos**, Georgia Southern University, **Xiaoyi Zhang**, IAS Princeton and University of Iowa, and **Shijun Zheng**, Georgia Southern University.

Homological Methods in Commutative Algebra (Code: SS 6A), **Alina C. Iacob**, Georgia Southern University, and **Adela N. Vraciu**, University of South Carolina.

Low Dimensional Topology and Contact and Symplectic Geometry (Code: SS 19A), **Gordana Matic**, University of Georgia, and **John Etnyre**, Georgia Institute of Technology.

Matrix Theory and Numerical Linear Algebra (Code: SS 8A), **Richard S. Varga**, Kent State University, and **Xiezhang Li**, Georgia Southern University.

Nonlinear Analysis of PDEs (Code: SS 15A), **Ronghua Pan**, Georgia Institute of Technology, **Tristan Roy**, Institiute for Advanced Study, and **Shijun Zheng**, Georgia Southern University.

Set-theoretic Topology (Code: SS 16A), **Frederic Mynard**, Georgia Southern University, and **Peter Nyikos**, University of South Carolina.

Sparse Data Representations and Applications (Code: SS 10A), **Alexander Petukhov** and **Alex Stokolos**, Georgia Southern University, **Ahmed Zayed**, DePaul University, and **Inna Kozlov**, Holon Institute of Technology, Department of Computer Science.

Symplectic and Poisson Geometry (Code: SS 12A), **Yi Lin**, Georgia Southern University, **Alvaro Pelayo**, Washington University, St. Louis, and **Francois Ziegler**, Georgia Southern University.

Accommodations

Participants should make their own arrangements directly with the properties listed below. Special rates for the meeting are available at the properties shown below for the period of March 11–13, 2011. When making reservations **participants should state that they are with the American Mathematical Society (AMS)**. Hotels have varying cancellation or early checkout penalties; be sure to ask for details when making your reservation. The room rates listed do not include applicable taxes; the current tax rate on hotel rooms is 12%. To guarantee a room reservation, we advise making your travel plans early.

A **shuttle service** between the airport (SAV) and the six hotels below has been arranged by the local coordinators. There will also be a limited bus service between these six hotels and the buildings where the meeting will take place:

Best Western University Inn, 1 Jameson Avenue, Statesboro, Georgia, 30458. Phone: 912-681-7900; fax: 912-681-7905; http://www.bestwestern.com/. US$52.50 per night, single/double occupancy. Amenities include complimentary breakfast, free wireless Internet access, and free parking; approximately 0.3 mile (5–10 minute walk) from the College of Information Technology Building.

Baymont Inn and Suites, 425 South Main Street, Statesboro, Georgia, 30458. Phone: 912-489-7368; fax: 912-489-3081; http://www.baymontstatesboro.com. US$69 per night, single/double occupancy. When you make your reservation please cite the **group code AMEMAT**. Cancellation must be made seven days prior to arrival to avoid being charged for the first night. Amenities include complimentary hot breakfast, computer in every room with free Internet access, free long distance phone calls, and free parking; approximately one mile (15–20 minute walk) from the College of Information Technology Building. **The deadline for reservations is 30 days prior to arrival.**

Hampton Inn, 616 Fair Road, Statesboro, Georgia, 30458. Phone: 912-681-7700; fax: 912-681-9677; http://www.hampton-inn.com/hi/statesboro. US$69 per night, one to four persons in a room. Amenities include complimentary hot breakfast, free wireless Internet access, and free parking; approximately 1.2 miles (15–20 minute walk) from the College of Information Technology building.

Howard Johnson Inn and Suites, 316 South Main Street, Statesboro, Georgia, 30458. Phone: 912-489-2626; fax: 912-764-6030; http://www.hojo.com. US$49.99 per night, single/double occupancy. Every room includes microwave oven, refrigerator, iron and ironing board, and hair dryer. Amenities include complimentary continental breakfast, free wireless Internet access, and free parking; approximately 1.3 miles (20–25 minute walk) from the College of Information Technology Building.

La Quinta Inn, 225 Lanier Drive, Statesboro, Georgia, 30458. Phone: 912-871-2525; fax: 912-871-3535; http://www.896.lq.com. US$55 per night, one to four persons in a room. When you make your reservation please cite **group number 138**. Amenities include complimentary hot breakfast, free wireless Internet access, and complimentary parking; approximately 1.5 miles (20-25 minute walk) from the College of Information Technology Building. **The deadline for reservations is December 15, 2010.**

Statesboro Quality Inn and Suites, 230 South Main Street, Statesboro, GA 30458. Phone: 912-489-3995; fax: 912-489-4157; http://www.qualityinnstatesboro.com. US$50.99 per night, single/double occupancy. Amenities include complimentary breakfast, free wireless Internet access, 10% discount at onsite restaurant Manny's Neighborhood Grille, and free parking; approximately 1.4 miles (25–30 minute walk) from the College of Information Technology Building.

Participants who drive to Statesboro may also consider the following hotels. However, no shuttle or bus service has been arranged to or from these hotels, although they are not too far from the campus, ranging from two to five miles.

Spring Hill Suites Statesboro, 105 Springhill Dr. Statesboro, GA 30458, Phone: 800-230-4134; http://www.hotelplanner.com/Hotels/271510-Statesboro/Deal-Springhill-Stes-Statesboro-105-Springhill-Dr-30458.

Holiday Inn Statesboro—University area, 455 Commerce Drive, Statesboro, GA 30458. Phone: 912-489-4545;

http://www.holidayinn.com/hotels/us/en/statesboro/tbrhi/hoteldetail.

Comfort Inn and Suites, 17870 Hwy 67, Statesboro, GA 30458. Phone: 912-681-2400; http://www.comfortinn.com/hotel-statesboro-georgia-GA380?sid=_M81g.vHEPtgGheg.13.

Local Information and Maps.

Please visit the AMS website at www.ams.org/meetings/sectional/2173_other.html and check the many links for various local area, campus, and on-campus parking maps. Information about the Department of Mathematics may be found at math.georgiasouthern.edu/.

Other Activities

AMS Book Sale: Stop by the on-site AMS bookstore and review the newest titles from the AMS, 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

Parking on campus is free on Saturday, March 12, and Sunday, March 13, and is free after 4:00 p.m. on Friday, March 11. Parking Lots 41 and 42 are closest to the College of Information Technology and the College of Business Administration Buildings, where the sessions will be held.

Registration and Meeting Information

The meeting will take place on the Statesboro campus of Georgia Southern University. All of the activities for the meeting will be held in the College of Information Technology (CIT or IT) and the College of Business Administration (COBA) Buildings. Registration, the AMS book sale, Invited Addresses, and some Special Sessions will be held in CIT, while some Special Sessions will be held in COBA. The registration desk will be open Saturday, March 12, 7:30 a.m.–4:00 p.m., and Sunday, March 13, 8:00 a.m.–noon. Fees are US$50 for AMS members, US$70 for nonmembers; and US$5 for students, unemployed mathematicians, and emeritus members. Fees are payable on-site by cash, check, or credit card.

Travel Information

Statesboro is located in Southeast Georgia, about a 50-minute drive from Savannah/Hilton Head International Airport (SAV) and is 10 minutes due north of Interstate I-16.

By air: The closest airport is Savannah/Hilton Head International Airport (SAV). Participants arriving by air who do not rent a car are encouraged to use the shuttle service arranged by the local coordinators. The shuttle will leave from Savannah Airport to Statesboro on Friday March 11th and take participants back on Sunday, March 13, and Monday, March 14. Participants who take a train or bus to Savannah should consider taking a taxi to the Savannah Airport and catch this shuttle. The shuttle fare is US**$50 round-trip** or US**$30 one-way**. Shuttle tickets may be purchased from Georgia Southern faculty and/or student volunteers at the K-Shuttle (Kelly Tours) counter near the baggage claim area of the airport. Return tickets can also be purchased from the registration desk inside the College of Information Technology Building during the meeting. Only **cash** or a **check** drawn on a U.S. bank will be accepted as payment for the shuttle fare.

Participants whose arrival and/or departure schedule do not permit them to take the shuttle may contact the local coordinators via email at smngai@georgiasouthern.edu on or before March 1, 2011, to make reservations for special shuttle service. The same fares apply. **There is no taxi or other public transportation service from Statesboro back to the airport**.

Special Airport Shuttle Schedule for this Meeting

Friday, March 11, 2011: Leaving Savannah International Airport for Statesboro and dropping off passengers at the following Statesboro hotels only: Hampton Inn, Howard Johnson Inn and Suites, Statesboro Quality Inn and Suites, Baymont Inn and Suites, Best Western University Inn, and La Quinta Inn.

The shuttle will depart from the Savannah International Airport every hour on the hour from 10:00 a.m. through 11 p.m. (and a final departure at 12:30 a.m.), arriving in Statesboro every hour on the hour from 11:00 a.m. through 12 midnight (and a final arrival time at 1:30 a.m.)

Sunday, March 13, 2011: The shuttle will leave from the parking lot adjacent to the College of Information Technology Building and the College of Education Building (**Parking Lot 41**).

The shuttle will depart from the College of Information and Technology every hour on the hour from 10:00 a.m. through 5:00 p.m., arriving at the Savannah International Airport every hour on the hour from 11:00 a.m. through 6:00 p.m.

Monday, March 14, 2011: See the table on the following page. The shuttle will pick up passengers from the indicated six hotels, in the order shown. Please wait outside of the hotel 10 minutes before the scheduled departure time.

Other ways of traveling between Savannah Airport and Statesboro

1) **Rental car**. The following rental car companies are located at the Savannah International Airport: Avis, Budget, Dollar, Enterprise, Hertz, National/Alamo, and Thrifty. For additional information, see http://www.savannahairport.com/airport/ground_transportation/.

2) **Taxi**. One way taxi fare from the airport to Statesboro is approximately US$100-US$120. There is **NO** taxi service from Statesboro to the airport.

By car: Take the interstate I-16 and take exit 116 if you are traveling East (coming from Atlanta/Macon). Turn left on US301/US25 until you reach the entrance of the GSU

Departing from						Arriving at
Hampton Inn	Howard Johnson	Quality Inn	Baymont Inn	Best Western	La Quinta	Savannah International Airport
04:00 am	→	…	…	→	04:10 am	05:10 am
05:30 am	→	…	…	→	05:40 am	06:40 am
07:00 am	→	…	…	→	07:10 am	08:10 am
08:30 am	→	…	…	→	08:40 am	09:40 am
10:00 am	→	…	…	→	10:10 am	11:10 am

campus. If you are traveling West on I-16 (coming from Savannah or from I-95), take exit 127 and take a right on US-67. Stay on US-67 (Fair Road) until you reach an entry to the GSU campus.

Transportation from hotels to campus

A limited free bus service between the College of Information Technology Building and the following will be provided: Hampton Inn, Howard Johnson Inn and Suites, Statesboro Quality Inn and Suites, Baymont Inn and Suites, Best Western University Inn, and La Quinta Inn. The bus will leave the hotels in the early mornings of Saturday, March 12 and Sunday, March 13, and take participants back from College of Information Technology Building to the hotels in the evening.

Weather

The average high temperature in Statesboro for March is 67ºF. (19ºC.); the average low temperature is 46ºF. (8ºC.). The average rainfall during March is about four inches.

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://sites.nationalacademies.org/pga/biso/visas/` and `http://travel.state.gov/visa/visa_1750.html`. If you need a preliminary conference invitation in order to secure a visa, please send your request to `pfs@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.

Iowa City, Iowa

University of Iowa

March 18–20, 2011

Friday–Sunday

Meeting #1069

Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: January 2011
Deadlines for abstracts: January 25, 2011
Program first available on AMS website: February 12, 2011
Issue of *Abstracts:* Volume 32, issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For consideration of contributed papers: Expired
For *Abstracts*: March 8, 2011

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Mihai Ciucu, Indiana University, *Title to be announced.*

David Damanik, Rice University, *Title to be announced.*

Chiu-Chu Liu, Columbia University, *Title to be announced.*

Kevin B. Ford, University of Illinois Urbana-Champaign, *Prime chains, arithmetic functions and branching random walks.*

Special Sessions

Algebraic Combinatorics (Code: SS 19A), **Mihai Ciucu**, Indiana University.

Algebraic K-Theory and Homotopy Theory (Code: SS 8A), **Teena Gerhardt**, Michigan State University, and **Daniel Ramras**, New Mexico State University.

Analytic and Algebraic Number Theory (Code: SS 5A), **Ling Long**, Iowa State University, and **Yangbo Ye**, University of Iowa.

Commutative Ring Theory (Code: SS 6A), **Daniel D. Anderson**, University of Iowa, and **David F. Anderson**, University of Tennessee Knoxville.

Computational Medical Imaging (Code: SS 21A), **Jun Ni** and **Lihe Wang**, University of Iowa.

Geometric Commutative Algebra and Applications (Code: SS 7A), **David Anderson**, University of Washington, and **Julianna Tymoczko**, University of Iowa.

Global and P-adic Representation Theory (Code: SS 3A), **Muthukrishnan Krishnamurthy**, **Philip Kutzco**, and **Yangbo Ye**, University of Iowa.

Graph Theory (Code: SS 17A), **Maria Axenovich**, **Lale Ozkahya**, and **Michael Young**, Iowa State University.

History of Mathematics (Code: SS 13A), **Colin McKinney**, Bradley University.

Modelling, Analysis and Simulation in Contact Mechanics (Code: SS 1A), **Weimin Han**, University of Iowa, and **Mircea Sofonea**, University of Perpignan.

Nonlinear Partial Differential Equations (Code: SS 20A), **Hongjie Dong**, Brown University, and **Dong Li**, **Lihe Wang**, and **Xiaoyi Zhang**, University of Iowa.

Numerical Analysis and Scientific Computing (Code: SS 14A), **Kendall E. Atkinson**, **Bruce P. Ayati**, **Weimin Han**, **Laurent O. Jay**, **Suely Oliveira**, and **David Stewart**, University of Iowa.

Recent Advances in Hyperbolic and Kinetic Problems (Code: SS 15A), **Tong Li**, University of Iowa, and **Hailing Liu**, Iowa State University.

Recent Developments in Nonlinear Evolution Equations (Code: SS 4A), **Yinbin Deng**, Central China Normal University, **Yong Yu** and **Yi Li**, University of Iowa, and **Shuangjie Peng**, Central China Normal University.

Recent Developments in Schubert Calculus (Code: SS 9A), **Leonardo Mihalcea**, Baylor University.

Representations of Algebras (Code: SS 2A), **Frauke Bleher**, University of Iowa, and **Calin Chindris**, University of Missouri.

Spectral Theory (Code: SS 12A), **David Damanik**, Rice University, and **Christian Remling**, University of Oklahoma.

Stochastic Processes with Applications to Mathematical Finance (Code: SS 18A), **Igor Cialenco**, Illinois Institute of Technology, and **José E. Figueroa-López**, Purdue University.

Thin Position (Code: SS 11A), **Jesse Johnson**, Oklahoma State University, and **Maggie Tomova**, University of Iowa.

Topological Problems in Molecular Biology (Code: SS 16A), **Isabel K. Darcy**, University of Iowa, **Stephen D. Levene**, University of Texas at Dallas, and **Jonathan Simon**, University of Iowa.

Universal Algebra and Order (Code: SS 10A), **John Snow**, Concordia University, **Jeremy Alm**, Illinois College, **Clifford Bergman**, Iowa State University, and **Kristi Meyer**, Wisconsin Lutheran College.

Accommodations

Participants should make their own arrangements directly with a hotel of their choice as early as possible. Special rates have been negotiated with the hotels listed below. Rates quoted do not include sales tax of 12%. The AMS is not responsible for rate changes or for the quality of the accommodations. When making a reservation, **participants should state that they are with the American Mathematical Society (AMS) Meeting** at the University of Iowa group. Cancellation and early checkout policies vary; be sure to check when you make your reservation.

Iowa House Hotel, 100 North Madison St., Iowa City, IA, 52242; Phone: 319-335-3513, fax: 319-335-0497; www.iowahousehotel.com. Rates are US$85 per night—single/double and includes parking, wireless Internet, and continental breakfast. The hotel is only about three blocks away from the meeting site on campus. Cancellation and early checkout policies vary; be sure to check when you make your reservation. **The deadline for reservations is February 18, 2011**.

Hotel Vetro Boutique Hotel, 201 S. Linn Street, Iowa City, IA 52240; Phone: 800-848-1335, fax: 319-337-7037; www.hotelvetro.com. Rates are US$119 per night—single/double and includes parking, wireless Internet, and continental breakfast. The hotel is only about three blocks away from the meeting site on campus. Cancellation and early checkout policies vary; be sure to check when you make your reservation. **The deadline for reservations is February 18, 2011**.

Sheraton Iowa City Hotel,100 210 South Dubuque Street, Iowa City, IA 52240; Phone: 319-337-4058, fax: 319-337-7037; www.sheratoniowacity.com. Rates are US$99 per night—single/double and includes parking, Internet, and continental breakfast. The hotel is only about three blocks away from the meeting site on campus. Cancellation and early checkout policies vary; be sure to check when you make your reservation. **The deadline for reservations is February 15, 2011**.

Heartland Inn Hotel; 87 2nd Street, Coralville, IA 52241; Phone: 319-351-8132, fax 319-351-2916; http://www.heartlandinns.com/loc_IowaCity.php. Rates are US$75 per night for a standard two queen or single king

room. Includes free wireless Internet, deluxe continental breakfast, free parking, and an indoor pool. A limited complimentary shuttle to and from the meeting is also being provided by the hotel. The Heartland Inn is about two miles away from the meeting site on the University of Iowa campus. **The deadline for reservations is February 17, 2011**.

Food Service

A list of on-campus and off-campus restaurants will be available at the registration desk.

Other Activities

Book Sales: Stop by the on-site AMS bookstore and review the newest titles from the AMS, 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

Iowa House guests may park at no charge in the IMU Parking Ramp. Fee-based parking is also available near the University's Pentacrest at the parking ramp on the south end of the Old Capitol Center.

Registration and Meeting Information

Registration and AMS Book Exhibit will be held in the Iowa Memorial Union (IMU) Ballroom. Invited Addresses and all other sessions will be held in The IMU Building 3rd floor as well as the Math Department of MacLean Hall. Please refer to the campus map for specific location at `http://www.uiowa.edu/~maps/i/imur1.htm`. The registration desk will be open Friday, March 18th, 12:00 p.m.–4:00 p.m.; Saturday, March 19th, 7:30 a.m.–4:00 p.m. Fees are US$50 for AMS members, US$70 for nonmembers; and US$5 for students, unemployed mathematicians, and emeritus members. Fees are payable on-site via cash, check or credit card.

Travel

By Plane: Nearby airports are located in Cedar Rapids, IA (CID) (22 miles); Moline, IL (MLI) (67 miles); and Des Moines, IA (DSM) (118 miles). Shuttle service is available at the Eastern Iowa Regional Airport (CID) in Cedar Rapids.

By bus: Greyhound bus services are located at 170 E Court Street in Iowa City, Iowa—just a few blocks away from the University of Iowa. Iowa City is not currently serviced by Amtrak.

By car: The University of Iowa is located in Iowa City, IA, 65 miles west of the Mississippi River, along Interstate 80. To reach the central campus, exit Interstate 80 at the Dubuque Street exit (Exit 244) and follow Dubuque Street south along the Iowa River to downtown Iowa City. Turn right on Market Street and then turn left on Madison Street and drive one block to the Iowa Memorial Union. The registration desk will be on the 2nd floor of the IMU.

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 **Avis Discount Number (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 `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

A typical climate summary for the month of March for Iowa City shows an average daily temperature from 27° Fahrenheit to 46° Fahrenheit with a slight chance of snow or rain.

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://sites.nationalacademies.org/pga/biso/visas/` and `http://travel.state.gov/visa/visa_1750.html`. If you need a preliminary conference invitation in order to secure a visa, please send your request to `pfs@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.

Worcester, Massachusetts

College of the Holy Cross

April 9–10, 2011

Saturday – Sunday

Meeting #1070

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: February 2011
Program first available on AMS website: March 10, 2011
Program issue of electronic *Notices*: April 2011
Issue of *Abstracts*: Volume 32, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: December 21, 2010
For abstracts: February 15, 2011

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Vitaly Bergelson, Ohio State University, *Title to be announced.*

Kenneth M. Golden, University of Utah, *Title to be announced.*

Walter D. Neumann, Columbia University, *What does a complex surface really look like?*

Natasa Sesum, University of Pennsylvania, *Title to be announced.*

Special Sessions

Celestial Mechanics (Code: SS 16A), **Glen R. Hall**, Boston University, and **Gareth E. Roberts**, College of the Holy Cross.

Combinatorial Representation Theory (Code: SS 14A), **Cristina Ballantine**, College of the Holy Cross, and **Rosa Orellana**, Dartmouth College.

Combinatorics of Coxeter Groups (Code: SS 19A), **Dana C. Ernst**, Plymouth State University, and **Matthew Macauley**, Clemson University.

Complex Analysis and Banach Algebras (Code: SS 1A), **John T. Anderson**, College of the Holy Cross, and **Alexander J. Izzo**, Bowling Green State University.

Computability Theory and Applications (Code: SS 18A), **Brooke Andersen**, Assumption College.

Dynamics of Rational Systems of Difference Equations with Applications (Code: SS 3A), **M. R. S. Kulenovic** and **O. Merino**, University of Rhode Island.

Geometric and Topological Problems in Curvature (Code: SS 17A), **Megan Kerr** and **Stanley Chang**, Wellesley College.

Geometry and Applications of 3-Manifolds (Code: SS 13A), **Abhijit Champanerkar** and **Ilya Kofman**, College of Staten Island, CUNY, and **Walter Neumann**, Barnard College, Columbia University.

Geometry of Nilpotent Lie Groups (Code: SS 11A), **Rachelle DeCoste**, Wheaton College, **Lisa DeMeyer**, Central Michigan University, and **Maura Mast**, University of Massachusetts-Boston.

History and Philosophy of Mathematics (Code: SS 5A), **James J. Tattersall**, Providence College, and **V. Frederick Rickey**, United States Military Academy.

Interactions between Dynamical Systems, Number Theory, and Combinatorics (Code: SS 9A), **Vitaly Bergelson**, The Ohio State University, and **Dmitry Kleinbock**, Brandeis University.

Mathematical and Computational Advances in Interfacial Fluid Dynamics (Code: SS 15A), **Burt S. Tilley**, Worcester Polytechnic Institute, and **Lou Kondic**, New Jersey Institute of Technology.

Mathematics and Climate (Code: SS 8A), **Kenneth M. Golden**, University of Utah, **Catherine Roberts**, College of the Holy Cross, and **MaryLou Zeeman**, Bowdoin College.

Modular Forms, Elliptic Curves, L-functions, and Number Theory (Code: SS 20A), **Sharon Frechette** and **Keith Ouellette**, College of the Holy Cross.

New Trends in College and University Faculty Engagement in K–12 Education (Code: SS 21A), **Jennifer Beineke**, Western New England College, and **Corri Taylor**, Wellesley College.

Number Theory, Arithmetic Topology, and Arithmetic Dynamics (Code: SS 10A), **Michael Bush**, Smith College, and **Farshid Hajir**, University of Massachusetts, Amherst.

Physically Inspired Higher Homotopy Algebra (Code: SS 4A), **Thomas J. Lada**, North Carolina State University, and **Jim Stasheff**, University of North Carolina, Chapel Hill.

Random Processes (Code: SS 7A), **Andrew Ledoan**, Boston College, and **Steven J. Miller** and **Mihai Stoiciu**, Williams College.

The Algebraic Geometry and Topology of Hyperplane Arrangements (Code: SS 6A), **Graham Denham**, University of Western Ontario, and **Alexander I. Suciu**, Northeastern University.

Topics in Partial Differential Equations and Geometric Analysis (Code: SS 12A), **Maria-Cristina Caputo**, University of Arkansas, and **Natasa Sesum**, Rutgers University.

Topological, Geometric, and Quantum Invariants of 3-manifolds (Code: SS 2A), **David Damiano**, College of the Holy Cross, **Scott Taylor**, Colby College, and **Helen Wong**, Carleton College.

Undergraduate Research (Code: SS 22A), **David Damiano**, College of the Holy Cross, **Giuliana Davidoff**, Mount

Holyoke College, **Steve Levandosky**, College of the Holy Cross, and **Steven J. Miller**, Williams College.

Las Vegas, Nevada

University of Nevada

April 30 – May 1, 2011

Saturday – Sunday

Meeting #1071

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: February 2011
Program first available on AMS website: March 17, 2011
Program issue of electronic *Notices*: April 2011
Issue of *Abstracts*: Volume 32, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: January 1, 2011
For abstracts: March 8, 2011

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Elizabeth Allman, University of Alaska, *Evolutionary trees and phylogenetics: An algebraic perspective*.

Danny Calegari, California Institute of Technology, *Stable commutator length in free groups*.

Hector Ceniceros, University of California Santa Barbara, *Immersed boundaries in complex fluids*.

Tai-Ping Liu, Stanford University, *Hilbert Sixth Problem*.

Special Sessions

Advances in Modeling, Numerical Analysis and Computations of Fluid Flow Problems (Code: SS 2A), **Monika Neda**, University of Nevada, Las Vegas.

Computational Algebra, Groups and Applications (Code: SS 7A), **Benjamin Fine**, Fairfield University, **Gerhard Rosenberger**, University of Hamburg, Germany, and **Delaram Kahrobaei**, City University of New York.

Discrete Dynamical Systems in Graph Theory, Combinatorics, and Geometry (Code: SS 15A), **Eunjeong Yi** and **Cong X. Kang**, Texas A&M University at Galveston.

Extremal Combinatorics (Code: SS 6A), **Jozsef Balogh**, University of California San Diego, and **Ryan Martin**, Iowa State University.

Flow-Structure Interaction (Code: SS 9A), **Paul Atzberger**, University of California Santa Barbara.

Geometric Group Theory and Dynamics (Code: SS 12A), **Matthew Day**, **Danny Calegari**, and **Joel Louwsma**, California Institute of Technology, and **Andy Putnam**, Rice University.

Geometric PDEs (Code: SS 1A), **Matthew Gursky**, Notre Dame University, and **Emmanuel Hebey**, Université de Cergy-Pontoise.

Knots, Surfaces and 3-manifolds (Code: SS 18A), **Stanislav Jabuka**, **Swatee Naik**, and **Chris Herald**, University of Nevada, Reno.

Lie Algebras, Algebraic Transformation Groups and Representation Theory (Code: SS 16A), **Andrew Douglas** and **Bart Van Steirteghem**, City University of New York.

Multilevel Mesh Adaptation and Beyond: Computational Methods for Solving Complex Systems (Code: SS 4A), **Pengtao Sun**, University of Nevada, Las Vegas, and **Long Chen**, University of California Irvine.

Nonlinear PDEs and Variational Methods (Code: SS 11A), **David Costa** and **Hossein Tehrani**, University of Nevada, Las Vegas, and **Zhi_Qiang Wang**, Utah State University.

Partial Differential Equations Modeling Fluids (Code: SS 5A), **Quansen Jiu**, Capital Normal University, Beijing, China, and **Jiahong Wu**, Oklahoma State University.

Recent Advances in Finite Element Methods (Code: SS 3A), **Jichun Li**, University of Nevada, Las Vegas.

Recent Developments in Stochastic Partial Differential Equations (Code: SS 8A), **Igor Cialenco**, Illinois Institute of Technology, and **Nathan Glatt-Holtz**, Indiana University, Bloomington.

Set Theory (Code: SS 14A), **Douglas Burke** and **Derrick DuBose**, University of Nevada, Las Vegas.

Special Session in Arithmetic Dynamics (Code: SS 17A), **Arthur Baragar**, University of Nevada, Las Vegas, and **Patrick Ingram**, University of Waterloo.

Special Session on Computational and Mathematical Finance (Code: SS 13A), **Hongtao Yang**, University of Nevada, Las Vegas.

Topics in Modern Complex Analysis (Code: SS 10A), **Zair Ibragimov**, California State University, Fullerton, **Zafar Ibragimov**, Urgench State University, and **Hrant Hakobyan**, Kansas State University.

Ithaca, New York

Cornell University

September 10–11, 2011

Saturday – Sunday

Meeting #1072

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: June 2011
Program first available on AMS website: July 28, 2011
Program issue of electronic *Notices*: September 2011
Issue of *Abstracts*: Volume 32, Issue 4

Deadlines

For organizers: February 10, 2011
For consideration of contributed papers in Special Sessions: May 24, 2011
For abstracts: July 19, 2011

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Mladen Bestvina, University of Utah, *Title to be announced.*

Nigel Higson, Pennsylvania State University, *Title to be announced.*

Gang Tian, Princeton University, *Title to be announced.*

Katrin Wehrheim, Massachusetts Institute of Technology, *Title to be announced.*

Special Sessions

Difference Equations and Applications (Code: SS 1A), **Michael Radin**, Rochester Institute of Technology.

Parabolic Evolution Equations of Geometric Type (Code: SS 4A), **Xiaodong Cao**, Cornell University, and **Bennett Chow**, University of California, San Diego.

Partial Differential Equations of Mixed Elliptic-Hyperbolic Type and Applications (Code: SS 3A), **Marcus Khuri**, Stony Brook University, and **Dehua Wang**, University of Pittsburgh.

Set Theory (Code: SS 2A), **Paul Larson**, Miami University, Ohio, **Justin Moore**, Cornell University, and **Ernest Schimmerling**, Carnegie Mellon University.

Special Session in Symplectic Geometry and Topology (Code: SS 5A), **Tara Holm**, Cornell University, and **Katrin Wehrheim**, M.I.T.

Winston-Salem, North Carolina

Wake Forest University

September 24–25, 2011

Saturday – Sunday

Meeting #1073

Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: June 2011
Program first available on AMS website: August 11, 2011
Program issue of electronic *Notices*: September 2011
Issue of *Abstracts*: Volume 32, Issue 4

Deadlines

For organizers: February 24, 2011
For consideration of contributed papers in Special Sessions: June 7, 2011
For abstracts: August 2, 2011

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Benjamin B. Brubaker, Massachusetts Institute of Technology, *Title to be announced.*

Shelly Harvey, Rice University, *Title to be announced.*

Allen Knutson, Cornell University, *Title to be announced.*

Seth M. Sullivant, North Carolina State University, *Title to be announced.*

Lincoln, Nebraska

University of Nebraska-Lincoln

October 14–16, 2011

Friday – Sunday

Meeting #1074

Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: August 2011
Program first available on AMS website: September 1, 2011
Program issue of electronic *Notices*: October 2011
Issue of *Abstracts*: Volume 32, Issue 4

Deadlines

For organizers: March 14, 2011
For consideration of contributed papers in Special Sessions: June 28, 2011
For abstracts: August 23, 2011

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Lewis Bowen, Texas A&M University, *Title to be announced.*

Emmanuel Candes, Stanford University, *Title to be announced* (Erdős Memorial Lecture).

Alina Cojocaru, University of Illinois at Chicago, *Title to be announced.*

Michael Zieve, University of Michigan, *Title to be announced.*

Special Sessions

Association Schemes and Related Topics (Code: SS 1A), **Sung Y. Song**, Iowa State University, and **Paul Terwilliger**, University of Wisconsin, Madison.

Salt Lake City, Utah

University of Utah

October 22–23, 2011
Saturday – Sunday

Meeting #1075
Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: August 2011
Program first available on AMS website: September 8, 2011
Program issue of electronic *Notices*: October 2011
Issue of *Abstracts*: Volume 32, Issue 4

Deadlines
For organizers: March 22, 2011
For consideration of contributed papers in Special Sessions: July 5, 2011
For abstracts: August 30, 2011

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Graeme Milton, University of Utah, *Title to be announced.*

Lei Ni, University of California San Diego, *Title to be announced.*

Igor Pak, University of California Los Angeles, *Title to be announced.*

Monica Visan, University of California Los Angeles, *Title to be announced.*

Special Sessions

Geometric Evolution Equations and Related Topics. (Code: SS 2A), **Andrejs Treibergs**, University of Utah, Salt Lake City, **Lei Ni**, University of California San Diego, and **Brett Kotschwar**, Arizona State University.

Special Session on Geometric, Combinatorial, and Computational Group Theory (Code: SS 1A), **Eric Freden**, Southern Utah University, and **Eric Swenson**, Brigham Young University.

Port Elizabeth, Republic of South Africa

Nelson Mandela Metropolitan University

November 29 – December 3, 2011
Tuesday – Saturday

Meeting #1076
First Joint International Meeting between the AMS and the South African Mathematical Society.
Associate secretary: Matthew Miller
Announcement issue of *Notices*: June 2011
Program first available on AMS website: Not applicable
Program issue of electronic *Notices*: Not applicable
Issue of *Abstracts*: Not applicable

Deadlines
For organizers: February 23, 2011
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/internmtgs.html`.

Invited Addresses

Mark J. Ablowitz, University of Colorado, *Title to be announced.*

James Raftery, University of Kwazulu Natal, *Title to be announced.*

Daya Reddy, University of Cape Town, *Title to be announced.*

Peter Sarnak, Princeton University, *Title to be announced.*

Robin Thomas, Georgia Institute of Technology, *Title to be announced.*

Amanda Weltman, University of Cape Town, *Title 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

Honolulu, Hawaii

University of Hawaii

March 3–4, 2012

Saturday – Sunday
Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: March 2012
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 3, 2011
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Tampa, Florida

University of South Florida

March 10–11, 2012

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*: March 2012
Issue of *Abstracts*: To be announced

Deadlines

For organizers: August 10, 2011
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Washington, District of Columbia

George Washington University

March 17–18, 2012

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*: March 2012
Issue of *Abstracts*: To be announced

Deadlines

For organizers: August 17, 2011
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Lawrence, Kansas

University of Kansas

March 30 – April 1, 2012

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*: April 2012
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

Tulane University

October 13–14, 2012

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*: October 2012
Issue of *Abstracts*: To be announced

Deadlines

For organizers: January 13, 2012
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

Ames, Iowa

Iowa State University

April 27–28, 2013

Saturday – 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*: April 2013
Issue of *Abstracts*: To be announced

Deadlines

For organizers: September 27, 2012
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

Operator Algebras and Topological Dynamics (Code: SS 1A), **Andrejs Treibergs**, University of Utah, Salt Lake City, **Lei Ni**, University of California, San Diego, and **Brett Kotschwar**, Arizona State University.

Alba Iulia, Romania

First Joint International Meeting of the AMS and the Romanian Mathematical Society, in partnership with the "Simion Stoilow" Institute of Mathematics of the Romanian Academy.

June 27–30, 2013

Thursday – Sunday
Associate secretary: Robert J. Daverman
Announcement issue of *Notices*: To be announced
Program first available on AMS website: Not applicable
Program issue of electronic *Notices*: Not applicable
Issue of *Abstracts*: Not applicable

Deadlines

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

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
Announcement issue of *Notices*: October 2016
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2017
Issue of *Abstracts*: Volume 38, Issue 1

Deadlines

For organizers: April 1, 2016
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Diego, California

San Diego Convention Center

January 10–13, 2018

Wednesday – Saturday
Associate secretary: Matthew Miller
Announcement issue of *Notices*: October 2017
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 1, 2017
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

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As part of the Society's commitment to the open flow of communication and community engagement, the AMS uses several social networking tools to supplement the channels currently in place for members, press, and the general public. We invite you to follow and share content of interest.

We invite you to use these networks to find news, updates on AMS programs, commentary, and contests; to connect with others who have similar interests; and to communicate with each other and the AMS. Link from **www.ams.org**.

www.ams.org/about-us/social

AMS
American Mathematical Society

Presenters of Papers

New Orleans, Louisiana; January 6–9, 2011

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

∗ *Special Session Speaker,* ⋆ *MAA Retiring Presidential Address,* ■ *NAM Invited Lecturer,* ▲ *SIAM Invited Lecturer,* • *AMS Invited Lecturer,* ◦ *MAA Invited Lecturer,* ◇ *Joint Invited Lecturer,* ◊ *ASL Invited Lecturer,* □ *AWM Emmy Noether Lecturer,* ► *Graduate Student,* ◄ *Undergraduate Student*

►Aazami, A. B. 1760
◦Abbott, S. 1332
►Abernathy, K. 820
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◊Abramsky, S. 1635
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►Adhikari, D. 1862
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∗Agusto, F. B. 656
∗Ahangar, R. R. 91
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∗►Ahmad, M. N. 1411
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∗Ahrendt, C. R. 2046
►Akar, M. 762
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►Al-Sharadqah, A. A. 367
∗Alali, B. 2016
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∗Aldroubi, A. 936
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∗Algom-Kfir, Y. 82
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◄Allenby, M. 2242
►Allison, M. E. 2193
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◄Alpert, H. 700
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∗Anastassiou, G. A. 2041
∗Andersen, K. 39
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∗Anderson, D. E. 1997
∗Anderson, D. R. 2040
∗►Anderson, M. B. 911
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∗Anderson, S. W. 1913
∗Anguelova, I. I. 1373
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∗Annaby, M. H. 937
∗◄Anselm, M. 572
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►Arellano, J. J. 229
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∗►Armond, C. 1423
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∗Asadian, F. 67
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•Auroux, D. 252
∗Avalos, G. 657
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∗Avigad, J. 604
∗Avigad, J. 1665
∗►Avsec, S. 1988
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∗►Badger, M. 1445
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∗Bagci, I. 1362
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∗Baginski, P. 914
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∗Bal, G. 346
∗Ball, J. A. 1672
►Ballif, S. C. 2195
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►Bancroft, E. E. 2199
◄Banks, K. R. 426
∗Bao, E. S. 2015
∗Bao, G. 348
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∗Barbaro, A. 1200
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►Barghi, A. 119
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∗Barker-Plummer, D. 587
∗Barnard, R. W. 1929
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∗Barrow-Green, J. E. 595
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∗Barton, A. E. 1442
∗Basmajian, A. S. 671
∗Basu, S. 1451
►Basyal, D. 1556
∗◄Battista, C. 577
∗Baum, P. F. 777
∗Baum, P. F. 1410
Beanland, K. J. 1878
∗Beattie, M. 1338
∗Beaudrie, B. 864
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∗►Beck, K. A. 646
◄Becker, A. D. 703
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∗Becnel, J. J. 632
Bede, B. 1482
∗►Bedrossian, J. P. 1202
Beezer, R. 1096
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∗Beheshti, R. 889
Behrens, C. 2153
∗Belinfante, J. G. 1155
►Bell, J. R. 1302
◦Bell, R. M. 1895
∗Bellan, P. M. 1192
◄Belli, H. M. 1244
∗►Bellsky, T. 1684
◄Belmont, E. K. 1850
Belock, J. A. 1592
►Ben-Artzi, J. 2266
∗Benedetto, J. J. 621
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∗Beneteau, C. 581
∗Bennett, A. G. 1911
Bennett, C. D. 155
◄Bennett, C. L. 435
∗Bennett, M. A. 877
Benson, P. D. 1620
◄Berchenko-Kogan, Y. I. 2087
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◄Berger, E. 690
∗Berger, H. 2042
Bergner, J. A. 472
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∗Berkesch, C. 1701
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∗Berndt, B. C. 1659
Berndt, R. M. 2280
Bernoff, A. J. 1325
∗Bernoff, A. J. 1437
•Bertozzi, A. L. 1129
∗►Beshaj, L. 337

Program of the Sessions

New Orleans, Louisiana, January 6–9, 2011

Tuesday, January 4

AMS Short Course on Computational Topology, Part I

8:30 AM – 5:00 PM

Organizer: **Afra Zomorodian**, Dartmouth College

7:45AM Registration (outside the Rhythms Ballroom, 2nd Floor).

8:30AM (1) *Persistence: Theory and practice.* **Afra Zomorodian**, Dartmouth College

10:00AM Break.

10:30AM (2) *Topological data analysis.* **Gunnar Carlsson**, Stanford University

1:30PM (3) *Cubical homology and dynamical systems.* **Marian Mrozek**, Jagiellonian University, Poland

3:00PM Break.

3:30PM Software Session.

AMS Short Course on Evolutionary Game Dynamics, Part I

9:00 AM – 5:00 PM

Organizer: **Karl Sigmund**, University of Vienna

7:45AM Registration (outside the Rhythms Ballroom, 2nd Floor).

9:00AM (4) *Introduction to evolutionary games.* **Karl Sigmund**, University of Vienna

10:15AM Break.

10:45AM (5) *Extensive form games, asymmetric games and games with continuous strategy spaces.* **Ross Cressman**, Wilfried Laurier University

2:00PM (6) *Global and unilateral adaptive dynamics.* **Sylvain Sorin**, Université Pierre et Marie Curie, Paris

3:15PM Break.

3:45PM (7) *Deterministic evolutionary game dynamics.* **Josef Hofbauer**, University of Vienna

MAA Short Course on What is a Matroid? Theory and Applications, From the Ground Up, Part I

9:00 AM – 5:00 PM

Organizer: **Nancy Ann Neudauer**, Pacific University

8:00AM Registration (outside the Rhythms Ballroom, 2nd Floor).

9:00AM (8) *Matroids you have known.* **Nancy Ann Neudauer**, Pacific University

9:45AM Break.

10:00AM (9) *Cryptomorphisms and optimization.* **Jenny McNulty**, University of Montana

1:30PM (10) *Matroid representations.* **Gary Gordon**, Lafayette College

3:00PM Break.

3:20PM (11) *Matroid operations.* **Dillon Mayhew**, Victoria University of Wellington

Wednesday, January 5

AMS Department Chairs Workshop

8:00 AM – 6:30 PM

Presenters: **Timothy Hodges**, University of Cincinnati
John Meakin, University of Nebraska-Lincoln
Helen Roberts, Montclair State University
Stephen Robinson, Wake Forest University

AMS Short Course on Computational Topology, Part II

8:30 AM – 5:00 PM

Organizer: **Afra Zomorodian**, Dartmouth College

8:30AM (12) *Euler calculus and data over networks.* **Robert Ghrist**, University of Pennsylvania

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 32, Issue 1 of *Abstracts of papers presented to the American Mathematical Society*, ordered according to the numbers in parentheses following the listings.

10:00AM Break.
10:30AM (13) *Planning with uncertainty.* **Michael Erdmann**, Carnegie Mellon University
1:30PM (14) *Optimal generators.* **Jeff Erickson**, University of Illinois at Urbana-Champaign
3:00PM Break.
3:30PM Panel Discussion.

MAA Ancillary Workshop on Statistics

8:30 AM – 5:00 PM

Teaching introductory statistics following GAISE and the Common Core.
Presenter: **Robert Gould**, University of California Los Angeles

AMS Short Course on Evolutionary Game Dynamics, Part II

9:00 AM – 5:00 PM

Organizer: **Karl Sigmund**, University of Vienna
9:00AM (15) *Stochastic evolutionary game dynamics.* **Bill Sandholm**, University of Wisconsin
10:15AM Break.
10:45AM (16) *Evolution of cooperation in finite populations* **Sabin Lessard**, Université de Montréal
2:00PM Each lecturer will give a 25-minute presentation on some open problems for discussion and interaction.

MAA Short Course on What is a Matroid? Theory and Applications, From the Ground Up, Part II

9:00 AM – 5:00 PM

Organizer: **Nancy Ann Neudauer**, Pacific University
9:00AM (17) *Transversal matroids.* **Joseph Bonin**, The George Washington University
10:30AM Break.
10:45AM (18) *Oriented matroids.* **Winfried Hochstättler**, Fern Universität, Hagen Germany
2:15PM (19) *Research in matroids.* **James Oxley**, Louisiana State University
3:45PM Break.
4:00PM Concluding Session: Tying it together.

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

Thursday, January 6

Joint Meetings Registration

7:30 AM – 4:00 PM

MAA Session on Harnessing Mobile Communication Devices and Online Communication Tools for Mathematics Education, I

7:40 AM – 10:55 AM

Organizers: **Michael B. Scott**, California State University Monterey Bay
Jason A. Aubrey, University of Missouri-Columbia
7:40AM ► (20) *Real Messy Statistics and Survey Monkey.* **Robb Sinn**, North Georgia College & State University (1067-H1-2407)
8:00AM ► (21) *Mobile Jumpstarts in a First Semester Calculus Course.* Preliminary report. **Jason D Holland**, Abilene Christian University (1067-H1-318)
8:20AM ► (22) *Blogging Together: Using a Class Blog to Enhance Learning in a Proof-Writing Class.* **Jill E Jordan**, Houghton College (1067-H1-1336)
8:40AM ► (23) *Mashups for course websites with Yahoo! Pipes.* **Matthew Leingang**, New York University (1067-H1-1791)
9:00AM (24) *Communicating Mathematically Through Podcasts.* **Sherrie Serros***, University of Wisconsin - Eau Claire, **Erick B Hofacker**, University of Wisconsin - River Falls, and **Rebecca Ledocq**, University of Wisconsin - La Crosse (1067-H1-2036)
9:20AM ► (25) *Using iPad class devices as entries into a situationally aware digital library to provide JIT/JIP (Just in Time/Just in Place) Mathematics.* **Frank Wattenberg**, United States Military Academy (1067-H1-2237)
9:40AM (26) *Life After Our 2010 MAA PREP – Emerging Technologies.* **Erick B Hofacker***, **Kathryn T Ernie**, University of Wisconsin - River Falls, **Sherrie Serros**, University of Wisconsin - Eau Claire, **Kay Shager**, University of Wisconsin - River Falls, and **Charles Serros**, University of Wisconsin - Eau Claire (1067-H1-2051)
10:00AM ► (27) *Interactive Math for (Almost) All Devices.* **Andrew J Cousino*** and **Andrew G Bennett**, Kansas State University (1067-H1-2130)
10:20AM ► (28) *On-Demand Mathematics: Creative Uses for Smartpen Technology.* Preliminary report. **Jeremy M Riehl***, **Lee A Evans** and **Kristin M Arney**, United States Military Academy (1067-H1-2186)
10:40AM ► (29) *Using Facebook in a Discrete Mathematics course.* **Klay Kruczek**, Western Oregon University (1067-H1-2206)

AMS-MAA-SIAM Special Session on Research in Mathematics by Undergraduates and Students in Post-Baccalaureate Programs, I

8:00 AM – 10:50 AM

Organizers: **Darren A. Narayan**, Rochester Institute of Technology
Bernard Brooks, Rochester Institute of Technology
Jobby Jacob, Rochester Institute of Technology
Jacqueline A. Jensen, Sam Houston State University
Carl V. Lutzer, Rochester Institute of Technology

8:00AM ► (30) *On Supersingular Elliptic Curves and Hypergeometric Functions.*
Keenan Monks, Hazleton Area High School (1067-11-1398)

8:30AM ► (31) *Statistical Analysis of Diagnostic Accuracy With Applications to Cricket.*
Lauren Mondin*, **Scott Clark**, **Courtney Weber**, **Jessica Winborn** and **Melinda Holt**, Sam Houston State University (1067-62-1380)

9:00AM ► (32) *Applications of and Alternatives to Algorithm X for the Exact Cover Problem.*
Eddie B Tu, Randolph-Macon College, and **Bjorn S Wastvedt***, St. Olaf College (1067-68-191)

9:30AM (33) *Packets, Solving Symmetries and Sudoku.*
Harrison Craig Chapman*, Bowdoin College, and **Malcolm E Rupert**, Western Washington University (1067-13-167)

10:00AM ► (34) *Unitary Equivalence to Matrices with Constant Main Diagonal.* Preliminary report.
John Myers, South Dakota School of Mines & Technology (1067-15-125)

10:30AM ► (35) *Unitary Equivalence of Vector Spaces over the Binary Field.* Preliminary report.
Sam L Scholze*, University of Wisconsin-Platteville, and **Ryan L Hotovy**, University of Nebraska-Lincoln (1067-15-126)

AMS-MAA Special Session on History of Mathematics, I

8:00 AM – 10:50 AM

Organizers: **Sloan E. Despeaux**, Western Carolina University
Craig G. Fraser, University of Toronto
Deborah Kent, Hillsdale College

8:00AM (36) *Gauss on the Composition of Quadratic Forms: Group Theory without Groups.* Preliminary report.
Lawrence A. D'Antonio, Ramapo College of New Jersey (1067-01-623)

8:30AM (37) *The Binomial Theorem from Newton to Cauchy.*
Robert E. Bradley, Adelphi University (1067-01-941)

9:00AM ► (38) *Johann Lambert's Use and Understanding of Mathematical Transcendence.* Preliminary report.
Bruce J. Petrie, Institute for the History and Philosophy of Science and Technology, University of Toronto (1067-01-1044)

9:30AM (39) *Lambert's ideas on the use of the ruler in traditional Euclidean constructions.*
Kirsti Andersen, Aarhus University (1067-01-1981)

10:00AM ► (40) *How "Kroneckerian" became an adjective.*
Jemma Lorenat, Simon Fraser University (1067-01-861)

10:30AM ► (41) *Gallardo's work, a needle in a haystack.* Preliminary report.
Alejandro R. Garciadiego, Universidad Nacional Autonoma de Mexico (UNAM) (1067-01-1090)

AMS-SIAM Special Session on Mathematics of Computation: Differential Equations, Linear Algebra, and Applications, I

8:00 AM – 10:50 AM

Organizers: **Susanne C. Brenner**, Louisiana State University
Chi-Wang Shu, Brown University

8:00AM (42) *Geometric and supergeometric convergence of spectral collocation method for Volterra or Fredholm integral equations with weakly singular kernels.*
Can Huang* and **Zhimin Zhang**, Wayne State University (1067-45-1868)

8:30AM (43) *Maximum-principle-satisfying and positivity-preserving high order discontinuous Galerkin and finite volume schemes for conservation laws.*
Xiangxiong Zhang, Brown University (1067-65-403)

9:00AM (44) *A unified approach to construct and analyze finite element methods for the Monge-Ampère equation.*
Michael J. Neilan, Louisiana State University (1067-65-832)

9:30AM (45) *Finite Difference Methods for Viscosity Solutions of the Monge-Ampère Equation.*
Brittany D. Froese* and **Adam M. Oberman**, Simon Fraser University (1067-65-382)

10:00AM (46) *A multipoint flux mixed finite element method on distorted quadrilaterals and hexahedra.*
Mary F. Wheeler, **Guangri Xue***, Institute for Computational Engineering and Sciences, The University of Texas at Austin, and **Ivan Yotov**, University of Pittsburgh (1067-65-448)

10:30AM (47) *The effect of numerical integration on the finite element computation of linear functionals.*
Ivo M. Babuska, The University of Texas at Austin, **Uday Banerjee**, Syracuse University, and **Hengguang Li***, Institute for Mathematics and its Applications (IMA), University of Minnesota (1067-03-705)

AMS-SIAM Special Session on Nonlinear Waves and Integrable Systems, I

8:00 AM – 10:50 AM

Organizers: **Gino Biondini**, State University of New York at Buffalo
Barbara Prinari, University of Colorado at Colorado Springs

8:00AM (48) *Initial-Boundary-Value Problems and Inverse Scattering Methods.* Preliminary report.
Jerry L. Bona, University of Illinois at Chicago (1067-35-1101)

8:30AM (49) *Spectral theory of nonlocal cross-interaction of two waves.*
Antonio Degasperis, Dipartimento di Fisica, Sapienza Universita' di Roma, Italy (1067-35-762)

9:00AM (50) *The Benjamin-Ono Equation in the Zero-Dispersion Limit.*
Peter D. Miller, University of Michigan (1067-35-990)

9:30AM (51) *Asymptotic analysis of a random matrix model, and/or application of said asymptotic analysis.*
Ken McLaughlin, University of Arizona (1067-31-1062)

10:00AM (52) *Dark and bright soliton solutions for coupled derivative nonlinear Schrödinger equation.*
Y. Ohta, Kobe University (1067-35-571)

10:30AM (53) *The motion of discrete curves and the discrete hodograph transformation.*
Kenichi Maruno*, The University of Texas - Pan American, **Kenji Kajiwara**, Kyushu University, **Yasuhiro Ohta**, Kobe University, and **Bao-Feng Feng**, The University of Texas - Pan American (1067-53-1083)

AMS Special Session on Mathematical Techniques in Musical Analysis, I

8:00 AM – 10:50 AM

Organizers: **Robert W. Peck**, Louisiana State University
Thomas M. Fiore, University of Michigan at Dearborn

8:00AM ► (54) *Mathematical Concepts in Musical Composition.* **Dmitri Tymoczko**, Princeton (1067-00-1966)

8:30AM ► (55) *The Pentahelix: a Four-Dimensional Realization of the Spiral Array.* **Stephon Alexander**, Haverford College, **Elaine Chew***, University of Southern California, **Robert Rowe**, New York University, and **Sam Rodriguez**, Haverford College (1067-51-1552)

9:00AM ► (56) *Diatonic Graphs.* Preliminary report. **J. W. Estes*** and **William Staton**, University of Mississippi (1067-05-369)

9:30AM (57) *The Mathematics of Contrapuntal Hierarchy in Music.* **Jason D Yust**, University of Alabama (1067-05-969)

10:00AM ► (58) *Wreath products and n-cube symmetry: a music-theoretical application.* Preliminary report. **Robert Peck***, Louisiana State University, and **Jack Douthett**, University of New Mexico (1067-20-1059)

10:30AM (59) Spira mirabilis, for player piano. **Clifton Callender**, Florida State University (1067-00-1969)

AMS Special Session on Integral Geometry: Analysis and Applications, I

8:00 AM – 10:50 AM

Organizers: **Gaik Ambartsoumian**, University of Texas, Arlington
Gestur Olafsson, Louisiana State University
Eric Todd Quinto, Tufts University
Boris S. Rubin, Louisiana State University

8:00AM (60) *The geodesic X-ray transform in presence of caustics.* **Plamen Stefanov**, Purdue University (1067-53-1400)

8:30AM (61) *Microlocal Aspects of Bistatic Synthetic Aperture Radar Imaging.* **Venky P Krishnan***, University of Bridgeport, and **Eric Todd Quinto**, Tufts University (1067-35-991)

9:00AM (62) *Conical Distributions on the Space of Flat Horocycles.* **Fulton B Gonzalez**, Tufts University (1067-43-1133)

9:30AM (63) *Reconstruction of a function from its spherical (circular) means with the centers lying on the surface of certain polygons and polyhedra.* **Leonid A Kunyansky**, University of Arizona (1067-44-534)

10:00AM (64) *Determination of a function from integrals over spheres of fixed radius.* **Markus Haltmeier**, Computational Science Center, University Vienna (1067-45-743)

10:30AM (65) *A support theorem for the horocycle transform on a hyperbolic space.* **Sigurdur Helgason**, MIT (1067-44-192)

AMS Special Session on Theory and Application of Stochastic Differential Equations and Stochastic Partial Differential Equations, I

8:00 AM – 10:50 AM

Organizers: **Armando Arciniega**, University of Texas at San Antonio
Edward J. Allen, Texas Tech University
Sivapragasam Sathananthan, Tennessee State University
Mahmoud Anabtawi, American University of Sharjah

8:00AM (66) *Stochastic Viral Kinetics.* **Linda J. S. Allen***, Texas Tech University, **Yuan Yuan**, The University of Texas MD Anderson Cancer Center, and **Sukhitha Vidurupola**, Texas Tech University (1067-92-1297)

8:30AM (67) *Differentiability Properties of Measures Generated by Solutions of Semilinear Stochastic Differential Equations.* **Fariborz Asadian**, Fort Valley State University (1067-60-974)

9:00AM (68) *Derivation Of Stochastic Partial Differential Equations for Reaction-Diffusion Processes.* **Elife Dogan*** and **Edward J. Allen**, Texas Tech University (1067-60-717)

9:30AM (69) *Systems of Kolmogorov Backward Equations for Two-Time-Scale Switching Diffusions.* **Tien Nguyen Dung*** and **George Yin**, Wayne State University (1067-60-502)

10:00AM (70) *Some results on existence and uniqueness of mild solutions of neutral SPDEs.* **T E Govindan**, I.P.N. Mexico City, Mexico (1067-60-1435)

10:30AM (71) *Numerical Methods for Annuity-Purchasing Decision Making.* **Zhuo Jin**, Department of Mathematics, Wayne State University (1067-60-394)

AMS Special Session on Analytic and Geometric Methods in Representation Theory, I

8:00 AM – 10:50 AM

Organizers: **Leticia Barchini**, Oklahoma State University
Hongyu He, Louisiana State University

8:00AM (72) *Rational smoothness of K-orbit closures in flag varieties.* **William M. McGovern**, University of Washington (1067-22-172)

8:30AM (73) *Closed form multiplicity polynomials attached to hook type Springer fibers for $SL(n, \mathbb{C})$.* **Matthew Housley**, University of Utah (1067-22-1118)

9:00AM (74) *Distinguished orbits and the L-S category of simply connected compact Lie groups.* **Markus Hunziker** and **Mark R. Sepanski***, Baylor University (1067-22-1219)

9:30AM (75) *Conformally invariant systems of maximal parabolic of two-step nilpotent type.* **Toshihisa Kubo**, Oklahoma State University (1067-17-454)

10:00AM (76) *The geometry of Gelfand-Zeitlin fibres.* Preliminary report. **Mark Colarusso***, Université de Laval, and **Sam Evens**, University of Notre Dame (1067-22-1243)

10:30AM (77) *Invariant functionals on Speh representations.* **Siddhartha Sahi**, Rutgers University (1067-22-677)

AMS Special Session on Geometric Group Theory, I

8:00 AM – 10:50 AM

Organizers: **Joshua B. Barnard**, University of South Alabama
Pallavi Dani, Louisiana State University

8:00AM (78) *Geometric properties of Thompson's group F.* **Sean Cleary**, The City College of New York, **Susan Hermiller***, University of Nebraska, **Melanie Stein**, Trinity College, and **Jennifer Taback**, Bowdoin College (1067-20-993)

8:30AM (79) *Snowflake Groups with Super-Exponential 2-Dimensional Dehn Functions.* **Quan T Tran**, University of Oklahoma (1067-00-1330)

9:00AM ► (80) *Geometry of Houghton's Group.* **Sang Rae Lee**, University of Oklahoma (1067-20-1535)

9:30AM (81) *Automorphisms of Buildings Constructed Via Covering Spaces.* **Aliska L. Gibbins**, Ohio State University (1067-20-2002)

10:00AM (82) *Asymmetry of the Lipschitz metric on Outer Space.* **Yael Algom-Kfir***, Yale University, and **Mladen Bestvina**, University of Utah (1067-20-2403)

10:30AM (83) *Line Patterns in Free Groups.* **Christopher H. Cashen**, University of Utah (1067-20-698)

AMS Special Session on Computational Algebraic and Analytic Geometry for Low-Dimensional Varieties, I

8:00 AM – 10:50 AM

Organizers: **Mika K. Seppala**, Florida State University
Tanush Shaskas, Oakland University
Emil Volcheck, National Security Agency

8:00AM (84) *Geometric estimates for the Birman-Series set.* Preliminary report. **Peter Buser***, Ecole Polytechnique Fédérale de Lausanne, and **Hugo Parlier**, Université de Fribourg, Switzerland (1067-53-1954)

8:30AM (85) *Disconnectedness of Singular Loci of Moduli Spaces of Complex Curves.* **Milagros Izquierdo***, Linköping University, and **Antonio F Costa**, UNED (1067-14-418)

9:00AM ► (86) *Circle Packings on Affine Tori.* Preliminary report. **Christopher T. Sass***, University of Tennessee, and **G. Brock Williams**, Texas Tech University (1067-30-507)

9:30AM (87) *On Rankin's Uniformization of Algebraic Curves.* **John J. George**, Florida State University (1067-30-1537)

10:00AM (88) *Using Half turns for algorithms on hyper-elliptic Riemann surfaces.* Preliminary report. **K.-D. Semmler**, EPF Lausanne (1067-51-1442)

10:30AM (89) *Compact Klein surfaces of genus 5 with extremal discs.* **Gou Nakamura**, Center for General Education, Aichi Institute of Technology (1067-30-1445)

AMS Special Session on Mathematical Modeling in Environmental Economics, I

8:00 AM – 10:50 AM

Organizers: **Natali Hritonenko**, Prairie View A&M University
Yuri Yatsenko, Houston Baptist University

8:00AM ► (90) *Sustainable Forest Management, Logging Size, and Carbon Sequestration Under Climate Changes.* **Natali Hritonenko***, Prairie View A&M University, **Renan-Ulrich Goetz**, Department of Economics, University of Girona, and **Deonica Paxton**, Prairie View A&M University (1067-92-640)

9:00AM ► (91) *Computational Approach to the Solution of Random Pertubed Logistic Model.* Preliminary report. **Reza R Ahangar**, Texas A & M University- Kingsville (1067-34-702)

9:30AM (92) *Optimal Use Of Mosquito treated nets and Insecticide In Controlling Malaria Disease.* **Bassidy Dembele***, Grambling State University, and **Abdul-Aziz Yakubu**, Howard University (1067-92-769)

10:00AM (93) *Poisson Arrival, Single-Processor, Exponential General Bulk Processing [M/M(m, M)/1] and Splitting Queueing System: A Mathematical Model for a Personnel Hiring Process.* Preliminary report. **Aliakbar Montazer Haghighi**, Prairie View A&M University (1067-90-889)

AMS Special Session on Expander Graphs in Pure and Applied Mathematics, I

8:00 AM – 10:45 AM

Organizers: **Alireza Salehi Golsefidy**, Princeton University
Alexander Lubotzky, Hebrew University of Jerusalem

8:00AM ► (94) *Counting primes in Apollonian circle packings.* **Elena Fuchs**, Institute for Advanced Study (1067-11-749)

8:30AM ► (95) *Constructing Small-Bias Sets from Algebraic-Geometric Codes.* **Avraham Ben-Aroya** and **Amnon Ta-Shma***, Tel-Aviv University (1067-05-1120)

9:00AM (96) *Expansion and words in simple groups of Lie type.* **E. Breuillard**, Universite Paris Sud, **B. Green**, University of Cambridge, **R. Guralnick***, University of Southern California, and **T. Tao**, UCLA (1067-20-389)

9:30AM (97) *On the diameter of finite simple groups.* **Emmanuel F Breuillard**, Universite Paris-Sud Orsay (1067-20-844)

10:00AM (98) *Recent applications of expanders in number theory.* **Emmanuel Kowalski**, ETH Zurich (1067-11-690)

MAA Invited Paper Session on The Rebirth of Special Functions

8:00 AM – 10:50 AM

Organizers: **Tewodros Amdeberhan**, Tulane University
Victor Moll, Tulane University

8:00AM ► (99) *Special Functions and Computer Algebra.* **Luis A Medina**, University of Puerto Rico, Rio Piedras (1067-AA-1927)

8:30AM ► (100) *Special Functions in Combinatorics.*
Lipika Deka, California State University, Monterey Bay (1067-AA-2279)

9:00AM ► (101) *Special functions and modular forms in number theory.*
Amanda Folsom, Yale University (1067-AA-1292)

9:30AM ► (102) *Special functions, mathematical physics, and number theory.*
Mark W. Coffey, Colorado School of Mines (1067-AA-1665)

10:00AM ► (103) *Special Functions and High Order Finite Element Methods.*
Veronika Pillwein, RISC, Joh. Kepler Univ. Linz (1067-AA-1306)

10:30AM (104) *Special Functions and Universal Behavior in Integrable Systems.*
Peter D. Miller, University of Michigan (1067-AA-992)

AMS Session on Fluid Mechanics, I, and Mechanics

8:00 AM – 10:55 AM

8:00AM (105) *On the Minimizing Total Collision Orbits in the Planar Newtonian N-body Problem.*
Hsin-Yuan Huang, School of Mathematics, University of Minnesota (1067-70-2050)

8:15AM (106) *Stability of step dynamics in nanowire growth.*
Nicholas O. Kirby, University of Kentucky (1067-74-1708)

8:30AM ► (107) *Analysis of Spherical Inflation Models for Intracranial Saccular Aneurysm Elastodynamics.* Preliminary report.
James Christopher Halsall, Farmingdale State College (1067-74-2286)

8:45AM Break.

9:00AM (108) *Permeability effect on magneto-convection in a mushy layer.*
Dambaru Bhatta* and **Daniel N. Riahi**, The University of Texas- Pan American, Edinburg, TX (1067-76-514)

9:15AM (109) *Inertial effects on viscous fingering in the complex plane.*
Andong He* and **Andrew Belmonte**, Penn State University (1067-76-960)

9:30AM (110) *Surface modes in inviscid free surface shear flows.*
Ahmed Kaffel* and **Michael Renardy**, Virginia Tech (1067-76-1091)

9:45AM (111) *A precise calculation of the critical Rayleigh and Wave Numbers for the Inhomogeneous Planar Bénard Problem.*
Matthew J Glomski* and **Matthew Adam Johnson**, Marist College (1067-76-1419)

10:00AM (112) *Thermal and mass flow in uniform stream with a sink and a heat source via variational technique for free boundary problems.*
Sadia M.. Makky*, Owens College, **Ali M. Ghalib**, PBS&J, Southeast Structures Division, and **Thaer S. Sliby**, Military Engineering College, Baghdad, Iraq (1067-76-1846)

10:15AM (113) *Approximations to the Navier-Stokes equation using a Leray-Iterated-Tikhonov model with Time Relaxation.* Preliminary report.
Nathaniel Mays*, **Ross Ingram**, University of Pittsburgh, **Iuliana Stanculescu**, Nova Southeastern University, and **Carolina Manica**, Instituto de Matematica - UFRGS (1067-76-2026)

10:30AM ► (114) *Annular stagnation flow on a moving cylinder.*
Antonio Mastroberardino, Penn State Erie, The Behrend College (1067-76-2045)

10:45AM (115) *Eventual Regularity of the Solutions to the Supercritical Dissipative Quasi-Geostrophic Equation.*
Michael G Dabkowski, University of Wisconsin-Madison (1067-76-2219)

AMS Session on Combinatorics and Graph Theory, I

8:00 AM – 10:55 AM

8:00AM (116) *Cycle-saturated graphs with minimum number of edges.*
Younjin Kim* and **Zoltan Furedi**, University of Illinois at Urbana-Champaign (1067-05-423)

8:15AM (117) *Gregarious Path Decompositions of Some Graphs.*
Guven Yuceturk* and **Hoffman G. Dean**, Auburn University (1067-05-2387)

8:30AM (118) *Algebraic and Graph-Theoretic Properties of the Box Product of Two Paths.*
Daniel Pragel, University of Arkansas Fort Smith (1067-05-646)

8:45AM ► (119) *Firefighting on Random Geometric Graphs.* Preliminary report.
Amir Barghi* and **Peter Winkler**, Dartmouth College (1067-05-790)

9:00AM (120) *Making graphs crossing-critical by multiplying their edges.*
Gelasio Salazar*, Instituto de Fisica. Universidad Autonoma de San Luis Potosi, Mexico, **Cesar Hernandez-Velez**, Instituto de Fisica, Universidad Autonoma de San Luis Potosi, Mexico, and **Laurent Beaudou**, Polytech Clermont-Ferrand (1067-05-2151)

9:15AM Break

9:30AM (121) *Ribbon Graphs and Twisted Duality.*
Joanna A. Ellis-Monaghan*, Saint Michael's College, and **Iain Moffatt**, University of South Alabama (1067-05-130)

9:45AM (122) *Some graph theoretical results for the task mapping problem for parallel computers.* Preliminary report.
Janet L. Fierson, United States Military Academy at West Point (1067-05-2374)

10:00AM (123) *Complex Contagions on Graph Dynamical Systems.*
Leon Chang, Columbia University, and **Siddharth S Raval***, Reed College (1067-05-208)

10:15AM (124) *Amalgamations and Detachments of Hypergraphs.*
Amin Bahmanian, Auburn University (1067-05-190)

10:30AM (125) *On Hyperstar Decompositions of Hypergraphs.*
Amin Bahmanian and **Dan Roberts***, Auburn University (1067-05-2312)

10:45AM ► (126) *Packing sparse hypergraphs.*
Christopher J Stocker*, **Alexandr V Kostochka**, University of Illinois at Urbana-Champaign, and **Peter Hamburger**, Western Kentucky University (1067-05-2388)

AMS Session on Combinatorics and Graph Theory, II

8:00 AM – 10:55 AM

8:00AM (127) *Deformation Retracts of Neighborhood Complexes of Stable Kneser Graphs.* Preliminary report.
Matthew D Zeckner* and **Benjamin J Braun**, University of Kentucky (1067-05-980)

8:15AM (128) *Iterated Iteratedly Piecewise Continuous Function Order Pattern Probability Distributions.*
Adam Hesterberg, Princeton University (1067-05-1851)

8:30AM ► (129) *Distribution Networks - A Generalization to Graphs: more application and less fuzzification.*
Omid Ghayour Najafabad, Chamran University (1067-05-2175)

8:45AM (130) *Integer invariants of skew lines in PG(3,q).*
Joshua E Ducey, University of Florida (1067-05-1773)

9:00AM ► (131) *Partitions, Young diagrams and ballot numbers.*
RJ Dolbin, Pepperdine University (1067-05-914)

9:15AM (132) *An efficient tree-based computation of a natural diffusion distance.*
Maxim J. Goldberg, Ramapo College of NJ, and **Seonja Kim***, SUNY Rockland Community College (1067-05-1043)

9:30AM ► (133) *The excedance algebra.* Preliminary report.
Eric L. Clark* and **Richard Ehrenborg**, University of Kentucky (1067-05-377)

9:45AM (134) *Towers of Algebras, Combinatorial Hopf Algebras and Dual Graded Graphs.*
Nantel Bergeron, York University, **Thomas Lam**, University of Michigan, and **Huilan Li***, Drexel University (1067-05-1257)

10:00AM (135) *Reduced decompositions and permutation patterns generalized to the higher Bruhat order.*
Delong Meng, MIT (1067-05-337)

10:15AM ► (136) *The Weak Bruhat Order and Separable Permutations.*
Fan Wei, Massachusetts Institute of Technology (1067-05-872)

10:30AM (137) *Shuffles of permutations.*
Camillia Smith Barnes, Sweet Briar College (1067-05-2082)

10:45AM ► (138) *Enumerating embeddings under generalized factor orders.* Preliminary report.
Thomas Langley*, Rose-Hulman Institute of Technology, and **Jeffrey Remmel**, University of California, San Diego (1067-05-2322)

MAA Session on Fostering, Supporting, and Propagating Math Circles for Students and Teachers, I

8:00 AM – 10:55 AM

Organizers: **Tatiana Shubin**, San Jose State University
Elgin H. Johnston, Iowa State University
James Tanton, St. Mark's Institute of Mathematics

8:00AM ► (139) *A Sampling of Successful Math Circle Topics*
James S Tanton, St. Mark's Institute of Mathematics (1067-F1-1630)

8:20AM (140) *Creating a Math Circle for Underrepresented Minority Students.*
Manda Riehl, University of Wisconsin, Eau Claire (1067-F1-2290)

8:40AM (141) *Sophie Math: a Math Circle Program for Girls.*
Silva Chang* and **Anne M Dougherty**, University of Colorado at Boulder (1067-F1-1903)

9:00AM ► (142) *The San Francisco Math Circle: An experiment in providing mathematical enrichment to "unenriched" students.*
Paul Zeitz, University of San Francisco (1067-F1-1638)

9:20AM ► (143) *San Francisco Math Circle: Examples of good "small group" mathematical activities.*
Paul Zeitz, University of San Francisco (1067-F1-1646)

9:40AM (144) *Obtaining funding for a Math Teachers' Circle: One group's journey.*
Angela Hodge, North Dakota State University (1067-F1-2150)

10:00AM ► (145) *Resources for math circles.*
Dave Auckly, Mathematical Sciences Research Institute (1067-F1-2394)

10:20AM (146) *Math Teachers' Circles - Impacting Teachers' Mathematical Knowledge for Teaching.*
Diana White, University of Colorado Denver (1067-F1-2067)

10:40AM (147) *How Do Math Teachers' Circles Affect Teachers? Themes from Teacher Surveys.*
Diana White, University of Colorado Denver, and **Brianna Donaldson***, American Institute of Mathematics (1067-F1-2107)

MAA Session on the Scholarship of Teaching and Learning in Collegiate Mathematics, I

8:00 AM – 10:55 AM

Organizers: **Jacqueline M. Dewar**, Loyola Marymount University
Thomas F. Banchoff, Brown University
Pam Crawford, Jacksonville University
Edwin P. Herman, University of Wisconsin-Stevens Point
Nathan Wodarz, University of Wisconsin-Stevens Point

8:00AM (148) *Changing Scales, Changing Perspectives.*
Carrie Muir, University of Colorado, Boulder (1067-V1-411)

8:20AM ► (149) *The Use of Videos to Encourage Pre-Class Preparation.* Preliminary report.
Francesco J. Echeverria and **James S. Rolf***, United States Air Force Academy (1067-V1-2147)

8:40AM ► (150) *Mathematical Word Problems: An Instructional Approach that evolved from its Cognitive Complexities.*
Jerry C. Obiekwe, The university of Akron-Wayne College (1067-V1-485)

9:00AM (151) *A Collaborative Process for Developing Digital Learning Materials: An Analysis of Student Performance and Feedback.*
Robert Hoar, **Jennifer Kosiak**, **Karoline Auby*** and **James Sobota**, University of Wisconsin-La Crosse (1067-V1-863)

9:20AM ► (152) *Using Visual Cues in Teaching Computational Skills.*
Gretchen Rimmasch* and **Jim Brandt**, Southern Utah University (1067-V1-1516)

9:40AM ► (153) *Learning Effects of Examples Applied to College Algebra Student Interests.*
Carrie A Campbell, Lincoln, NE (1067-V1-1918)

10:00AM (154) *The Effects of NCAT's Redesign on Student Learning in Beginning Statistics.*
Aubrey D. Magoun*, **David Hare** and **Charlotte H. Owens**, The University of Louisiana at Monroe (1067-V1-52)

10:20AM ► (155) *An analysis of student understanding of voting power in a a quantitative literacy class.* Preliminary report.
Curtis D. Bennett*, **Suzanne Larson** and **Laura J. Massa**, Loyola Marymount University (1067-V1-2246)

10:40AM ► (156) *Comparing geometry curriculums: The impact on pre-service elementary teachers' pedagogical content knowledge.* Preliminary report.
Hortensia Soto- Johnson, **Sarah Rozner*** and **Kristin Noblet**, University of Northern Colorado (1067-V1-1998)

MAA Session on Wavelets In Undergraduate Education, I

8:00 AM – 10:55 AM

Organizers: **Caroline Haddad**, SUNY Geneseo
Catherine A. Beneteau, University of South Florida
David K. Ruch, Metropolitan State College of Denver
Patrick J. Van Fleet, University of St. Thomas

8:00AM (157) *Introducing Wavelets to First Years and Sophomores.*
Rachel J Weir, Allegheny College (1067-Y5-1925)

8:20AM ► (158) *Efficiently Programming RGB-to-HSI Conversion.*
Joseph M Gonzalez*, **Brian K Holder-Chow Lin On**, **Robert Le** and **Michael Anthony Miller**, University of South Florida (1067-Y5-1606)

8:40AM ► (159) *Undergraduate Research Projects on Pansharpening.* Preliminary report.
John Merkel*, Oglethorpe University, **Patrick Van Fleet**, University of St. Thomas, and **David Ruch**, Metropolitan State College of Denver (1067-Y5-1829)

9:00AM ► (160) *Using Wavelets and Statistics to Detect Differences.* Preliminary report.
Edward F Aboufadel, Grand Valley State University (1067-Y5-1752)

9:20AM ► (161) *Denoising Capillary Electrophoresis Signals with Wavelets.* Preliminary report.
Bruce Atwood*, **Kevin Braun** and **Tess Jacquez**, Beloit College (1067-Y5-1561)

9:40AM ► (162) *Undergraduate research in wavelets and circadian rhythms.* Preliminary report.
Tanya Leise, Amherst College (1067-Y5-981)

10:00AM ► (163) *Exploring Biomedical Signals with the Maple Wavelets Package.*
Jeff Knisley, East Tennessee State University (1067-Y5-2085)

10:20AM ► (164) *Lloyd-Max Quantization Schemes.*
Helmut Knaust, University of Texas at El Paso (1067-Y5-1826)

10:40AM ► (165) *Wavelets and Lifting.* Preliminary report.
Patrick J Van Fleet, University of St. Thomas (1067-Y5-1611)

MAA General Contributed Paper Session, I

8:00 AM – 10:55 AM

Organizers: **Kristen Meyer**, Wisconsin Lutheran College
Thomas R. Hagedorn, The College of New Jersey

8:00AM ► (166) *An Action Research Report: Does the Ability to Purchase a Week's Worth of Groceries for under One Dollar Influence the Chance that a Student will make an "Innumeracy Type" Statistical Error?*
Larry Wayne Lewis, Spalding University (1067-Z1-1756)

8:15AM ► (167) *Rectangular to Polar Transformations.* Preliminary report.
Gerald M. Higdon, Fitchburg State University (1067-Z1-1143)

8:30AM ► (168) *Chebyshev Polynomials and their Relationship to Trigonometry and the Fibonacci Numbers.* Preliminary report.
John C Maceli, Ithaca College NY (1067-Z1-2214)

8:45AM Break

9:00AM ► (169) *A Blended Approach to Teaching Finite Mathematics at the University of Illinois.* Preliminary report.
Jesse E Miller, University of Illinois at Urbana-Champaign (1067-Z1-845)

9:15AM ► (170) *Teaching Finite Mathematics Using Online Homework System.*
Yun Lu, Kutztown University of Pennsylvania (1067-Z1-2330)

9:30AM ► (171) *Initial Assessment of an Enhanced College Algebra Course.* Preliminary report.
Robert Wieman, Virginia State University (1067-Z1-2351)

9:45AM (172) *How to teach college classes with a large diversity in students abilities and interest.*
Josip Derado, Kennesaw State University (1067-Z1-1990)

10:00AM (173) *Comparison of Student Performance between Inquiry Based Learning and Lecture Methods when Teaching Induction.* Preliminary report.
Michael S. Gagliardo, Jacksonville University (1067-Z1-1020)

10:15AM ► (174) *Service-learning in Mathematics Curriculum.* Preliminary report.
Natali Hritonenko*, **Lauretta Byars** and **Alisha Lowe**, Prairie View A&M University (1067-Z1-1027)

10:30AM ► (175) *Improving Learning Through a Lesson Study Community of Practice.* Preliminary report.
Joy L. Becker* and **Laura J. Schmidt**, University of Wisconsin-Stout (1067-Z1-1352)

10:45AM ► (176) *Connecting student knowledge and course performance at the University of Illinois.*
Alison Ahlgren*, University of Illinois, and **Marc Harper**, UCLA (1067-Z1-583)

MAA General Contributed Paper Session, II

8:00 AM – 10:55 AM

Organizers: **Kristen Meyer**, Wisconsin Lutheran College
Thomas R. Hagedorn, The College of New Jersey

8:00AM ► (177) *Differences between Mathematicians and Physicists.*
Tevian Dray* and **Corinne A. Manogue**, Oregon State University (1067-Z1-2355)

8:15AM (178) *Super Greedy Type Algorithms.*
Entao Liu, University of South Carolina (1067-Z1-1265)

8:30AM ► (179) *Convexity Adjustment in the Valuation of the Financial Derivatives.* Preliminary report.
Alejandra Sánchez, Universidad Complutense de Madrid; Universidad Nacional de Colombia- Bogotá (1067-Z1-1741)

8:45AM (180) *An Adaptive Spectral Element Method to Price American Options.* Preliminary report.
Matthew Willyard* and **David A. Kopriva**, Florida State University Mathematics (1067-Z1-2019)

9:00AM ► (181) *Modeling Time-Dependent Electroosmotic Flow.* Preliminary report.
Emese Lipcsey-Magyar*, North Carolina State University, **Ava Hamilton**, **Rachel Roe-Dale**, **Kimberley Frederick** and **Katherine Roguski**, Skidmore College (1067-Z1-1760)

9:15AM (182) *A mixed implicit-explicit multirate numerical scheme for time-dependent equations.*
Brandon Chabaud* and **Qiang Du**, Pennsylvania State University (1067-Z1-1574)

9:30AM (183) *A novel method for solving nonlinear equations.*
Mohsen Mahmood Doroodchi*, Cardinal Stritch University, **Habibolla Latifizadeh** and **Esmail Hesameddini**, Shiraz University of Technology, Shiraz, Iran (1067-Z1-683)

9:45AM (184) *Gibbs Measures for Unbounded Local Energy Functions on* $\mathbb{N}^{\mathbb{Z}^d}$.
Stephen R Muir, University of North Texas (1067-Z1-1266)

10:00AM (185) *Existence and Stability of Standing Wave Solutions Arising from Synaptically Coupled Neuronal Networks.*
Melissa A Stoner* and **Linghai Zhang**, Lehigh University (1067-Z1-1261)

10:15AM ► (186) *Real Time Boundary Element Node Location Optimization.* Preliminary report.
J D Menges, United States Military Academy (1067-Z1-2337)

10:30AM ► (187) *Optimal Control.*
Qingxia Li, Lincoln University (1067-Z1-733)

10:45AM (188) *Periodic solutions of Some Ecological Models with Strong Allee Effects.*
Smita Pati, Birla Institute of Technology, Mesra, Ranchi (1067-Z1-2428)

MAA General Contributed Paper Session, III

8:00 AM – 10:55 AM

Organizers: **Kristen Meyer**, Wisconsin Lutheran College
Thomas R. Hagedorn, The College of New Jersey

8:00AM ► (189) *Al-Kashi's Key to Arithmetic: Its Context, Contents, and Educational Impact Up Through the Ottoman Empire.* Preliminary report.
Osama H. Taani, New Mexico State University (1067-Z1-1636)

8:15AM ► (190) *Euler Drives the Leibniz Machine and Takes the Log and Trig Functions out for a Spin on the Complex Numbers.*
David Dennis, San Bernardino, CA, and **Susan L. Addington***, California State University, San Bernardino (1067-Z1-1935)

8:30AM (191) *The intellectual journey of Hua Loo-keng from China to the Institute of Advanced Studies.*
Jean W. Richard* and **Abdramane Serme**, BMCC/CUNY-The City University of New York (1067-Z1-2178)

8:45AM (192) *Fibonacci, Liber Abaci, and Medieval Mathematics.*
Charlie L. Smith, Park University (1067-Z1-2249)

9:00AM ► (193) *Mr. Peacock's Calculus Text of 1820 and Its Place in Calculus Reform at Cambridge.*
Richard H Stout, Gordon College (1067-Z1-1982)

9:15AM ► (194) *The Real Story of Edward Lorenz.*
Jody Sorensen, Augsburg College (1067-Z1-1568)

9:30AM ► (195) *Fixing Fluxions: Benjamin Robins' response to Berkeley's "The Analyst".*
Eugene C. Boman, Penn State, Harrisburg campus (1067-Z1-1910)

9:45AM ► (196) *Revisiting Lester Hill.*
Chris Christensen, Northern Kentucky University (1067-Z1-444)

10:00AM ► (197) *How Christiaan Huygens Tuned the Musical Scale.*
John F. Bukowski, Juniata College (1067-Z1-1923)

10:15AM ► (198) *Counting.*
Patricia Baggett*, New Mexico State University, and **Andrzej Ehrenfeucht**, University of Colorado (1067-Z1-480)

10:30AM ► (199) *Math vs. Maths: A Yankee Mathematician in Sir Isaac's Court.*
Samuel M Hansen, University of Nevada, Las Vegas/ACMEScience (1067-Z1-1158)

10:45AM ► (200) *Fifty years of College Math. Have I learned anything?*
Bryan V Hearsey, Lebanon Valley College (1067-Z1-2236)

SIAM Minisymposium on Applications of Difference and Differential Equations in Ecology and Epidemiology, I

8:00 AM – 10:55 AM

Organizers: **Zhilan Feng**, Purdue University
Yun Kang, Arizona State University

8:00AM (201) *Modeling Vertical Transmission in Mosquito-Transmitted Diseases.*
James M Hyman*, Tulane University, **Nakul Chitnis**, Swiss Tropical Institute, and **Carrie Manore**, Oregon State University (1067-92-936)

8:30AM (202) *Spatiotemporal variation of mistletoes: a dynamic modeling approach.*
Rongsong Liu*, **Carlos Martinez del Rio**, University of Wyoming, and **Jianhong Wu**, York University (1067-92-1005)

9:00AM (203) *Network epidemics with just one equation.*
Joel C Miller*, Harvard School of Public Health, and **Erik Volz**, University of Michigan (1067-92-874)

9:30AM ► (204) *Hepatitis C virus drug resistance and modeling.*
Libin Rong*, Oakland University, **Harel Dahari**, University of Illinois Chicago, **Ruy Ribeiro** and **Alan Perelson**, Los Alamos National Lab (1067-92-694)

10:00AM (205) *Uniform Persistence in Discrete and Continuous Non-autonomous Dynamical Systems with Application to an Epidemic Model of an Amphibian Population.* Preliminary report.
Paul Leonard Salceanu, University of Louisiana at Lafayette (1067-92-570)

10:30AM ► (206) *Disease Dynamics and Allee effect in Discrete-time Population Models.* Preliminary report.
Abdul-Aziz Yakubu*, Howard University, and **Najat Ziyadi**, Morgan State University (1067-92-710)

Employment Center

8:00 AM – 7:00 PM

AMS Special Session on Quadratic Forms in Algebra and Geometry, I

8:30 AM – 10:50 AM

Organizers: **Jorge F. Morales**, Louisiana State University

Anne Queguiner-Mathieu, Université de Paris 13

8:30AM (207) *Lattices, periodic configurations and Gaussian potential energy.*
Abhinav Kumar*, Massachusetts Institute of Technology, **Henry L Cohn**, Microsoft Research New England, and **Achill Schuermann**, University of Rostock (1067-52-2232)

9:00AM (208) *Improved sphere packing lower bounds from Hurwitz lattices.*
Stephanie Vance, Adams State College (1067-52-728)

9:30AM (209) *Weyl's inequality and systems of quadratic forms.*
Rainer Dietmann, Royal Holloway, University of London (1067-11-1564)

10:00AM (210) *Multi-Variable Period Polynomials Associated to Cusp Forms for $SL_2(\mathbb{Z})$.* Preliminary report.
Oliver Gjoneski, Duke University (1067-22-2273)

10:30AM (211) *Multiplicative properties of integral binary quadratic forms and orders of elements in the form class group.*
Andrew G. Earnest, Southern Illinois University Carbondale (1067-11-1372)

AMS Session on Number Theory, I

8:30 AM – 10:55 AM

8:30AM (212) *The Geyer-Jarden Conjecture in positive characteristic and the degree of torsion points.*
Oscar G. Villareal, Orange, CA (1067-11-2091)

8:45AM (213) *Relations between class numbers of binary cubic forms.*
Jorge Dioses, Oklahoma State University (1067-11-2361)

9:00AM (214) *A property of division points.*
David Grant and **Su-ion Ih***, University of Colorado at Boulder (1067-11-1529)

9:15AM ► (215) *Continuation of the Riemann zeta function via derivations.* Preliminary report.
Caleb Emmons, Pacific University (1067-11-614)

9:30AM ► (216) *Ramanujan Congruence Properties of the Restricted Partition Function $p(n, m)$.*
J. Brandt Kronholm, Saint Mary's College of Maryland (1067-11-635)

9:45AM (217) *Some congruences connecting values at $s = 0$ of partial zeta functions with units.* Preliminary report.
Barry R Smith, Lebanon Valley College (1067-11-1735)

10:00AM (218) *Isometry Classes of Quadratic Forms over p-adic Rings.* Preliminary report.
Laura L Steil* and **David Leep**, University of Kentucky (1067-11-905)

10:15AM (219) *Galois groups of totally and tamely ramified sextic extensions of local fields.*
Chad Awtrey, Elon University (1067-11-499)

10:30AM (220) *Identities of symmetry for Bernoulli polynomials.*
Dae San Kim* and **Kyoung Ho Park**, Sogang University (1067-11-221)

10:45AM ► (221) *A Frobenius Problem for the Ring of Integers in a Number Field.*
Ken Dutch*, Eastern Kentuncky University, **Peter Johnson**, Auburn University, **Christopher Maier**, University of Texas at Dallas, and **Jordan Paschke**, University of Rochester (1067-11-1171)

AMS Session on Mathematics Education, I

8:30 AM – 10:55 AM

8:30AM ► (222) *The ALARM Experiment.* Preliminary report.
Ira Gerhardt, Manhattan College (1067-97-268)

8:45AM ► (223) *The Effectiveness of Blended Instruction in Postsecondary General Education Mathematics Courses.*
Anna E Bargagliotti*, **John Haddock**, **Fernanda Botelho**, University of Memphis, and **Jim Gleason**, University of Alabama (1067-97-70)

9:00AM ► (224) *Synopsis of a Program Promoting Mathematics and Science Studies among Hispanics and Other Minorities.* Preliminary report.
Juan H Hinojosa, **Firooz Khosraviyani***, **Rohitha Goonatilake** and **Rafic A Bachnak**, Texas A&M International University (1067-00-2244)

9:15AM (225) *A First Year Experience Seminar.*
Ximena Catepillan, Millersville University of Pennsylvania (1067-00-1673)

9:30AM ► (226) *The UCLA Applied Math REU Program.*
Todd Wittman, UCLA (1067-97-134)

9:45AM ► (227) *What Can Students Learn from the Dice Game Hog?* Preliminary report.
Deborah E. Seacrest, University of Nebraska-Lincoln (1067-97-1580)

10:00AM ► (228) *Integrating Graduate Research into the Middle School Class Room.* Preliminary report.
Stewart W Hengeveld, Montclair State University (1067-97-2158)

10:15AM ► (229) *A Rigorous Reconstruction of Some Concepts in Elementary Algebra for Avoiding Misconceptions.* Preliminary report.
Juan J Arellano, Texas A&M International University (1067-97-2398)

10:30AM ► (230) *Impact of Automated Proof Systems on Teaching Mathematics.*
Alexander Y Vaninsky, Hostos Community College of The City University of New York (1067-97-12)

10:45AM (231) *A New Paradigm in Collaborative Textbook Writing.*
Troy J Siemers*, **Daniel S Joseph** and **Gregory N Hartman**, Virginia Military Institute (1067-97-935)

AMS Session on Logic and Algebraic Systems

8:45 AM – 10:55 AM

8:45AM (232) *A characterization of computable analysis on unbounded domains using differential equations equations.*
Kerry Ojakian, Queens College (CUNY) (1067-03-729)

9:00AM (233) *Comparing the Weak and Strong Omega Coloring Number of Graphs.*
Matthew Anthony Jura, Manhattan College (1067-03-2275)

9:15AM (234) *Questions of Divisibility in a Group of Density Continuous Functions.*
Michelle Knox, Midwestern State University (1067-06-542)

9:30AM (235) *Admissible Orders on Quotients of the Free Associative Algebra.*
Jeremiah William Johnson, Penn State Harrisburg (1067-06-663)

9:45AM (236) *The spaces $Min(L)$ and $Min(L)^{-1}$.*
Papiya Bhattacharjee, Penn State Erie, The Behrend College (1067-06-1159)

10:00AM (237) *Real root counting for parametric polynomial systems and applications to Maxwell's conjecture.* **Ya-lun Tsai**, University of Minnesota-Twin cities (1067-08-859)

10:15AM (238) *J-sets in Commutative and Uncommutative Semigroups.* **John H. Johnson**, Howard University (1067-08-1102)

10:30AM (239) *Cluster Analysis of Heterogeneous Data on Rankings and Flags.* Preliminary report. **Paige E. Rinker**, Dartmouth College (1067-08-1739)

10:45AM (240) *An Asymptotic Result on the Wilf Conjecture.* **Alex Zhai**, Harvard University (1067-08-1873)

AMS Special Session on Transseries and Ordered Exponential Fields, I

9:00 AM – 10:50 AM

Organizers: **Gerald A. Edgar**, The Ohio State University
Ovidiu Costin, The Ohio State University
Lou P. van den Dries, University of Illinois, Urbana-Champaign

9:00AM (241) *Generalized power series and exponential real closed fields.* Preliminary report. **Karen M. Lange*** and **Julia F. Knight**, University of Notre Dame (1067-03-679)

9:30AM (242) *Structures associated with real closed fields.* **Julia F. Knight*** and **Karen Lange**, University of Notre Dame (1067-03-669)

10:00AM (243) *Applications of Transseries to the Geometry of Fractals.* **Ovidiu Costin**, The Ohio State University, and **Min Huang***, University of Chicago (1067-40-1538)

10:30AM (244) *Transseries, trans-analyticity and trans-transseries.* **Ovidiu Costin**, Ohio State University (1067-40-1626)

MAA Minicourse #4: Part A

9:00 AM – 11:00 AM

Getting students involved in undergraduate research.

Organizers: **Aparna W. Higgins**, University of Dayton
Joseph A. Gallian, University of Minnesota-Duluth

MAA Minicourse #7: Part A

9:00 AM – 11:00 AM

The mathematics of Islam and its use in the teaching of mathematics.

Organizer: **Victor J. Katz**, University of the District of Columbia

MAA Minicourse: #8: Part A

9:00 AM – 11:00 AM

The ubiquitous Catalan numbers and their applications.

Organizer: **Thomas Koshy**, Framingham State University

MAA Panel Discussion

9:00 AM – 10:20 AM

For MAA Student Chapter advisors: Dynamic answers to your questions.

Organizers: **Jacqueline Jensen**, Sam Houston State University
Robert W. Vallin, Slippery Rock University
Joyati Debnath, Winona State University

Panelists: **Bob Anastasio**, MAA
Kay Somers, Moravian College
Robert W. Vallin

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: **Betsy Yanik**, Emporia State University

MAA Panel Discussion

9:00 AM – 10:20 AM

National Science Foundation programs supporting learning and teaching in the mathematical sciences.

Organizers: **Lee Zia**, NSF DUE
Henry Warchall, NSF DMS
Dennis Davenport, NSF DUE
Stephanie Fitchett, NSF DUE

Student Hospitality Center

9:00 AM – 5:00 PM

AMS Session on Mathematical Biology and Ecology, I

9:15 AM – 10:55 AM

9:15AM (245) *Lattice Gas Cellular Automata modeling of lineage dynamics and feedback control.* **Shabnam Moobedmehdiabadi**, University of California, Irvine, CA (1067-92-2284)

9:30AM ► (246) *Analysis of Discrete Models of Biological Systems Using Computer Algebra.* **Franziska Hinkelmann***, Virginia Bioinformatics Institute, Virginia Tech, **Madison Brandon**, University of Tennessee - Knoxville, **Bonny Guang**, Harvey Mudd College, **Rustin McNeill**, University of North Carolina, **Alan Veliz-Cuba**, University of Nebraska-Lincoln, **Grigoriy Blekherman**, Institute for Pure and Applied Mathematics, UCLA, and **Reinhard Laubenbacher**, Virginia Bioinformatics Institute, Virginia Tech (1067-92-1486)

9:45AM ► (247) *Stable Tissue Topology and Cell Division in 3D.* Preliminary report. **Michael G Kerckhove**, University of Richmond (1067-92-2170)

10:00AM ► (248) *A Categorization of Brazilian Free-Tailed Bat (Tadarida brasiliensis) Chirps.* **Gregory Alan Backus***, Bard College, **Albert Boggess**, **May Boggess**, Texas A&M, and **Kirsten Bohn**, Texas A&M, Department of Biology (1067-92-149)

10:15AM ► (249) *Computational docking of molecular wires to the reaction center of Rhodobacter sphaeroides.* Preliminary report.
Byong Y Kwon, George Mason University (1067-92-1208)

10:30AM (250) *Utilizing gene pathway-based priors in Bayesian association studies.* Preliminary report.
Abra Brisbin*, Division of Biomedical Statistics and Informatics, Department of Health Sciences Research, Mayo Clinic, **Liewei Wang**, Division of Clinical Pharmacology, Department of Molecular Pharmacology and Experimental Therapeutics, Mayo Clinic, and **Brooke L. Fridley**, Division of Biomedical Statistics and Informatics, Department of Health Sciences Research, Mayo Clinic (1067-92-2030)

10:45AM (251) *The effect of sampling rate on the statistics of microtubules.* Preliminary report.
Shantia Yarahmadian*, Mississippi State University, and **Sidney L. Shaw**, Indiana University, Department of Biology (1067-92-1434)

MAA Department Liaisons Meeting

9:30 AM – 11:00 AM

AMS Invited Address

10:05 AM – 10:55 AM

(252) *The symplectic geometry of symmetric products and invariants of 3-manifolds with boundary.*
Denis Auroux, University of California Berkeley (1067-57-8)

AMS-MAA Invited Address

11:10 AM – NOON

► (253) *Curves, surfaces, and solitons.*
Chuu-Lian Terng, University of California at Irvine (1067-53-7)

AMS Colloquium Lectures: Lecture I

1:00 PM – 2:00 PM

► (254) *Expander graphs in pure and applied mathematics, I.* Preliminary report.
Alexander Lubotzky, The Hebrew University of Jerusalem (1067-05-13)

MAA Invited Address

2:15 PM – 3:05 PM

(255) *Laplacian growth and the mystery of the abelian sandpile: A visual tour.*
Yuval Peres, Microsoft Research (1067-A0-38)

AMS-MAA-SIAM Special Session on Research in Mathematics by Undergraduates and Students in Post-Baccalaureate Programs, II

2:15 PM – 6:05 PM

Organizers: **Darren A. Narayan**, Rochester Institute of Technology
Bernard Brooks, Rochester Institute of Technology
Jobby Jacob, Rochester Institute of Technology
Jacqueline A. Jensen, Sam Houston State University
Carl V. Lutzer, Rochester Institute of Technology

2:15PM ► (256) *The Geometry and Dynamics of an Ecological Arms Race.*
Abigail Fisher*, **Elizabeth Cowdery**, **Michelle Winerip**, **Allison Reed-Harris** and **Jayna Resman**, Smith College (1067-92-1136)

2:45PM ► (257) *Groups and Change Ringing.* Preliminary report.
Sarah Costrell*, **Margaret Ewing**, **Jessica Lord** and **Viktoria Pardey**, Smith College (1067-20-1138)

3:15PM ► (258) *Mathematical modeling of interface-dominated materials properties.*
Russell J Mahoney* and **Maria G Emelianenko**, George Mason University (1067-74-1037)

3:45PM ► (259) *The Subgraph Summability Number of a Graph.*
Ligo G Richard*, Westminster College, and **Larson-Koester R Miriam**, Mount Holyoke College (1067-05-139)

4:15PM ► (260) *Optimal Ranges for ECG Noise Removal by Using Wavelets.*
Marilyn Manee Smith*, **Megan Elizabeth Haske** and **Darren Everett Sowards**, Central Michigan University (1067-00-143)

4:45PM ► (261) *A Solution to the Inverse Eigenvalue Problem for 3-by-3 Totally Nonnegative Matrices of Class 2.*
Robert Fraser*, **Michael C Steward**, Case Western Reserve University, **Shahla Nasserasr** and **Charles Johnson**, College of William and Mary (1067-15-120)

5:15PM ► (262) *Counting Formulas and Partition Zeta Functions of Atomic Measures.*
Kate E Ellis, California State University, Stanislaus (1067-28-79)

5:45PM ► (263) *Continuously Moving Parseval Frames on Smooth Manifolds.* Preliminary report.
Ryan L. Hotovy*, University of Nebraska- Lincoln, **Eileen R. Martin**, The University of Texas at Austin, and **Daniel Freeman**, University of Texas at Austin (1067-53-124)

AMS-MAA Special Session on History of Mathematics, II

2:15 PM – 6:05 PM

Organizers: **Sloan E. Despeaux**, Western Carolina University
Craig G. Fraser, University of Toronto
Deborah Kent, Hillsdale College

2:15PM (264) *Math Needs Paper and Imagination?: Embodying the Mathematical Knowledge in 17th century Japan.*
Tomoko L Kitagawa, Harvard University (1067-01-1308)

2:45PM ► (265) *Early Chinese Mathematics: its Development from pre-Qin to Wei.* Preliminary report.
Joseph W. Dauben, National Chiao-Tung University, Taiwan (1067-01-1078)

3:15PM (266) *Chinese Roots of Linear Algebra.*
Roger Hart, University of Texas at Austin (1067-01-1570)

3:45PM ► (267) *Trigonometric Tables in China.*
Jiang-Ping Jeff Chen, St. Cloud State University, Minnesota (1067-01-132)

4:15PM ► (268) *The Mathematical Study of Historical Numerical Tables: Successes, Failures, Issues.*
Glen R Van Brummelen, Quest University (1067-01-1348)

4:45PM (269) *Diagrams and spheres: reflections on an early Arabic edition of Menelaus' Spherics.*
Nathan Sidoli, Waseda University (1067-01-1076)

5:15PM (270) *Ptolemy's justification for the study of mathematics.*
Jacqueline Feke, Stanford University (1067-01-1575)

5:45PM (271) *Seventeenth-century debates on ratio and proportionality revisited.*
Antoni Malet, Universitat Pompeu Fabra (1067-01-2423)

AMS-SIAM Special Session on Mathematics of Computation: Differential Equations, Linear Algebra, and Applications, II

2:15 PM – 6:05 PM

Organizers: **Susanne C. Brenner**, Louisiana State University
Chi-Wang Shu, Brown University

2:15PM (272) *Superlinear convergence of MINRES.*
Valeria Simoncini, University of Bologna, and **Daniel B Szyld***, Temple University (1067-65-1904)

2:45PM (273) *A Hybridizable Discontinuous Galerkin Method for Steady-State Convection-Diffusion-Reaction Problems.*
Bernardo Cockburn, University of Minnesota, **Bo Dong***, Drexel University, **Johnny Guzman**, Brown University, **Marco Restelli**, Max-Planck-Institut für, and **Riccardo Sacco**, Politecnico di Milano (1067-65-1771)

3:15PM (274) *Discontinuous Galerkin Schemes for Vlasov-Poisson Systems.*
Yingda Cheng*, University of Texas at Austin, **Irene M Gamba** and **Phillip J Morrison**, University of Texas at Austin (1067-65-363)

3:45PM (275) *Applications of recovery techniques in finite element methods.*
Ahmed A. Naga*, Applied Automation Technologies, Inc., and **Zhimin Zhang**, Wayne State University (1067-65-652)

4:15PM (276) *Template Matching via l_1 regularization with Application to Hyperspectral Imaging.*
Zhaohui Guo* and **Stanley Osher**, University of California, Los Angeles (1067-49-1080)

4:45PM ► (277) *Multi-level Algorithms for Infinite-dimensional Integration on $\mathbb{R}^{\mathbb{N}}$.*
Ben Niu*, **Fred J. Hickernell**, Illinois Institute of Technology, **Klaus Ritter**, Fachbereich Mathematik, Technische Universität Darmstadt, Schloßgartenstr. 7, Darmstadt , Germany, and **Thomas Müller-Gronbach**, Universität Passau, Germany (1067-65-1797)

5:15PM (278) *Fast Spectral Sparse Grid Methods for High Dimensional Non-periodic Problems.*
Haijun Yu* and **Jie Shen**, Purdue University (1067-65-1681)

5:45PM ► (279) *Visibility based pursuit-evasion and related control problems.*
Ryo Takei, University of California, Los Angeles (1067-49-1522)

AMS-SIAM Special Session on Nonlinear Waves and Integrable Systems, II

2:15 PM – 6:05 PM

Organizers: **Gino Biondini**, State University of New York at Buffalo
Barbara Prinari, University of Colorado at Colorado Springs

2:15PM (280) *A Burgers model for striped pattern formation in the strong bending regime.*
Nicholas M Ercolani, University of Arizona (1067-35-883)

2:45PM (281) *Numerical solution of the Novikov-Veselov equation.*
Ryan Croke, Colorado State University, **Matti J Lassas**, University of Helsinki, **Jennifer L Mueller***, Colorado State University, **Samuli Siltanen**, University of Helsinki, and **Andreas Stahel**, Bern University of Applied Sciences (1067-35-970)

3:15PM (282) *Matrix exponential methods to derive exact solutions of nonlinear evolution equations.*
Cornelis Van Der Mee* and **Francesco Demontis**, University of Cagliari (1067-34-1195)

3:45PM (283) *On classical and radiating strain solitary waves in layered waveguides.*
Karima Khusnutdinova*, Loughborough University, UK, **Galina Dreiden**, **Alexander Samsonov** and **Irina Semenova**, Ioffe Physical Technical Institute, Russia (1067-35-723)

4:15PM ► (284) *Proper Orthogonal Decomposition for Characterizing Nonlinear Wave Dynamics in Mode-Locked Lasers.*
J. Nathan Kutz, University of Washington (1067-35-78)

4:45PM (285) *Oblique Shock Waves in Dispersive Eulerian Fluids.*
Mark A. Hoefer, North Carolina State University (1067-76-822)

5:15PM (286) *Population dynamics models for pulse dynamics in broadband fiber optics communication systems.*
Avner Peleg* and **Quan Nguyen**, State University of New York at Buffalo (1067-35-540)

5:45PM (287) *Linear Stability of Gap Solitons in One-dimensional Periodic Media.*
Guenbo Hwang*, University of Vermont, **Triantaphyllos R Akylas**, Massachusetts Institute of Technology, and **Jianke Yang**, University of Vermont (1067-35-1057)

AMS Special Session on Quadratic Forms in Algebra and Geometry, II

2:15 PM – 6:05 PM

Organizers: **Jorge F. Morales**, Louisiana State University
Anne Queguiner-Mathieu, Université de Paris 13

2:45PM (288) *The gamma filtration and codimension 3 cycles on projective homogeneous varieties.*
Skip Garibaldi*, Emory University, and **Kirill Zainoulline**, University of Ottawa (1067-14-984)

3:15PM (289) *Zero Cycles on Principal Homogeneous Spaces under Semisimple Groups.*
Jodi A. Black, Emory University (1067-11-959)

3:45PM (290) *Levels and Pythagoras numbers of commutative rings.* Preliminary report.
David B. Leep, University of Kentucky (1067-11-1282)

4:15PM (291) *The 3-Pfister number of quadratic forms.*
Mélanie Raczek, Université Catholique de Louvain (1067-12-476)

4:45PM (292) *The Graded Witt Group Kernel of Biquadratic Extensions in Characteristic Two.* Preliminary report.
Bill Jacob*, University of California, Santa Barbara, and **Roberto Aravire**, Universidad Arturo Prat (1067-12-757)

5:15PM (293) *Higher dimensional local-global principles.* **David Harbater**, University of Pennsylvania, **Julia Hartmann**, Aachen University, and **Daniel Krashen***, University of Georgia (1067-12-2199)

5:45PM (294) *Semiorderings and stability index under field extensions.* Preliminary report. **Karim Johannes Becher**, Universität Konstanz, **David B Leep**, University of Kentucky, and **Claus Schubert***, SUNY Cortland (1067-11-524)

AMS Special Session on Mathematical Techniques in Musical Analysis, II

2:15 PM – 6:05 PM

Organizers: **Robert W. Peck**, Louisiana State University
Thomas M. Fiore, University of Michigan at Dearborn

2:15PM (295) *Eine Kleine Mathmusik: Six Mathematical Compositions for Bridges Pécs 2010.* **Rachel Wells Hall**, Saint Joseph's University (1067-00-1056)

2:45PM (296) *Fokker's 'Periodicity Blocks', Hellegouarch's 'Natural Scales', and my 'Generated Tone Systems'.* **Marek Zabka**, Department of Musicology, Comenius University, Bratislava, Slovakia (1067-20-943)

3:15PM ► (297) *The Coin Problem, Central Words, and Guido of Arezzo.* **David L. Clampitt**, The Ohio State University (1067-05-688)

3:45PM (298) *Well-formed Scales and Alteration: An Arithmetic Investigation into Music Notation.* **Thomas Noll**, Escola Superior de Musica de Catalunya, Barcelona: Departament de Teoria i Composició (1067-20-1040)

4:15PM (299) *Massively all-interval voice-leading structures.* **Jonathan Wild**, Schulich School of Music, McGill University (1067-05-792)

4:45PM (300) *The Rational Number System as a Generator of Musical Form.* **Robert Wannamaker**, California Institute of the Arts (1067-00-1961)

5:15PM (301) *Topology of Musical Data.* **William A. Sethares**, University of Wisconsin, Madison, WI (1067-55-321)

5:45PM (302) *Towards Gestural Music Analysis.* **Guerino Bruno Mazzola**, University of Minnesota, School of Music (1067-18-483)

AMS Special Session on Integral Geometry: Analysis and Applications, II

2:15 PM – 6:05 PM

Organizers: **Gaik Ambartsoumian**, University of Texas, Arlington
Gestur Olafsson, Louisiana State University
Eric Todd Quinto, Tufts University
Boris S. Rubin, Louisiana State University

2:15PM (303) *Singular value decomposition for the truncated Hilbert transform.* **Alexander Katsevich**, University of Central Florida (1067-44-929)

2:45PM (304) *Local Inversion of the Sonar Transform Regularized by the Approximate Inverse.* **Eric Todd Quinto***, Tufts University, **Andreas Rieder**, Karlsruhe Institute of Technology, and **Thomas Schuster**, Helmut Schmidt Universität (1067-92-187)

3:15PM (305) *Microlocal properties for the slant-hole SPECT operator.* **Raluca Felea***, Rochester Institute of Technology, and **Todd Quinto**, Tufts University (1067-44-432)

3:45PM (306) *Local rigidity results for Riemannian metrics on a manifold with boundary.* **James Vargo**, Texas A&M University (1067-53-1335)

4:15PM (307) *L^2-wellposedness for Schrödinger type equations on $\mathbf{S^n}$.* Preliminary report. **Tomoyuki Kakehi**, Okayama University (1067-35-2010)

4:45PM (308) *The Admissibility Problem for Radon transforms on projective spaces over finite fields.* Preliminary report. **Eric L Grinberg***, University of Massachusetts, Boston, and **David V. Feldman**, University of New Hampshire (1067-52-1959)

5:15PM ► (309) *On simplexes determined by fractal subsets of the Euclidean space.* **Alex Iosevich**, University of Rochester (1067-42-417)

5:45PM (310) *Partial Abel Transforms on Damek-Ricci spaces and their application.* Preliminary report. **William O. Bray**, University of Maine (1067-42-112)

AMS Special Session on Theory and Application of Stochastic Differential Equations and Stochastic Partial Differential Equations, II

2:15 PM – 6:05 PM

Organizers: **Armando Arciniega**, University of Texas at San Antonio
Edward J. Allen, Texas Tech University
Sivapragasam Sathananthan, Tennessee State University
Mahmoud Anabtawi, American University of Sharjah

2:15PM (311) *Immortal Particle for a Catalytic Branching Process.* **Min Kang**, North Carolina State University (1067-60-467)

2:45PM (312) *Hybrid network dynamic inequalities under hereditary and random perturbations.* Preliminary report. **Gangaram S Ladde**, University of South Florida (1067-60-1941)

3:15PM (313) *On a class of abstract measure-dependent stochastic evolution equations.* Preliminary report. **Mark A McKibben**, Goucher College (1067-60-360)

3:45PM (314) *Generalized Random Differential Inequalities and Applications.* Preliminary report. **Jinghan Meng*** and **Gangaram S Ladde**, University of South Florida (1067-60-1980)

4:15PM (315) *Dynamic Modeling of Network Externality.* Preliminary report. **Arnut Paothong*** and **Gangaram S Ladde**, University of South Florida (1067-62-1011)

4:45PM (316) *Machine learning methods in Finance.* Preliminary report. **Kandethody M Ramachandran**, University of South Florida (1067-60-1978)

5:15PM (317) *Stochastic models for heat flow in a cylinder.* Preliminary report.
Edward W. Swim*, Sam Houston State University, and **Mark P. Adams**, United States Army (1067-65-2038)

5:45PM (318) *On Optimal Harvesting Problems in Random Environments.*
Qingshuo Song, City University of Hong Kong, **Richard Stockbridge** and **Chao Zhu***, University of Wisconsin-Milwaukee (1067-60-409)

AMS Special Session on Analytic and Geometric Methods in Representation Theory, II

2:15 PM – 6:05 PM

Organizers: **Leticia Barchini**, Oklahoma State University
Hongyu He, Louisiana State University

2:15PM (319) *Eigenspace representations for homogeneous spaces.*
Sigurdur Helgason, MIT (1067-22-323)

3:15PM (320) *The Belkale-Kumar cup product and relative Lie algebra cohomology.*
William Graham*, University of Georgia, and **Sam Evens**, University of Notre Dame (1067-22-1929)

3:45PM (321) *A realization of an irreducible unitary representation.*
Juhyung Lee, Oklahoma State University (1067-22-1242)

4:15PM (322) *Geometric models for the spectra of certain Gelfand pairs associated with Heisenberg groups.*
Gail Ratcliff* and **Chal Benson**, East Carolina University (1067-43-813)

4:45PM (323) *Equivariant Cohomology Class Formulas for K-Orbit Closures in the Flag Variety.* Preliminary report.
Benjamin J Wyser, University of Georgia (1067-14-2105)

5:15PM (324) *Ramanujan's master theorem for symmetric spaces.*
Gestur Olafsson*, Louisiana State University, and **Angela Pasquale**, University of Metz, France (1067-22-909)

5:45PM (325) *Square integrable harmonic spinors.* Preliminary report.
Roger Zierau* and **Leticia Barchini**, Mathematics Department, Oklahoma State University (1067-22-1295)

AMS Special Session on Geometric Group Theory, II

2:15 PM – 6:05 PM

Organizers: **Joshua B. Barnard**, University of South Alabama
Pallavi Dani, Louisiana State University

2:15PM (326) *On (co)homological characterizations of exact groups.*
Jacek Brodzki, **Graham A. Niblo**, University of Southampton, **Piotr W. Nowak***, Texas A&M University, and **Nick J. Wright**, University of Southampton (1067-20-370)

2:45PM (327) *Reduced 1-cohomology and relative (T).*
Talia Fernos*, Hebrew University of Jerusalem and University of North Carolina at Greensboro, and **Alain Valette**, Universite de Neuchatel (1067-20-2422)

3:15PM (328) *Extremality of the rotation quasimorphism on the modular group.* Preliminary report.
Joel Louwsma, California Institute of Technology (1067-57-1530)

3:45PM (329) *Stable commutator length and maps from bounded surfaces to closed surfaces.*
Matthew B. Day, California Institute of Technology (1067-57-682)

4:15PM (330) *What is a cross ratio?*
Francois Labourie, Universite Paris-Sud, Orsay (1067-51-1350)

4:45PM (331) *Hyperplane arrangements in negatively curved manifolds and relative hyperbolicity.*
Igor Belegradek, Georgia Institute of Technology, and **G. Christopher Hruska***, University of Wisconsin–Milwaukee (1067-20-2414)

5:15PM (332) *Local Quasiconvexity of Groups acting on Small Cancellation Complexes.*
Eduardo Martínez-Pedroza*, McMaster University, and **Daniel T. Wise**, McGill University (1067-20-563)

5:45PM (333) *Conjugacy classes of solutions to systems of equations over hyperbolic groups.*
Daniel Groves*, University of Illinois at Chicago, and **Henry Wilton**, California Institute of Technology (1067-20-1392)

AMS Special Session on Computational Algebraic and Analytic Geometry for Low-Dimensional Varieties, II

2:15 PM – 6:05 PM

Organizers: **Mika K. Seppala**, Florida State University
Tanush Shaskas, Oakland University
Emil Volcheck, National Security Agency

2:15PM (334) *Rational curves on cubic hypersurfaces.*
Izzet Coskun*, University of Illinois at Chicago, and **Jason Starr**, SUNY Stony Brook (1067-14-1220)

2:45PM (335) *Existence and computation of rational general solutions of parametrizable ODEs.*
Franz Winkler, RISC, J. Kepler University Linz, Austria (1067-14-573)

3:15PM (336) *Computations in Cubic Function Fields of Characteristic Three.*
Jonathan Webster, Bates College (1067-11-726)

3:45PM (337) *The arithmetic of genus two curves.*
Lubjana Beshaj*, University of Vlora, Vlora, Albania, and **Tanush Shaska**, Oakland University (1067-14-810)

4:15PM (338) *The Inverse Galois Problem with minimal ramification over function fields.*
Nigel Boston and **Meghan De Witt***, University of Wisconsin-Madison (1067-12-1991)

4:45PM (339) *Isotopic Approximations of Singular Algebraic Curves.*
Michael A Burr*, Fordham University, **Sung Woo Choi**, Duksung Women's University, **Ben Galehouse**, Max-Planck-Institut für Informatik, and **Chee K Yap**, Courant Institute, NYU (1067-14-2129)

5:15PM (340) *Class Number and Regulator Computation in Purely Cubic Function Fields of Unit Rank Two.*
Eric J Landquist*, Kutztown University, **Felix Fontein** and **Renate Scheidler**, University of Calgary (1067-11-1939)

5:45PM (341) *Ideals of curves given by points.*
Elisabetta Fortuna, **Patrizia Gianni**, University of Pisa, and **Barry M Trager***, IBM T.J.Watson Research Center (1067-14-2271)

AMS Special Session on Mathematical Modeling in Environmental Economics, II

2:15 PM – 5:00 PM

Organizers: **Natali Hritonenko**, Prairie View A&M University
Yuri Yatsenko, Houston Baptist University

2:15PM ► (342) *Modeling a Carbon Market Using an Engineering Approach: Blue Chips Turning Green.*
Steven A Bleiler*, Portland State University, **Yoko Nagase**, Oxford Brookes University, and **Thomas Fielden**, Portland State University (1067-90-1389)

3:15PM (343) *Modeling of the optimal economic response to environmental adaptation.*
Yuri Yatsenko, School of Business, Houston Baptist University (1067-90-641)

4:15PM (344) *Undergraduate research examples on Mathematical Modeling in Environmental Economics.*
Kaibin Fu, Prairie View A&M University (1067-92-1268)

4:45PM (345) *Some hyperbolic equations arising in mathematical cosmology.*
Anahit Galstyan, University of Texas-Pan American (1067-35-2182)

AMS Special Session on Interactions of Inverse Problems, Signal Processing, and Imaging, I

2:15 PM – 6:05 PM

Organizer: **Zuhair Nashed**, University of Central Florida

2:15PM (346) *Quantitative photoacoustics and other hybrid inverse problems.*
Guillaume Bal, Columbia University (1067-35-1726)

2:45PM (347) *Compressive imaging by the MUSIC algorithm.*
Albert Fannjiang, UC Davis (1067-68-278)

3:15PM (348) *Inverse scattering via near-field imaging.* Preliminary report.
Gang Bao*, Zhejiang University and Michigan State University, and **Junshan Lin**, Michigan State University (1067-78-1198)

3:45PM ► (349) *Satellite Gravity Gradiometry (SGG).*
Willi Freeden, University of Kaiserslautern (1067-86-2429)

4:15PM (350) *Identification of interfaces using the pressure parts (or the shear parts) of the elastic waves.*
Drossos Gintides, National Technical University of Athens, and **Mourad Sini***, RICAM, Austrian Academy of Sciences (1067-35-342)

4:45PM (351) *Shape Reconstruction based on Integral Invariants: Theory and Applications.*
Thomas Fidler, Computational Science Center, University of Vienna, Austria (1067-65-1197)

5:15PM (352) *Generalized local regularization of linear inverse problems, with application to Volterra problems in L^p-spaces.* Preliminary report.
Cara D. Brooks* and **Patricia K. Lamm**, Michigan State University (1067-45-1775)

5:45PM ► (353) *Image and Data Fusion.*
Todd Wittman, UCLA (1067-94-2177)

MAA Minicourse #11: Part A

2:15 PM – 4:15 PM

Using video case studies in teaching a proof-based gateway course to the mathematics major.

Organizers: **James T. Sandefur**, Georgetown University
Connie M. Campbell, Milllsaps College
Kay Somers, Moravian College

MAA Minicourse #2: Part A

2:15 PM – 4:15 PM

Getting mathematics majors to think outside the book: Course activities that promote exploration, discovery, conjecture, and proof.

Organizers: **Suzanne Dorée**, Augsburg College
Jill Dietz, St. Olaf College
Brian P. Hopkins, St. Peter's College

MAA Minicourse #9: Part A

2:15 PM – 4:15 PM

Learning discrete mathematics via historical projects.

Organizers: **Jerry M. Lodder**, New Mexico State University
Guran Bezhanishvili, New Mexico State University
David J. Pengelley, New Mexico State University
Janet H. Barnett, Colorado State University, Pueblo

AMS Session on Statistics

2:15 PM – 5:55 PM

2:15PM ► (354) *Supporting Women in STEM fields: The Wi^2STEM Club"s Impact on Student Members at Clayton State University.* Preliminary report.
Michelle York*, **Catherine Matos** and **Mary Hudachek-Buswell**, Clayton State University (1067-62-2280)

2:30PM (355) *Fair Regulation and Calculation Of Scores In Competitions Involving Judges' assessment.*
Chengyu Liu*, University of Wisconsin-Madison, and **Wei Pan**, Capital Medical University (1067-62-1875)

2:45PM (356) *Applying Recurrent Event Survival Analysis on China One child one family policy.* Preliminary report.
Boubakari Ibrahimou, Western Kentucky University (1067-62-1155)

3:00PM ► (357) *A Poisson Approximation for the Number of kl-Matches II.* Preliminary report.
Michael Donders*, McDaniel College, **Katherine Grzesik**, SUNY Oswego, **Chelsea Ross**, East Tennessee State University, and **Heather Shappell**, Arcadia University (1067-62-1774)

3:15PM ► (358) *The Power Cauchy Distribution: Derivation, Description, and Composite Models.*
Brian T Rooks*, University of North Carolina Chapel Hill, and **Amy C Schumacher**, Birmingham-Southern College (1067-62-170)

3:30PM (359) *Zero Inflated Exponential Distribution.*
Sougata Dhar and **Santanu Chakraborty***, University of Texas - Pan American (1067-62-595)

3:45PM (360) *Optimal designs for rational function regression.* **David Papp**, Rutgers University (1067-62-1111)

4:00PM (361) *Preliminary Report on the Power of the Bootstrap Ratio Test for Normality.* **Maria E. Calzada** and **Holly M. Gardner***, Loyola University New Orleans (1067-62-1144)

4:15PM ► (362) *Characterizations of t-distribution via conditional expectations of order statistics.* **George P Yanev***, The University of Texas - Pan American, and **M Ahsanullah**, Rider University (1067-62-1167)

4:30PM (363) *Tail Dependence Density of Vine copulas.* **Peiling Wu**, Math Department of Washington State University (1067-62-1384)

4:45PM (364) *Increased Adaptivity in Smoothed Polynomial Histograms with Application to Massive and Pre-Binned Datasets.* **Galen I Papkov**, Florida Gulf Coast University (1067-62-1418)

5:00PM ► (365) *Estimating Variance-Mean Mixtures of Normals.* **Hasan Hamdan**, **Ling Xu**, James Madison University, **Holly Gardner**, Loyola University New Orleans, **Sam Helmich**, Winona State University, **Caitlin Steiner***, College of William & Mary, and **Kevin Stoll**, Baldwin-Wallace College (1067-62-1492)

5:15PM (366) *The Joint Distribution of Surplus Immediately Before Ruin And The Deficit at Ruin Under Interest Force.* Preliminary report. **Kumer Pial Das*** and **Md. Shamim Sarker**, Lamar University (1067-62-2185)

5:30PM (367) *A novel Algorithm for ellipse fitting.* Preliminary report. **Ali A Al-Sharadqah**, University of Alabama at Birmingham (1067-62-719)

5:45PM ► (368) *On the Comparison of One Stage and Two Stage Selection Procedures in Bayes Approach.* Preliminary report. **Jin Tan**, University of Illinois at Chicago (1067-62-1657)

AMS Session on Topics in Algebra

2:15 PM – 6:10 PM

2:15PM (369) *The Invariance and the General Cohomology Comparison Theorems.* **Alin Stancu**, Columbus State University (1067-18-1719)

2:30PM (370) *An approach to the stable derived category via model categories.* Preliminary report. **Daniel Bravo**, Wesleyan University (1067-18-866)

2:45PM (371) *Lower Algebraic K-theory of virtually free groups.* **Seshendra Pallekonda**, King's College, PA (1067-19-1288)

3:00PM (372) *Combining Triple Diagonal Forms.* **Edward Eugene Rehkopf**, University of Southern Indiana (1067-15-1997)

3:15PM (373) *Determinants of sum of orbits under compact Lie group.* **Mary Clair Thompson*** and **Tin-Yau Tam**, Auburn University (1067-15-2040)

3:30PM ► (374) *The cprank and rank of a completely positive matrix.* Preliminary report. **Wasin So***, San Jose State University, and **Changqing Xu**, Zhejiang A&F University (1067-15-506)

3:45PM ► (375) *Solution Theory for Bilinear Systems of Equations.* **Dian Yang**, College of William and Mary (1067-15-182)

4:00PM ► (376) *Spectral Analysis of Non-Hermitian Matrices.* **Philip V Vu***, Williams College, and **Matthew Coudron**, University of Minnesota (1067-15-387)

4:15PM ► (377) *The Energy of Graphs.* **Audrey Margaret Hubbard***, Ave Maria University, and **Christian Matthew Woods**, University of Pittsburgh (1067-15-155)

4:30PM (378) *Euclidean Squared Distance Matrices.* Preliminary report. **Thomas Milligan**, University of Central Oklahoma (1067-15-2062)

4:45PM (379) *Numerical stability of an algorithm for the complete CS decomposition.* **Brian D. Sutton**, Randolph-Macon College (1067-15-2209)

5:00PM ► (380) *Behavior of Ritz Values for Normal Matrices and Jordan Blocks.* Preliminary report. **Russell L Carden***, **Mark Embree** and **Derek Hansen**, Rice University (1067-15-1712)

5:15PM ► (381) *Computation of zero forcing number for some families of graphs.* Preliminary report. **Darren D. Row**, Iowa State University (1067-15-1303)

5:30PM ► (382) *A Monte Carlo Algorithm for Computing Dot Products with Application to Information Retrieval.* **Sylvester David Eriksson-Bique**, University of Helsinki, **Mary Katherine Solbrig***, Reed College, **Michael Stefanelli**, College of New Jersey, **Sarah Warkentin**, Harvey Mudd College, **Ralph Abbey** and **Ilse Ipsen**, North Carolina State University (1067-15-472)

5:45PM ► (383) *Applying Simon-Ando Theory to Data Clustering.* **Charles D. Wessell*** and **Carl D. Meyer**, North Carolina State University (1067-15-553)

6:00PM ► (384) *Multilinear Algebra and Tensors.* Preliminary report. **William R Henderson***, **Jeffrey M Wyman**, **Carla D Martin**, James Madison University, and **Misha E Kilmer**, Tufts University (1067-15-54)

AMS Session on Number Theory, II

2:15 PM – 5:40 PM

2:15PM (385) *Study of Polynomial Solutions to Certain Diophantine Equations.* **Emel Demirel*** and **Aihua Li**, Montclair State University (1067-97-739)

2:30PM (386) *On Somos' dissection identities.* **Zhu Cao**, University of Mississippi (1067-11-2334)

2:45PM (387) *Higher order spt-functions.* **F. G. Garvan**, University of Florida (1067-11-2000)

3:00PM ► (388) *On the transcendence of Fourier and other infinite series.* **Chester J Weatherby**, University of Delaware (1067-11-2299)

3:15PM (389) *Limiting structure for some central binomial evaluations.* **John R. Greene**, University of Minnesota Duluth (1067-11-938)

3:30PM (390) *The k-Zeckendorf Array.* **Curtis N Cooper**, University of Central Missouri (1067-11-1277)

3:45PM ► (391) *Enumeration of Triangles in Rational Residue Graphs.* **Mark Budden**, Western Carolina University, **Nicole Calkins**, **William Nathan Hack**, **Joshua K Lambert** and **Kimberly Thompson***, Armstrong Atlantic State University (1067-11-1528)

4:00PM ► (392) *Enumeration of Triangles in Quartic Residue Graphs.*
Mark Budden, Western Carolina University, **Nicole Calkins***, **William Nathan Hack**, **Joshua K Lambert** and **Kimberly Thompson**, Armstrong Atlantic State University (1067-11-1029)

4:15PM (393) *A connection between Hopf orders and Laurent series.* Preliminary report.
Alan Koch, Agnes Scott College (1067-11-1987)

4:30PM ► (394) *Random Additive 3-Bases & Sum-free Sets.* Preliminary report.
Chang Mou Lim*, Yale University, and **Nicholas George Triantafillou**, University of Michigan, Ann Arbor (1067-11-1872)

4:45PM (395) *On Nathanson's problem in number theory and geometric group theory.*
Krishanu Roy Sankar, Massachusetts Institute of Technology (1067-11-1094)

5:00PM (396) *Lipschitz Bounds for Rational Functions Defined over the Berkovick Projective Line over an Algebraically Closed and Complete Non-Archimedean Field.* Preliminary report.
Stephen Edward Winburn, University of Georgia (1067-11-1718)

5:15PM (397) *EZADS Inputs which Produce Half-Factorial Block Monoids.*
Jeffrey A Manning, California Institute of Technology (1067-11-1074)

5:30PM (398) *A Note on the Power Subgroups of the Modular Group.*
Omer Yayenie, Murray State University (1067-11-362)

AMS Session on Mathematics Education, II

2:15 PM – 3:55 PM

2:15PM (399) *Items for Assessment of Mathematical Content Knowledge for Secondary Teachers.*
Hugo Rossi, University of Utah (1067-97-1252)

2:30PM ► (400) *Prospective Teachers' Self-assessment Based on Reflective Writing Assignments in a Pre-service Math Course.* Preliminary report.
James R. Valles Jr* and **Rebecca Ortiz**, Texas Tech University (1067-97-175)

2:45PM ► (401) *Numerical Reasoning: An Inquiry-Based Course for K-8 Teachers.*
Rachel Cochran, **Jason Fulmore**, Center for Educational Accountability, **John C. Mayer**, University of Alabama at Birmingham, and **Bernadette Mullins***, Birmingham-Southern College (1067-97-1768)

3:00PM ► (402) *Connecting Mathematics Learning with Teaching.*
Virginia L. Keen, University of Dayton (1067-97-1557)

3:15PM (403) *Teaching Mathematics in the Technological Classroom: Teachers Do, Technology Doesn't.* Preliminary report.
Robert G Page, Framingham State University (1067-97-1967)

3:30PM ► (404) *An Electronic Classroom Model for Mathematics Content Courses.*
Brooke E Evans* and **Patricia McKenna**, Metropolitan State College of Denver (1067-97-2365)

3:45PM ► (405) *Aligning middle and high school teachers' teaching to new algebra trends in California.* Preliminary report.
Imre Tuba* and **Jeff Burt**, San Diego State University, Imperial Valley (1067-97-2400)

AMS Session on Combinatorics and Graph Theory, III

2:15 PM – 6:10 PM

2:15PM (406) *Maximal minimal k-rankings of caterpillar trees and cycles.*
Lauren R. McGough, MIT (1067-05-2049)

2:30PM ► (407) *The Set Chromatic Number of a Directed Graph.* Preliminary report.
J Larry Langley* and **K Sarah Merz**, University of the Pacific (1067-05-1351)

2:45PM (408) *Conflict free coloring of (simple) hypergraphs with few edges.*
Mohit Kumbhat*, **A Kostochka**, University of Illinois, Urbana-Champaign, and **T Luczak**, Emory University (1067-05-607)

3:00PM ► (409) *On graph labelings and cyclic G-designs.*
Ryan C Bunge*, Illinois State University, **Avapa Chantasartrassmee**, University of the Thai Chamber of Commerce, **Saad El-Zanati** and **Charles Vanden Eynden**, Illinois State University (1067-05-2201)

3:15PM ► (410) *On Rosa-Type Labelings of 3-regular Graphs.*
Wannasiri Wannasit*, Chiang Mai University, and **Saad El-Zanati**, Illinois State University (1067-05-2213)

3:30PM (411) *Modular Edge-Graceful Graphs.*
Futaba Fujie-Okamoto, University of Wisconsin La Crosse (1067-05-1495)

3:45PM (412) *Hall m-completable graphs.* Preliminary report.
Sibel Ozkan, Michigan Technological University, and **Erik E Westlund***, University of Wisconsin-Marshfield/Wood County (1067-05-1651)

4:00PM ► (413) *Planarized Pascal's triangle mod a general prime p graphs and their Properties.*
Heather M. Shappell*, Arcadia University, **Katherine Grzesik**, SUNY Oswego, and **Mike Donders**, McDaniel College (1067-05-1723)

4:15PM ► (414) *Graph Labeling with Distance-Two Constraints.*
Jobby Jacob, Rochester Institute of Technology (1067-05-2261)

4:30PM (415) *On the λ-numbers of subclasses of generalized Petersen graphs.*
Sarah Spence Adams, **Paul Booth***, **Harold Jaffe**, Franklin W. Olin College of Engineering, **Denise Sakai Troxell**, Babson College, and **Steven Luke Zinnen**, Franklin Olin College of Engineering (1067-05-2058)

4:45PM (416) *Dynamic Monopolies and k-Conversion Sets in Graph Products and Triangular Grids: Modeling the Spread of Fault in Distributed Network Systems.*
Sarah Spence Adams, **Zachary Brass**, **Connor Stokes***, Franklin W. Olin College of Engineering, **Denise Sakai Troxell**, Babson College, and **Steven Luke Zinnen**, Franklin W. Olin College of Engineering (1067-05-2103)

5:00PM (417) *On-line Degree Ramsey Numbers: Building and Painting Graphs, One Edge at a Time.*
David S. Rolnick, Massachusetts Institute of Technology (1067-05-2342)

5:15PM ► (418) *Zero Forcing Sets and Bipartite Circulants.* Preliminary report.
Seth A. Meyer, University of Wisconsin - Madison (1067-05-2134)

5:30PM ► (419) *On a (p, q)-edge coloring of K_n.*
Zachary Kudlak*, Mount Saint Mary College, and **Luboš Thoma**, University of Rhode Island (1067-05-1738)

5:45PM (420) *Almost-rainbow edge-colorings of some small subgraphs.*
Elliot J Krop*, Clayton State University, and **Irina Krop**, DePaul University (1067-05-1316)

6:00PM ► (421) *Max-optimal and sum-optimal labelings of graphs.*
Darren A. Narayan*, Rochester Institute of Technology, and **Robert Jamison**, Clemson University and The University of Haifa (1067-05-1270)

AMS Session on Combinatorics and Graph Theory, IV

2:15 PM – 6:10 PM

2:15PM (422) *Monochromatic sums equal to products in* $\mathbb{N}$.
Neil Hindman, Howard University (1067-05-587)

2:30PM ► (423) *Poset-Free Families in Boolean Lattices.*
Wei-Tian Li, University of South Carolina (1067-05-1499)

2:45PM ► (424) *Order in the Conjugacy Decomposition of the Rook Monoid.* Preliminary report.
Ryan K Therkelsen, Bellarmine University (1067-05-805)

3:00PM (425) *Resistance analysis of infinite networks.*
Palle E. T. Jorgensen, U. Iowa, and **Erin P. J. Pearse***, U. Oklahoma (1067-05-1733)

3:15PM ► (426) *Efficient Domination of Tessellations and other Infinite Graphs with Extra Symmetry.* Preliminary report.
Katie Rose Banks*, Harvard University, and **Chang Mou Lim**, Yale University (1067-05-1414)

3:30PM ► (427) *On Universal Cycles for new Classes of Combinatorial Structures.* Preliminary report.
Antonio Blanca, Georgia Institute of Techonology (1067-05-1104)

3:45PM ► (428) *Omnimosaics.* Preliminary report.
Nicholas George Triantafillou*, University of Michigan - Ann Arbor, and **Katie R. Banks**, Harvard University (1067-05-964)

4:00PM ► (429) *The Probability of an Even Number of Hills among Generalized Dyck Paths.* Preliminary report.
Naiomi T. Cameron, Lewis & Clark College (1067-05-703)

4:15PM ► (430) *Extraordinary Subsets of* $1, 2, 3, \ldots, n$.
Ralph P. Grimaldi, Rose-Hulman Institute of Technology (1067-05-850)

4:30PM ► (431) *A Wilf-Zeilberger Approach to Sums of Choi, Zornig and Rathie.*
Samantha Dahlberg, Michigan State University, **Timothy Ferdinands**, University of Notre Dame, and **Akalu Tefera***, Grand Valley State University (1067-05-1179)

4:45PM ► (432) *A Generalization of Algorithm-Z with Application.* Preliminary report.
Ae Ja Yee and **Kagan Kursungoz***, The Pennsylvania State University (1067-05-1408)

5:00PM ► (433) *A recursive Construction of Non-binary de Bruijn Sequences.*
Abbas Mahdi Alhakim*, American University of Beirut, and **Mufutau B Akinwande**, Clarkson University (1067-05-1447)

5:15PM ► (434) *A Nim-type game played on the complete graph.*
Lindsay Anne Merchant, North Dakota State University (1067-05-123)

5:30PM (435) *Winning strategy for Chomp Grid with 0, 1, 2, or 3 pieces in the 3rd row.*
Crystal L. Bennett*, North Carolina Agricultural & Technical State University, **Joshua Chukwuka**, Morgan State University, and **Kenneth Berg**, University of Maryland (1067-05-2277)

5:45PM (436) *The 2-adic valuation of the complementary Bell numbers.*
Valerio De Angelis*, Xavier University of Louisiana, **Victor H Moll** and **Tewodros Amdeberhan**, Tulane University (1067-05-1614)

6:00PM ► (437) *Sequences of matchings.* Preliminary report.
Sarah H Holliday, Southern Polytechnic State University (1067-05-1745)

MAA Session on Cryptology for Undergraduates

2:15 PM – 6:10 PM

Organizers: **Robert Edward Lewand**, Goucher College
Chris Christensen, Northern Kentucky University

2:15PM ► (438) *Algebraic Cryptanalysis as a tool for teaching Cryptology.*
Daniel Cabarcas, University of Cincinnati (1067-C5-706)

2:35PM ► (439) *Cryptography Tools: A Teaching Tool for the Investigation of Classical Cryptography and Cryptanalysis.*
Don Spickler, Salisbury University (1067-C5-811)

2:55PM ► (440) *Group Signature Schemes: How to share a secret without telling it.*
Cheryl L. Beaver, Western Oregon University (1067-C5-2202)

3:15PM (441) *Cryptography, a Great Topic for Undergraduate Mathematics Courses.*
Aihua Li, Montclair State University (1067-C5-1942)

3:35PM ► (442) *A Cryptology Course for the Non-Mathematician.*
Todd Feil, Denison University (1067-C5-446)

3:55PM ► (443) *A Brief Fly-Through of Cryptology for First-Semester Students using Active Learning and Common Technology.*
Robert Talbert, Franklin College (1067-C5-2059)

4:15PM ► (444) *A first-year seminar in cryptology.*
Robert A Beezer, University of Puget Sound (1067-C5-1428)

4:35PM ► (445) *Student Codebooks: An in-depth writing assignment.*
Stuart Boersma, Central Washington University (1067-C5-543)

4:55PM ► (446) *Codes in History, the Arts, and Literature.*
Kay E. Smith, Saint Olaf College (1067-C5-1192)

5:15PM ► (447) *Making Cryptography Come Alive.*
Kristi Meyer, Wisconsin Lutheran College (1067-C5-1315)

5:35PM (448) *Using Cryptography to Show Students that Math is Everywhere.* Preliminary report.
Mike May, Saint Louis University (1067-C5-1356)

5:55PM ► (449) *How to Construct a Spy Dossier.*
Peter J. Littig, University of Washington, Bothell (1067-C5-1816)

MAA Session on The Mathematics of Games and Puzzles, I

2:15 PM – 6:10 PM

Organizers: **Laura Taalman**, James Madison University
Robin L. Blankenship, Morehead State University

2:15PM (450) *Twist Untangle and its Discontents.*
Sandy Ganzell, **Alex Meadows***, St. Mary's College of Maryland, and **John Ross**, Johns Hopkins University (1067-P1-1784)

2:35PM ► (451) *Counting the Number of Hextile Knot Mosaics in a Diagram with Fixed Center and Radius.* Preliminary report.
Robin Leigh Blankenship*, **Michael Blankenship**, Morehead State University, and **Craig Hamilton**, University of Kentucky and Morehead State University (1067-P1-2340)

2:55PM ► (452) *Chessboard problems peppered with pawns.* Preliminary report.
Doug Chatham, Morehead State University (1067-P1-826)

3:15PM (453) *Discovering the Art of Mathematics: Straight-Cut Origami.*
Christine von Renesse* and **Volker Ecke**, Westfield State University (1067-P1-1892)

3:35PM ► (454) *Tropical determinants and cheating when solving the Rubik's cube.*
Thomas J Dinitz*, Colgate University, **Matthew Hartman**, Xavier University, and **Jenya Soprunova**, Kent State University (1067-P1-642)

3:55PM ► (455) *The 36Cube Puzzle.*
W D Wallis, Southern Illinois University, Carbondale, IL. (1067-P1-322)

4:15PM ► (456) *The minimal number of entries of a solvable Ken Ken.*
Philip Cobb, Queensborough Community College (1067-P1-886)

4:35PM ► (457) *On the Use of Fractional Matchings to Find Pairing Strategy Draws in N^d Tic-Tac-Toe.*
Klay T Kruczek, Western Oregon University (1067-P1-770)

4:55PM ► (458) *Tic-Tac-Toe with Eeny, Meeny, Miny, Moe.*
Dennis P. Walsh, Middle Tennessee State University (1067-P1-2306)

5:15PM (459) *A Winning Strategy for Tic-Tac-Toe on an Affine Plane of Order 4.*
Matthew P Conlen* and **Juraj Milcak**, The Fields Institute (1067-P1-2376)

5:35PM ► (460) *"Fire and Ice".*
Mary J. Riegel, The University of Montana (1067-P1-1644)

5:55PM ► (461) *Using SET® to Visualize AG(4,3).*
Elizabeth W McMahon*, Lafayette College, and **Kyle Kalail**, Hastings College (1067-P1-1024)

MAA Session on Getting Students Involved in Writing Proofs

2:15 PM – 6:30 PM

Organizers: **Aliza Steurer**, Dominican University
Jennifer Franko-Vasquez, University of Scranton
Rachel Schwell, Central Connecticut State University

2:15PM ► (462) *On peer grading to improve proof writing.*
Xuan Hien Nguyen* and **Andrew Bennett**, Kansas State University (1067-G1-1579)

2:35PM ► (463) *From Evaluating Proofs to Constructing Proofs.* Preliminary report.
Kyeong Hah Roh, Arizona State University (1067-G1-2239)

2:55PM ► (464) *(How) Can We Teach Proofs? A Classical Approach.*
Bernd S. W. Schroeder, Louisiana Tech University (1067-G1-309)

3:15PM ► (465) *A Group Project.*
Mary K Flagg, University of Houston (1067-G1-456)

3:35PM ► (466) *Using Bluetooth Technology in a Proof Writing Course.* Preliminary report.
Firas Y Hindeleh, Grand Valley State University (1067-G1-668)

3:55PM ► (467) *Using Clickers to Generate Discussion on Writing Proofs.*
Shannon R. Lockard, Bridgewater State University (1067-G1-2131)

4:15PM (468) *The Lurch Project: A word processor that checks your math.*
Nathan C Carter*, Bentley University, and **Kenneth G Monks**, University of Scranton (1067-G1-2168)

4:35PM ► (469) *Students of MATH 341,* Advances in Number Theory, **1** (2010), 1–30.
Sam Vandervelde, St. Lawrence University (1067-G1-1757)

4:55PM ► (470) *Teaching Proofs in Abstract Algebra: How important are proof structure, group work, and student presentations?*
Mindy Beth Capaldi, Valparaiso University (1067-G1-911)

5:15PM (471) *Within ϵ of independence: An attempt to produce independent proof-writers via an IBL approach in a real analysis course.*
Dana C. Ernst*, Plymouth State University, and **Angela Hodge**, North Dakota State University (1067-G1-2358)

5:35PM ► (472) *Engaging abstract algebra students in the craft of proof writing.* Preliminary report.
Jennifer A Bergner, Salisbury University (1067-G1-1100)

5:55PM ► (473) *Introducing Proofs to Calculus Students.*
Minah Oh, James Madison University (1067-G1-1107)

6:15PM ► (474) *Successful Strategies for Improving the Proof Writing of Linear Algebra Students.*
Lesley W Wiglesworth, Centre College (1067-G1-2346)

MAA Session on Harnessing Mobile Communication Devices and Online Communication Tools for Mathematics Education, II

2:15 PM – 3:10 PM

Organizers: **Michael B. Scott**, California State University Monterey Bay
Jason A. Aubrey, University of Missouri-Columbia

2:15PM ► (475) *The Joy of Numbers and Wikis.* Preliminary report.
Erica L Johnson, St. John Fisher College (1067-H1-2039)

2:35PM ► (476) *The experience of newbie helpers in a mathematics, open, online, homework help forum: Becoming part of a community of helpers.*
Carla C. van de Sande*, Arizona State University, and **E. Hsu**, San Francisco State University (1067-H1-2269)

2:55PM ► (477) *Treatment for the "Submit Answer" Addict: Active Interventions for Struggling Calculus Students identified by WeBWorK Performance Data.*
Aaron Wangberg, Winona State University (1067-H1-2382)

MAA Session on the Scholarship of Teaching and Learning in Collegiate Mathematics, II

2:15 PM – 5:10 PM

Organizers: **Jacqueline M. Dewar**, Loyola Marymount University

Thomas F. Banchoff, Brown University
Pam Crawford, Jacksonville University
Edwin P. Herman, University of Wisconsin-Stevens Point
Nathan Wodarz, University of Wisconsin-Stevens Point

2:15PM (478) *Re-testing as a strategy to promote equity.* **Dale J Winter**, Carnegie Mellon University (1067-V1-1490)

2:35PM (479) *Designing Precalculus for a Diverse Audience.* **Erich A McAlister**, Fort Lewis College (1067-V1-1612)

2:55PM ► (480) *Effects of a Modified Moore Method on Performance, Attitudes and Efficacy in Precalculus.* **Brad Bailey**, North Georgia College & State University (1067-V1-1151)

3:15PM ► (481) *A comparison of two paths in college level calculus.* Preliminary report. **Erin Terwilleger Mullen*** and **Amit Savkar**, University of Connecticut (1067-V1-2119)

3:35PM (482) *Implementing a Web-based System for Tagging Errors in Freshman Calculus Using Pen-Technology.* **Marilyn Reba***, **Allen Guest**, **Calvin Williams** and **Roy Pargas**, Clemson University (1067-V1-1413)

3:55PM ► (483) *A quantitative and qualitative comparison of homework structures in a multivariable calculus class.* Preliminary report. **Judith Lynn Gieger***, **John C. Nardo**, **Karen L. Schmeichel** and **Leah R. Zinner**, Oglethorpe University (1067-V1-1900)

4:15PM (484) *Student learning and retention of key concepts in sequences and series.* **Rebecca J. Schmitz*** and **Harvey Keynes**, University of Minnesota (1067-V1-2088)

4:35PM ► (485) *What Does it Mean for a Student to Understand the First-Year Calculus?: Perspectives of 24 Experts.* **Kimberly Santucci Sofronas***, Emmanuel College, **Thomas C DeFranco**, **Charles Vinsonhaler**, University of Connecticut, **Nick Gorgievski**, Nichols College, **Larissa Schroeder**, University of Hartford, and **Chris Hamelin**, University of Connecticut (1067-V1-203)

4:55PM ► (486) *Group Work and Self-Efficacy in a Business Calculus Class.* **Gregory A Kelsey**, University of Illinois at Urbana-Champaign (1067-V1-30)

MAA Session on Innovations in Service-Learning at All Levels

2:15 PM – 6:10 PM

Organizers: **Karl-Dieter S. Crisman**, Gordon College
Rachelle Ankney, North Park University
Robert V. Perlis, Louisiana State University

2:15PM ► (487) *Opportunities and Challenges in Incorporating Service-Learning in Mathematical Sciences Programs.* **Charles R. Hadlock**, Bentley University (1067-K1-1465)

2:35PM (488) *Community Service-Learning in Mathematics: Models for Course Design.* **Debra L. Hydorn**, University of Mary Washington (1067-K1-1296)

2:55PM ► (489) *Serve While You Learn: A Quantitative Literacy Course.* Preliminary report. **Karen Batt Stanish**, Keene State College (1067-K1-2137)

3:15PM (490) *Serving Hope- How to build service-learning into your non-major mathematics courses to benefit the local community.* **Melinda S Schulteis**, Concordia University, Irvine (1067-K1-855)

3:35PM ► (491) *Just Math: Learning about Justice with Math vs. Doing Justice with Math.* Preliminary report. **Rachelle M. Ankney**, North Park University (1067-K1-1507)

3:55PM (492) *Real Data & Service Learning Projects in Statistics.* **Brad Bailey*** and **Robb Sinn**, North Georgia College & State University (1067-K1-1524)

4:15PM ► (493) *Mathematical and Moral Development Through Service-Learning.* Preliminary report. **Karl-Dieter Crisman**, Gordon College (1067-K1-2037)

4:35PM ► (494) *Service-Learning in an Interdisciplinary Mathematics and Economics Course.* **Shafii-Mousavi Morteza***, Indiana University South Bend, and **Kochanowski Paul**, Indiana Univesity South Bend (1067-K1-76)

4:55PM ► (495) *Disaster Modeling – Beyond the Numbers.* **Benjamin Galluzzo**, Shippensburg University (1067-K1-2164)

5:15PM (496) *A Model for the Community.* **Tim Chartier**, Davidson College (1067-K1-913)

5:35PM ► (497) *A Service Project in a Capstone Modeling Course.* **Ethan Berkove**, Lafayette College (1067-K1-1402)

5:55PM ► (498) *Northern Territory Maths Camp.* **B. Carrigan***, **C. Carrigan**, **B. Kozak** and **C. Rodger**, Auburn University (1067-K1-1320)

MAA Session on Wavelets In Undergraduate Education, II

2:15 PM – 3:30 PM

Organizers: **Caroline Haddad**, SUNY Geneseo
Catherine A. Beneteau, University of South Florida
David K. Ruch, Metropolitan State College of Denver
Patrick J. Van Fleet, University of St. Thomas

2:15PM ► (499) *Who Are You? An Image Identification Project Using Wavelet Packet Analysis.* **Kevin F. Palmowski**, State University of New York at Geneseo (1067-Y5-1539)

2:35PM ► (500) *Multiwavelets and Image Compression.* **Cristen Bonz***, **Elizabeth Motz** and **Susan Ray**, University of St Thomas (1067-Y5-1901)

2:55PM ► (501) *An Undergraduate Research Project on Multiwavelets.* Preliminary report. **Bruce W. Atkinson**, Samford University (1067-Y5-1269)

3:15PM ► (502) *Teaching operator theory to undergraduates via frames.* Preliminary report. **Veronika Furst**, Fort Lewis College (1067-Y5-1753)

MAA General Contributed Paper Session, IV

2:15 PM – 5:55 PM

Organizers: **Kristen Meyer**, Wisconsin Lutheran College

Thomas R. Hagedorn, The College of New Jersey

2:15PM ► (503) *Comparing Circular and Spherical Inversions.* Preliminary report.
Deirdre L Smeltzer* and **Owen D Byer**, Eastern Mennonite University (1067-Z1-1470)

2:30PM ► (504) *Applications of Spherical Inversions.* Preliminary report.
Owen D Byer* and **Deirdre L Smeltzer**, Eastern Mennonite University (1067-Z1-1476)

2:45PM ► (505) *The* (ColoredCubes)^3 *Problem.*
Ethan Berkove, Lafayette College (1067-Z1-1405)

3:00PM ► (506) *Folding Math Together - A Senior Seminar in Origami.*
Cathy W. Carter*, **Brittany Nicole Course** and **Alan Killen**, Christian Brothers University (1067-Z1-2115)

3:15PM ► (507) *Tiling a square with squares.* Preliminary report.
Iwan Praton, Franklin and Marshall College (1067-Z1-565)

3:30PM (508) *Platonic Solid Puzzles and Patterns.*
Mike Long, Shippensburg University (1067-Z1-1957)

3:45PM ► (509) *Packing the hypercube.*
David Offner, Westminster College (1067-Z1-1737)

4:00PM ► (510) *Asymptotic Connectivity of Hyperbolic Tilings.* Preliminary report.
Robin Neumayer, University of South Carolina (1067-Z1-2255)

4:15PM ► (511) *Affine Transformations and Conformal Invariants.* Preliminary report.
James R. Valles Jr* and **Alexander Yu. Solynin**, Texas Tech University (1067-Z1-2378)

4:30PM ► (512) *Non-existence of regular polygons in the Cartesian plane with vertices at integer coordinates, except for squares.*
Jon Davidson, Southern State Community College (1067-Z1-1992)

4:45PM ► (513) *Discussing Symmetries of Polyhedra on their Structures.*
Joy Marie D'Andrea, University of South Florida (1067-Z1-1415)

5:00PM ► (514) *A Geodesic- and Parallel-Transport Based, Mass-Spring-Damper Error System on the Euclidean Sphere.*
Jason M Osborne, Frank W. Olin College of Engineering (1067-Z1-519)

5:15PM (515) *Contact angle for minimal surfaces in the sphere* S^5.
Rodrigo Ristow Montes, Federal University of Parana - UFPR (1067-Z1-23)

5:30PM ► (516) *Minimizing networks in Snell Geometry; the Snell-Steiner criterion.*
J Mealy* and **Gregory Koch**, Austin College (1067-Z1-1685)

5:45PM ► (517) *Building a Noncommutative Ring from a Finite Directed Graph.* Preliminary report.
Michael J Bardzell, Salisbury University (1067-Z1-1019)

SIAM Minisymposium on Applications of Difference and Differential Equations in Ecology and Epidemiology, II

2:15 PM – 6:10 PM

Organizers: **Zhilan Feng**, Purdue University
Yun Kang, Arizona State University

2:15PM (518) *A Stage-Structured Dispersal Model with Constant and Periodic Environments.*
Azmy S. Ackleh*, **Ross A. Chiquet** and **Pei Zhang**, University of Louisiana at Lafayette (1067-92-545)

2:45PM (519) *The Net Reproductive Number R_0 for Periodic Matrix Models of Structured Population Growth.*
J. M. Cushing*, University of Arizona, and **A. S. Ackleh**, University of Louisiana at Lafayette (1067-92-654)

3:15PM ► (520) *Bifurcation and stability of a Ricker-type competition model.* Preliminary report.
Saber N Elaydi, Trinity University (1067-39-670)

3:45PM (521) *A Darwinian dynamics model for the evolution of "comfort behavior" in seabirds.* Preliminary report.
Shandelle M. Henson, Andrews University (1067-92-758)

4:15PM (522) *Recent Results on Control Problems for Chemostats.*
Frederic Mazenc, Projet INRIA DISCO, CNRS-Supelec, and **Michael Malisoff***, Louisiana State University (1067-92-461)

4:45PM (523) *Two Peas in a Pod: Discrete and Continuous Lotka-Volterra Competition Systems.* Preliminary report.
Lih-Ing Wu Roeger, Texas Tech University (1067-39-632)

5:15PM (524) *On a Mutation Selection Model.* Preliminary report.
Azmy S. Ackleh, University of Louisiana at Lafayette, and **Robert J. Sacker***, University of Southern California (1067-92-605)

5:45PM (525) *Persistence of interacting populations in fluctuating environments.*
Sebastian Schreiber, University of California, Davis (1067-92-709)

MAA Committee on Graduate Students/Young Mathematicians Network Panel Discussion

2:15 PM – 3:35 PM

How to interview for a job in the mathematical sciences.

Organizer: **David Manderschied**, University of Nebraska-Lincoln

Panelists: **Michael Axtell**, College of St. Thomas
Allen Butler, Daniel H. Wagner Associates, Inc.
James Freeman, Cornell College
David Manderschied
Sarah Ann Stewart, Belmont University

MAA Panel Discussion

2:15 PM – 3:35 PM

Reporting progress: A minisymposium of projects from the NSF Course, Curriculum, and Laboratory Improvement Program.

Organizers: **Dennis Davenport**, NSF DUE
Stephanie Fitchett, NSF DUE
Lee Zia, NSF DUE

AWM Business Meeting

2:15 PM – 2:45 PM

AMS Session on Differential Topology and Knot Theory

2:30 PM – 5:55 PM

2:30PM (526) *Diffeomorphism Invariants from Topological Quantum Field Theories.*
Paul H Drube, University of Iowa (1067-55-1921)

2:45PM (527) *A troublesome embedding of the unknot.*
Alexander Zupan, The University of Iowa (1067-57-2205)

3:00PM (528) *Concordance Genus of Knots.*
M Kate Kearney, Indiana University (1067-57-2234)

3:15PM (529) *Investigating hyperbolic link complements.* Preliminary report.
Morwen Thistlethwaite and **Anastasiia Tsvietkova***, University of Tennessee, Knoxville (1067-57-335)

3:30PM (530) *Primitive/primitive and primitive/Seifert representatives of knots.* Preliminary report.
Brandy J Guntel, The University of Texas at Austin (1067-57-552)

3:45PM (531) *Fractional powers of Dehn twists.*
Kashyap Rajeevsarathy, University of Oklahoma (1067-57-933)

4:00PM (532) *Classification of One-sided Incompressible Surfaces in Two Infinite Families of Seifert Fibered Spaces.*
Zhenyi Liu, Schaumburg, IL (1067-57-1176)

4:15PM (533) *Tunnel One, Fibered Links.*
Matt Rathbun, Michigan State University (1067-57-1275)

4:30PM (534) *On the $\mathcal{R}$-filtration for the Heegaard Floer chain complex of a branched double-cover.*
Eamonn Tweedy, University of California Los Angeles (1067-57-1994)

4:45PM (535) *Khovanov-Rozansky Homology and Conway Mutation.*
Thomas Jaeger, Michigan State University (1067-00-2084)

5:00PM (536) *Connections between Floer-type invariants and Morse-type invariants of Legendrian knots.*
Michael B. Henry, The University of Texas at Austin (1067-57-1497)

5:15PM (537) *HOMFLY-PT polynomial and Legendrian links in the solid torus.*
Dan Rutherford, Duke University (1067-57-2073)

5:30PM (538) *Identifying the Canonical Component for the Whitehead Link.*
Emily R Landes, University of Texas, Austin (1067-54-967)

5:45PM (539) *A Geometric Reverse to Quillen's Plus Construction.*
Jeffrey J Rolland, University of Wisconsin - Milwaukee (1067-57-1097)

MAA Section Officers

2:30 PM – 5:00 PM

Chair: **Rick Gillman**, Valparaiso University

AWM Schafer Minisymposium

2:45 PM – 6:15 PM

Organizers: **Sami Assaf**, Massachusetts Institute of Technology
Patricia Hersh, North Carolina State University

2:45PM ► (540) *Life in the Trenches with Alice–The Early Years.*
Mary W. Gray, American University, Washington DC (1067-01-567)

3:15PM ► (541) *Sparse Regular Random Graphs: Spectra and Eigenvectors.*
Ioana Dumitriu* and **Soumik Pal**, University of Washington (1067-60-2169)

3:45PM (542) *Bose-Einstein condensation, the NLS, and a phase transition.*
Kay L Kirkpatrick, Courant Institute/Paris IX Dauphine (1067-82-496)

4:15PM (543) *Do the primes behave independently?*
Melanie Matchett Wood, American Institute of Mathematics and Stanford University (1067-11-529)

4:45PM (544) *Traces and topological fixed point theory.*
Kate Ponto, University of Kentucky (1067-55-1226)

5:15PM Panel Discussion: Getting Started as a Research Mathematician.

AMS Special Session on Transseries and Ordered Exponential Fields, I

3:15 PM – 5:05 PM

Organizers: **Gerald A. Edgar**, The Ohio State University
Ovidiu Costin, The Ohio State University
Lou P. van den Dries, University of Illinois, Urbana-Champaign

3:15PM (545) *On linearly ordered structures of finite rank.*
Charles Steinhorn, Vassar College (1067-03-1168)

3:45PM (546) *Super-exact quasi-analytic classes and o-minimality.*
Tobias Kaiser, Universität Passau, Germany, **Jean-Philippe Rolin**, Université de Bourgogne, France, and **Patrick Speissegger***, McMaster University (1067-26-821)

4:15PM (547) *Transseries: Composition, Recursion, and Convergence.*
Gerald A Edgar, The Ohio State University (1067-06-661)

4:45PM (548) *Surreal Ordered Exponential Fields.*
Philip Ehrlich, Ohio University (1067-06-528)

MAA Invited Address

3:20 PM – 4:10 PM

(549) *On the intersection of graphs and geometry.*
Edward R. Scheinerman, Johns Hopkins University (1067-A0-39)

MAA Invited Paper Session on Laplacian Growth: Visual Mathematics

3:30 PM – 6:20 PM

Organizers: **Yuval Peres**, Microsoft Research
Lionel Levine, Massachusetts Institute of Technology
Alexander Holroyd, Microsoft Research

3:30PM ► (550) *Digital Snowflakes.*
Janko Gravner, University of California at Davis (1067-AB-1370)

4:00PM ► (551) *Random Sorting.*
Alexander E Holroyd, Microsoft Research (1067-AB-1446)

4:30PM ► (552) *Sandpiles, domino tilings, and Chebyshev polynomials.* Preliminary report.
David Perkinson, Reed College (1067-AB-1770)

5:00PM *Fast Simulation of Large-Scale Growth Models.*
(553) **Tobias Friedrich**, Max-Planck-Institut für Informatik (1067-AB-2012)

5:30PM *Self-organizing structures in rotor-router blobs.*
► (554) **James G. Propp**, University of Massachusetts Lowell (1067-AB-2120)

6:00PM *On the Roundness of Rotor Router Blobs.*
► (555) **Matthew Cook**, University of Zurich and ETH Zurich (1067-AB-2198)

MAA-NCTM Mutual Concerns Committee Panel Discussion

3:50 PM – 5:10 PM

Transition from high school to college: Should there be an alternate to calculus?
Organizer: **Gail Burrill**, Michigan State University
Panelists: **Danny Kaplan**, Macalester College
Gregory D. Foley, Ohio University
Thomas R. Butts, University of Texas at Dallas
Al Cuoco, Education Development Center
Michael Shaughnessy, Portland State University
Gail Burrill

MAA Project NExT-Young Mathematicians' Network Poster Session

4:00 PM – 6:00 PM

Organizers: **Michael Axtell**, University of St. Thomas
Kim Roth, Juniata College

Reception for Undergraduate Students

4:00 PM – 5:00 PM

MAA Panel Discussion

5:00 PM – 7:00 PM

Current issues in actuarial science education.
Organizers: **Robert Buck**, Slippery Rock University
Bettye Anne Case, Florida State University
Kevin Charlwood, Washburn University
Steve Paris, Florida State University
Panelists: **Steve Paris**
Bettye Anne Case
Robert Buck

AWM Schafer Minisymposium Panel Discussion

5:15 PM – 6:15 PM

Getting started as a research mathematician.
Moderator: **Elizabeth Wilmer**, Oberlin College
Panelists: **Linda Green**, Dominican University of California
Zvezdelina Stankova, Mills College
Caroline Klivans, University of Chicago
Josephine Yu, Georgia Institute of Technology

SIGMAA on Mathematicians in Business, Industry, and Government Business Meeting

5:30 PM – 6:30 PM

SIGMAA on the History of Mathematics Reception and Business Meeting

5:30 PM – 6:30 PM

SIGMAA on Quantitative Literacy Business Meeting

5:30 PM – 6:00 PM

Reception for Graduate Students and First-Time Participants

5:30 PM – 6:30 PM

SIGMAA on Quantitative Literacy Reception and Panel Discussion

6:00 PM – 7:00 PM

Mathematics and democracy ten years later.

SIGMAA on the History of Mathematics Guest Lecture

6:30 PM – 7:15 PM

6:30PM *Bridges of Trigonometry in the Anglo-American*
► (556) *Colonies and the United States.* Preliminary report.
Joe Albree, Auburn University Montomery (1067-A0-355)

AMS Josiah Willard Gibbs Lecture

8:30 PM – 9:30 PM

(557) *Mathematical problems in systemic risk.*
George C. Papanicolaou, Stanford University (1067-60-2)

AWM Reception

9:30 PM – 11:00 PM

Friday, January 7

Joint Meetings Registration

7:30 AM – 4:00 PM

MAA Session on Innovative and Effective Ways to Teach Linear Algebra

7:20 AM – 11:55 AM

Organizers: **David M. Strong**, Pepperdine University
Gilbert Strang, Massachusetts Institute of Technology
David C. Lay, University of Maryland

7:20AM *Rotations via Quaternions and Interpolation.*
► (558) **Paul Raymond Bouthellier**, University of Pittsburgh-Titusville (1067-L1-328)

7:40AM *Ray-based Tomography: An application for linear*
► (559) *algebra.*
Murphy Waggoner, Simpson College (1067-L1-1459)

8:00AM ► (560) *Visualizing Discrete Dynamical Systems.*
Thomas W Polaski, Winthrop University (1067-L1-1523)

8:20AM ► (561) *A geometric view of orthogonal diagonalization of symmetric matrices.*
Robert L. Sachs, George Mason University (1067-L1-1615)

8:40AM ► (562) *A nickel and dime example for motivating a variety of linear algebra concepts.*
David Strong, Pepperdine University (1067-L1-413)

9:00AM ► (563) *I am the Alpha, I am the Omega.*
Aldo R Maldonado, Park University (1067-L1-868)

9:20AM (564) *What Educational Portal of International Linear Algebra Society(ILAS) can do?*
Kim Kyung-Won* and **Lee Sang-Gu**, Sungkyunkwan University (1067-L1-971)

9:40AM (565) *Mobile Sage-Math for Linear Algebra and its Application.*
Lee Sage-Gu* and **Kim Kyung-Won**, Sungkyunkwan University (1067-L1-972)

10:00AM ► (566) *An Evaluation of Students' Experiences in a Technology-based Linear Algebra Course.* Preliminary report.
Karsten K. Schmidt, Schmalkalden University of Applied Sciences, Germany (1067-L1-459)

10:20AM ► (567) *Eigenvalues first? Teaching linear algebra with computation, then application, then theory.* Preliminary report.
Jason Grout, Drake University (1067-L1-1877)

10:40AM ► (568) *Interviews to Assess Vocabulary and Understanding.* Preliminary report.
Steven M Hetzler, Salisbury University (1067-L1-2094)

11:00AM ► (569) *Detailing an Innovative, Student-Centered Instructional Sequence that Builds from Students' Intuitive Understandings of Vector to Formal Definitions of Span and Linear Dependence.*
Megan J Wawro*, San Diego State University & University of California, San Diego, and **Michelle Zandieh**, Arizona State University (1067-L1-1430)

11:20AM ► (570) *Inverting the Linear Algebra Classroom.*
Robert Talbert, Franklin College (1067-L1-2079)

11:40AM ► (571) *The Second Undergraduate Level Course in Linear Algebra.* Preliminary report.
Steven J Leon, University of Massachusetts Dartmouth (1067-L1-1379)

AMS-MAA-SIAM Special Session on Research in Mathematics by Undergraduates and Students in Post-Baccalaureate Programs, III

8:00 AM – 11:50 AM

Organizers: **Darren A. Narayan**, Rochester Institute of Technology
Bernard Brooks, Rochester Institute of Technology
Jobby Jacob, Rochester Institute of Technology
Jacqueline A. Jensen, Sam Houston State University
Carl V. Lutzer, Rochester Institute of Technology

8:00AM ► (572) *A Generalization of Continued Fractions.*
Maxwell Anselm* and **Steven H Weintraub**, Lehigh University (1067-11-33)

8:30AM (573) *The Splitting Fields of Generalized Rikuna Polynomials.*
Zev Chonoles*, Brown University, **John Cullinan**, Bard College, **Hannah Hausman**, **Allison Pacelli**, **Sean Pegado**, Williams College, and **Fan Wei***, Massachusetts Institute of Technology (1067-12-1117)

9:00AM ► (574) *Minimum Number of Holes in Unavoidable Sets of Partial Words.* Preliminary report.
F. Blanchet-Sadri, University of North Carolina at Greensboro, **Laure Flapan***, Yale University, and **Stephen Watkins**, Vanderbilt University (1067-05-904)

9:30AM (575) *Minimum hole sparsity for partial word avoidability.*
F. Blanchet-Sadri, University of North Carolina at Greensboro, **Kevin Black**, Harvey Mudd College, and **Andrew Zemke***, Rochester Institute of Technology (1067-05-1178)

10:00AM ► (576) *Generating Artificial Social Networks.*
Kate Burgers*, Harvey Mudd College, and **Julianne Upton**, Linfield College (1067-91-310)

10:30AM ► (577) *Bifurcation structure of external cavity mode and compound laser mode solutions.*
Christina Battista*, Rochester Institute of Technology, and **Jeannette Benham**, Bard College (1067-37-313)

11:00AM ► (578) *The Computation of* $R(K_5 - P_3, K_5) = 25$*.*
Jesse Calvert*, Washington University in St. Louis, and **Michael Schuster**, North Carolina State University (1067-05-312)

11:30AM (579) *Rank numbers for generalized ladders, some trees and unicyclic graphs.*
Peter Richter*, University of Rochester, **Emily Sergel**, Rutgers University, and **Anh Tran**, Rochester Institute of Technology (1067-05-311)

AMS-MAA-MER Special Session on Mathematics and Education Reform, I

8:00 AM – 11:50 AM

Organizers: **William H. Barker**, Bowdoin College
William G. McCallum, University of Arizona
Bonnie S. Saunders, University of Illinois at Chicago

8:00AM ► (580) *The Mathematical Education of Teachers.* Preliminary report.
W. James Lewis, University of Nebraska-Lincoln (1067-97-1749)

8:30AM ► (581) *Teaching Mathematics to Future Teachers: The Value of Co-Teaching Courses with Mathematics Educators.*
Catherine Beneteau*, University of South Florida, and **Saad El-Zanati**, Illinois State University (1067-97-1605)

9:00AM ► (582) *Teaching Mathematics to Future Teachers: Connecting Mathematics to Aspects of Teaching in University Courses.*
Rebecca H McGraw* and **Chantel Blackburn**, University of Arizona (1067-97-1592)

9:30AM (583) *Breadth, Depth, Disputes, Drama, and Campus Pranks: The Possibilities and Pleasures of Co-teaching Logic.*
James M Henle, Smith College (1067-03-88)

10:00AM ► (584) *A course emphasizing mathematical logic and reasoning that is appropriate for general education and elementary education majors.*
Warren W. Esty, Montana State University, Bozeman, MT 59717 (1067-97-916)

10:30AM ► (585) *Seemingly Abstruse Logical Principles Have Practical Importance.*
Susanna S Epp, DePaul University (1067-97-2162)

11:00AM ► (586) *Applied Logic Courses in the Mathematics Curriculum.*
Lawrence S. Moss, Indiana University, Bloomington (1067-97-725)

11:30AM ► (587) *Technology in Logic Education: Courseware, Automated Assessment and Data Mining.*
Dave Barker-Plummer, CSLI/Stanford University (1067-97-1571)

AMS-MAA Special Session on History of Mathematics, III

8:00 AM – 11:50 AM

Organizers: **Sloan E. Despeaux**, Western Carolina University
Craig G. Fraser, University of Toronto
Deborah Kent, Hillsdale College

8:00AM This part of this session is also cosponsored by The International Commission for the History of Mathematics (ICHM).

8:00AM ► (588) *The Quadrature of the Circle: 17th century impossibility arguments.*
Jesper Lutzen, University of Copenhagen (1067-01-1079)

8:30AM ► (589) *The quarrel on the invention of the calculus in Jean E . Montucla and Joseph J. L. de Lalande, Histoire des Mathématiques (1758/1799-1802).*
Niccolò Guicciardini, Universitá di Bergamo, Italy (1067-01-1017)

9:00AM ► (590) *"Splendidly isolated"? Some reflections on the transnationality of 19th-century British mathematics.* Preliminary report.
Adrian Rice, Randolph-Macon College (1067-01-521)

9:30AM ► (591) *Salvatore Pincherle and the 1918 Grand Prix des sciences mathématiques: The Third Man.* Preliminary report.
Daniel S. Alexander, Drake University (1067-01-2027)

10:00AM (592) *Shades of modernism in understandings of applied mathematics: von Neumann's economic system of equations and Rashevsky's model of cellular multiplication.*
Tinne Hoff Kjeldsen, IMFUFA, NSM, Roskilde University (1067-01-1160)

10:30AM ► (593) *The lure of the fundamental probability set of equally likely events.* Preliminary report.
Byron E. Wall, York University (1067-01-1110)

11:00AM ► (594) *Mobilizing Mathematics: The American Mathematical Society and World War II.* Preliminary report.
Karen V. H. Parshall, University of Virginia (1067-01-1225)

11:30AM ► (595) *George Birkhoff–"the Poincaré of America".*
June E. Barrow-Green, The Open University (1067-01-1018)

AMS-SIAM Special Session on Mathematics of Computation: Algebra and Number Theory, I

8:00 AM – 11:50 AM

Organizers: **Gregor Kemper**, Technische Universität München
Michael J. Mossinghoff, Davidson College
Igor E. Shparlinski, Macquarie University

8:00AM (596) *The sum-product algorithm for binary codes having check nodes of degree two.*
Michael E. O'Sullivan*, San Diego State University, and **John Brevik**, Long Beach State Univ. (1067-94-1716)

8:30AM (597) *Complexity of the Graph Isomorphism Problem.* Preliminary report.
Derksen Harm, University of Michigan (1067-05-2154)

9:00AM (598) *Combining Group Theory and Number Theory Computations.*
Nigel Boston, University of Wisconsin - Madison (1067-11-374)

9:30AM ► (599) *Class Group and Regulator Computation in Quadratic Fields.*
Michael J Jacobson, Jr., University of Calgary (1067-11-1191)

10:00AM ► (600) *Genus 1 point counting in quadratic space and essentially quartic time.*
Andrew V Sutherland, Massachusetts Institute of Technology (1067-11-436)

10:30AM (601) *Finding the rational points on a certain genus 12 curve.*
Ralph Greenberg, University of Washington, **Karl Rubin** and **Alice Silverberg***, University of California, Irvine (1067-11-708)

11:00AM (602) *Efficient Divisor Reduction on Hyperelliptic Curves.*
Renate Scheidler*, Unversity of Calgary, Canada, **Roberto Avanzi**, Ruhr-Universitaet Bochum, Germany, **Michael J Jacobson, Jr.**, University of Calgary, Canada, and **Andreas Stein**, Universitaet Oldenburg, Germany (1067-11-330)

11:30AM ► (603) *Finding small sets whose subset sums include a given set.* Preliminary report.
David Petrie Moulton, IDA–Center for Communications Research (1067-11-1014)

AMS-ASL Special Session on Logic and Analysis, I

8:00 AM – 11:50 AM

Organizers: **Jeremy Avigad**, Carnegie Mellon University
Ulrich W. Kohlenbach, Technische Universität Darmstadt
Henry Towsner, University of California Los Angeles

8:00AM (604) *Inverting the Furstenberg correspondence.*
Jeremy Avigad, Department of Philosophy, Carnegie Mellon University (1067-37-1533)

8:30AM (605) *Beyond the Correspondence Principle.*
Henry P Towsner, University of California at Los Angeles (1067-03-750)

9:00AM (606) *Algorithmic randomness and ergodic theorems.*
Mathieu Hoyrup, LORIA, INRIA Nancy - France (1067-68-808)

9:30AM (607) *Invariant measures on countable models.*
Nathanael L. Ackerman, University of California, Berkeley, **Cameron E. Freer***, University of Hawaii at Manoa, and **Rehana R. Patel**, Harvard University (1067-03-794)

10:00AM (608) *A constructive law of large numbers with applications.*
Peter Gacs, Boston University (1067-60-2076)

10:30AM (609) *Computability and Complexity of Computable Cauchy Problems.*
Ning Zhong, University of Cincinnati (1067-03-741)

11:00AM (610) *Recursive analysis of singular ordinary differential equations.*
Peter Buser*, Ecole Polytechnique Fédérale de Lausanne, and **Bruno Scarpellini**, University of Basel (1067-03-2034)

11:30AM (611) *Exploratory Experimentation and Computation.*
David H Bailey, Lawrence Berkeley National Labs, and **Jonathan M Borwein***, University of Newcastle, NSW Australia (1067-33-223)

AMS Special Session on Birational Geometry and Moduli Spaces (Mathematics Research Communities session), I

8:00 AM – 11:50 AM

Organizers: **Kevin Tucker**, University of Utah
Dawei Chen, University of Illinois at Chicago
Amanda Knecht, University of Michigan
David Swinarski, University of Georgia

8:00AM (612) *The quantum equivariant cohomology of flag varieties.*
Linda Chen, Swarthmore College (1067-14-1103)

8:30AM (613) *Polynomial Families of Tautological Classes on* $\mathcal{M}_{g,n}^{rt}$.
Steffen S Marcus*, Brown University, and **Renzo Cavalieri**, Colorado State University (1067-14-1206)

9:00AM (614) *Picard groups of normal surfaces.* Preliminary report.
Scott R Nollet, Texas Christian University (1067-14-572)

9:30AM (615) *Local Structure of the Compactified Jacobian.*
Jesse Kass*, University of Michigan, **Sebastian Casalaina-Martin**, University of Colorado at Boulder, and **Filippo Viviani**, University of Roma Tre (1067-14-1276)

10:00AM (616) *Ulrich bundles on del Pezzo surfaces.*
Yusuf Mustopa, University of Michigan (1067-14-789)

10:30AM (617) *Interpolation on surfaces in* $\mathbb{P}^3$.
Jack Huizenga, Harvard University (1067-14-671)

11:00AM (618) *The cone conjecture for Calabi–Yau pairs.*
Artie Prendergast-Smith, Leibniz Universität Hannover (1067-14-1227)

11:30AM (619) *DB pairs and vanishing theorems.*
Sándor J Kovács, University of Washington (1067-14-1075)

AMS Special Session on Wavelets, Tilings, and Iterated Function Systems, I

8:00 AM – 11:50 AM

Organizers: **Palle E. Jorgensen**, University of Iowa
David R. Larson, Texas A&M University
Gestur Olafsson, Louisiana State University

8:00AM (620) *Tensor products of generalized multiresolution analyses.* Preliminary report.
Judith A. Packer, University of Colorado at Boulder (1067-42-1165)

8:30AM (621) *Balayage and the theory of generalized Fourier frames.* Preliminary report.
Enrico Au-Yeung and **John J. Benedetto***, Norbert Wiener Center, UMD, College Park (1067-42-263)

9:00AM (622) *Sampling in reproducing kernel Banach spaces on Lie groups.*
Jens Gerlach Christensen, University of Maryland, College Park (1067-43-556)

9:30AM (623) *Homogeneous Besov spaces on the stratified Lie groups as generalized coorbit spaces.* Preliminary report.
Azita Mayeli, City College of Technology, City University of New York (1067-46-1794)

10:00AM (624) *Wavelets and Framelets in Sobolev Spaces.* Preliminary report.
Bin Han, University of Alberta (1067-42-1309)

10:30AM (625) *Isometries on Bernoulli measures.* Preliminary report.
Palle Jorgensen, University of Iowa, **Keri Kornelson***, University of Oklahoma, and **Karen L. Shuman**, Grinnell College (1067-42-637)

11:00AM (626) *Finite sums of projections.*
Victor Kaftal*, University of Cincinnati, **Ping W Ng**, University of Louisiana, and **Shuang Zhang**, University of Cincinnati (1067-47-1624)

11:30AM (627) *Bessel Sequences of Exponentials on Fractal Measures.*
Eric Weber, Iowa State University (1067-42-1050)

AMS Special Session on Stochastic Analysis and Random Phenomena, I

8:00 AM – 11:50 AM

Organizers: **Ambar N. Sengupta**, Louisiana State University
P. Sundar, Louisiana State University

8:00AM (628) *Brownian Motions on Metric Graphs.*
Vadim Kostrykin, University of Mainz, **Jurgen K. Potthoff***, University of Mannheim, and **Robert Schrader**, Institute of Theoretical Physics, Free University Berlin (1067-60-1441)

8:30AM (629) *SBM as the unique strong solution to an SPDE.*
Jie Xiong, University of Tennessee (1067-60-1301)

9:00AM ► (630) *Gaussian Calculus and Wick Products (Joint work with Paolo Da Pelo and Alberto Lanconelli from the University of Bari, Italy).* Preliminary report.
Aurel Iulian Stan, The Ohio State University at Marion (1067-60-1460)

9:30AM (631) *Self-similarity and long range dependence: some recent developments for the multivariate setting.*
Gustavo Didier*, Tulane University, and **Vladas Pipiras**, UNC-Chapel Hill (1067-60-1620)

10:00AM (632) *A Support Theorem for a Gaussian Radon Transform in Infinite Dimensions.*
Jeremy J Becnel*, Stephen F. Austin State University, and **Ambar N Sengupta**, Louisiana State University (1067-46-478)

10:30AM (633) *Equivalence Relationship between Forward Backward SDEs and Backward SPDEs.*
Jin Ma, **Hong Yin*** and **Jianfeng Zhang**, University of Southern California (1067-60-766)

11:00AM (634) *A Stochastic Lagrangian Particle Model and Nonlinear Filtering for Three Dimensional Euler Flow with Jumps.*
Meng Xu*, University of Wyoming, and **Sritharan**, Naval Postgraduate School (1067-60-624)

11:30AM (635) *Bridges of random walks in a random environment.*
Jonathon Peterson*, Cornell University, and **Nina Gantert**, Institut fur Mathematishe Statistik (1067-60-136)

AMS Special Session on Model Theory of Fields and Applications (Mathematics Research Communities session), I

8:00 AM – 11:45 AM

Organizers: **Benjamin A. Hutz**, CUNY Graduate Center
Jana Marikova, Western Illinois University
Jerome Poineau, University of Strasbourg
Yimu Yin, University of Pittsburgh

8:00AM (636) *Unexpected imaginaries in valued fields with analytic structure.* Preliminary report.
Deirdre Haskell*, McMaster University, **Ehud Hrushovski**, Hebrew University, and **Dugald Macpherson**, University of Leeds (1067-03-2427)

9:00AM (637) *Topology of Berkovich Spaces.*
Jérôme Poineau, University of Strasbourg (1067-14-987)

9:30AM (638) *On definability of types in dependent theories.*
Vincent N Guingona, University of Maryland, College Park (1067-03-947)

10:00AM (639) *The Set of Restricted Complex Exponents for Expansions of the Reals.* Preliminary report.
Michael A. Tychonievich, The Ohio State University (1067-03-1628)

10:30AM (640) *Globalizing locally compact local groups.*
Lou van den Dries, University of Illinois at Urbana-Champaign, and **Isaac M Goldbring***, University of California, Los Angeles (1067-22-232)

11:00AM Discussion.

AMS Special Session on Commutative Algebra (Mathematics Research Communities session), I

8:00 AM – 11:50 AM

Organizers: **Christine Berkesch**, Stockholm University
Bhargav Bhatt, University of Michigan, Ann Arbor
Jason McCullough, University of California, Riverside
Javid Validashti, University of Kansas

8:00AM (641) *Applications of graded integral closures.* Preliminary report.
Craig Huneke, University of Kansas (1067-13-1239)

8:30AM (642) *Coefficient theorems of Briançon-Skoda type.* Preliminary report.
Ian M. Aberbach and **Aline Hosry***, University of Missouri (1067-13-491)

9:00AM (643) *Symbolic power of some classes of algebras.* Preliminary report.
Paolo Mantero, Purdue University, and **Yu Xie***, University of Notre Dame (1067-13-385)

9:30AM (644) *Local cohomology modules as G-modules.*
Emily E Witt, University of Michigan (1067-13-390)

10:00AM (645) *The Second Hilbert Coefficient of a Parameter Ideal in an Unmixed Ring.*
Lori A McDonnell, University of Nebraska-Lincoln (1067-13-1071)

10:30AM (646) *Conditions for the existence of totally reflexive modules.* Preliminary report.
Kristen A Beck, The University of Texas at Arlington (1067-13-408)

11:00AM (647) *Extending the Strong Lefschetz Property.*
Melissa Lindsey, Purdue University (1067-13-672)

11:30AM (648) *Inverse systems, Gelfand-Tsetlin patterns and the weak Lefschetz property.*
Brian Harbourne, University of Nebraska, **Hal Schenck** and **Alexandra Seceleanu***, University of Illinois at Urbana-Champaign (1067-14-1472)

AMS Special Session on Structured Models in Ecology, Evolution, and Epidemiology: Periodicity, Extinction, and Chaos, I

8:00 AM – 11:50 AM

Organizers: **Sophia R.-J. Jang**, Texas Tech University
Linda J. S. Allen, Texas Tech University
Lih-Ing W. Roeger, Texas Tech University

8:00AM (649) *Nonlinear matrix models, evolution, and the dynamic dichotomy of semelparous populations.*
Jim M. Cushing, University of Arizona (1067-92-1724)

8:30AM ▶ (650) *Modeling the Owned Cat Population in Knox County, Tennessee.* Preliminary report.
Suzanne Lenhart, University of Tennessee (1067-92-1137)

9:00AM (651) *Predicting Attenuant and Resonant 2-Cycles in Periodically Forced Discrete-Time 2-Species Population Models.* Preliminary report.
John E. Franke*, North Carolina State University, and **Matthew A. Morena**, University of New Hampshire (1067-92-1914)

9:30AM ▶ (652) *Influenza and SEIR model with isolation.*
Velasco-Hernandez, Instituto Mexicano del Petroleo, and **Maria Leite***, University of Oklahoma (1067-34-1977)

10:00AM (653) *Predator-prey model with strong Allee effect on prey population.*
Jinfeng Wang, Harbin Normal University, **Junping Shi***, College of William and Mary, and **Junjie Wei**, Harbin Institute of Technology (1067-34-1082)

10:30AM (654) *A Spatiotemporal Model of Barley and Cereal Yellow Dwarf Virus Transmission Dynamics with Seasonality, Age Structure and Plant Competition.*
Vrushali A Bokil*, **Carrie Manore**, **Sean M Moore**, Oregon State University, **Elizabeth T Borer**, University of Minnesota, and **Parviez R Hosseini**, EcoHealth Alliance (1067-92-1832)

11:00AM (655) *A mathematical model for the spatial transmission of dengue in a periodic environment.*
Andrew L Nevai*, University of Central Florida, and **Edy Soewono**, Institut Teknologi Bandung (1067-92-2016)

11:30AM ▶ (656) *Optimal Control of the Spread of Malaria Super-Infectivity.* Preliminary report.
Folashade B. Agusto* and **Suzanne Lenhart**, NIMBioS, University of Tennessee, Knoxville (1067-92-516)

AMS Special Session on Boundary Control and Moving Interface in Coupled Systems of Partial Differential Equations, I

8:00 AM – 11:50 AM

Organizers: **Lorena Bociu**, University of Nebraska-Lincoln
Jean-Paul Zolesio, CNRS-INLN and INRIA, Sophia Antipolis, France

8:00AM (657) *Concerning the uniform stabilization of fluid-structure interaction PDE models.* **George Avalos**, University of Nebraska-Lincoln (1067-35-756)

8:30AM (658) *Global uniqueness and stability in inverse problems for second order hyperbolic equations with a non-homogeneous Neumann boundary term.* **Roberto Triggiani**, University of Virginia (1067-35-772)

9:00AM (659) *Arterial blood flow modeling.* **Giovanna Guidoboni**, Department of Mathematical Sciences, Indiana University and Purdue University at Indianapolis (IUPUI) (1067-35-667)

9:30AM (660) *Variational Solution to Incompressible Euler Equation.* **Jean-Paul Zolesio**, CNRS-INLN (1067-35-1362)

10:00AM (661) *A moving interface problem in blood flow.* **Suncica Canic**, University of Houston (1067-35-1169)

10:30AM (662) *Shape optimization for hyperbolic boundary problems with conservative boundary conditions.* **Matthias Eller**, Georgetown University (1067-35-767)

11:00AM (663) *Generation of dynamical flow and long time behavior of solutions to wave equation with acoustic boundary conditions.* **Irena Lasiecka*** and **Philip Graber**, University of Virginia (1067-35-596)

11:30AM (664) *Existence for a linearized steady-state fluid-nonlinear elasticity interaction.* **Lorena Bociu***, University of Nebraska-Lincoln, and **Jean-Paul Zolesio**, INRIA, Sophia Antipolis Cedex, France (1067-35-406)

AMS Special Session on Groups, Geometry, and Applications, I

8:00 AM – 11:50 AM

Organizer: **Delaram Kahrobaei**, City University of New York

8:00AM (665) *Subgroup distortion and bounded cohomology.* **Indira Chatterji***, Orléans (France) and OSU, **Guido Mislin**, ETHZ and OSU, **Christophe Pittet**, Marseille (France), and **Laurent Saloff-Coste**, Cornell University (1067-20-1346)

8:30AM (666) *Hyperbolic Surface Subgroups of One-ended Doubles of Free Groups.* **Sang-hyun Kim***, Tufts University/KAIST, and **Sang-il Oum**, KAIST (1067-20-1187)

9:00AM (667) *Pushing fillings in right-angled Artin groups.* **Aaron Abrams**, Emory University, **Noel Brady**, University of Oklahoma, **Pallavi Dani***, Louisiana State University, **Moon Duchin**, University of Michigan, and **Robert Young**, IHES (1067-20-1806)

9:30AM (668) *Generic Properties of Groups and Surface Subgroups.* Preliminary report. **Sang-hyun Kim**, Tufts University, and **Paul E. Schupp***, University of Illinois, Stevens Institute of Technology (1067-20-1709)

10:00AM (669) *Infinite words and groups.* **Alexei Miasnikov**, Stevens Institute of Technology (1067-20-1095)

11:00AM (670) *Groups with a quasiconvex hierarchy.* **Mark F Hagen**, McGill University (1067-20-526)

11:30AM (671) *Involutions and the word length of the Mobius group.* **Ara S. Basmajian**, CUNY, Graduate center and Hunter college (1067-30-367)

MAA Minicourse #3: Part A

8:00 AM – 10:00 AM

Geometry and algebra in mathematical music theory.

Organizers: **Thomas M. Fiore**, University of Michigan-Dearborn
Dmitri Tymoczko, Department of Music, Princeton University
Robert Peck, School of Music, Louisiana State University

AMS Session on Optimization, Game Theory, and Applications of Mathematics

8:00 AM – 11:55 AM

8:00AM ► (672) *Asset Price Dynamics: Differential Equations and Instability.* **Mark DeSantis**, University of Pittsburgh (1067-37-1693)

8:15AM (673) *Hybrid Runge-Kutta and Quasi-Newton Algorithms.* **Darin Mohr**, The University of Iowa (1067-90-1965)

8:30AM ► (674) *Lower Bounds for the Ropelength of Reduced Conformations.* **Robert Douglas McGuigan**, San Jose State University (1067-00-386)

8:45AM ► (675) *An Effective Method for Replenishing Items with Seasonal Intermittent Demand.* **Meike Niederhausen*** and **Gary Mitchell**, University of Portland (1067-90-2005)

9:00AM (676) *Sparsity Optimization with Applications in Bioscience.* Preliminary report. **Sarah A King**, North Carolina State University (1067-90-2142)

9:15AM ► (677) *Nash equilibria in a one-dimensional dispersion game.* **Arash Enayati Khorzoghi**, Carnegie Mellon University (1067-91-1559)

9:30AM (678) *Evolutionary Game Theory on Measure Spaces.* **John M Cleveland***, Penn State (University Park) State College, PA, and **Azmy S Ackleh**, University of Louisiana at Lafayette (1067-91-1819)

9:45AM ► (679) *Cascading Behavior in Networks: A Game Theory Approach to Modeling Voting Behavior.* Preliminary report. **Jim C. Manning***, University of South Carolina, and **Margaret Cozzens**, DIMACS, Rutgers University (1067-91-2128)

10:00AM ► (680) *The Borda Count, the Kemeny Rule, and the Permutahedron.* **Karl-Dieter Crisman**, Gordon College (1067-91-234)

10:15AM (681) *Braess's Paradox in Random Graphs.* **Stephen J. Young*** and **Fan Chung**, University of California, San Diego (1067-91-2021)

10:30AM ► (682) *An Analysis of the U.S. Consumer Price Index –An Application of the ARMA and the GARCH Model.* Preliminary report. **Qi Sun**, Lafayette College (1067-91-153)

10:45AM ► (683) *Agent-based Asset Pricing Dynamics with incomplete market in Lucas Framework.* Preliminary report. **Yuanying Guan**, Florida State University (1067-91-1112)

11:00AM ► (684) *An Agent-Based Modeling Approach to Financial Markets.* **William K Brayer**, Georege Mason (1067-91-1473)

11:15AM ► (685) *A Stability Study of Asset Price Equilibrium Models.* Preliminary report.
Arjun Sanghvi, George Mason University (1067-91-1721)

11:30AM ► (686) *Options pricing with transaction costs and stochastic volatility.* Preliminary report.
Emmanuel Kengni Ncheuguim*, New Mexico State University, and **Maria Mariani**, University of Texas at El Paso (1067-91-1884)

11:45AM ► (687) *Martingale properties of the wealth process in a spin market model.* Preliminary report.
Yilun Dong*, Swarthmore College, and **Ted Theodosopoulos**, Saint Ann's School (1067-91-1919)

AMS Session on Combinatorics and Graph Theory, V

8:00 AM – 11:55 AM

8:00AM ► (688) *Degree sequences and graphs with disjoint spanning trees.*
Hong-Jian Lai, **Yanting Liang*** and **Ping Li**, West Virginia University (1067-05-536)

8:15AM ► (689) *Hypercube orientations with only two in-degrees.*
Joe Buhler, CCR, La Jolla, **Steve Butler***, UCLA, **Ron Graham** and **Eric Tressler**, UCSD (1067-05-1463)

8:30AM (690) *Minimal Percolating Sets in the Hypercube and Related Graphs.*
Emily Berger, Massachusetts Institute of Technology (1067-05-2226)

8:45AM (691) *Unifying Laver's Theorem and the Graph Minor Theorem via Proof System Minors.*
Christian Joseph Altomare, The Ohio State University (1067-05-2295)

9:00AM (692) *Generating Planar Quintangulations.* Preliminary report.
Jianning Su*, **Jinko Kanno**, Louisiana Tech University, and **Ko Yamamoto**, Yokohama National University (1067-05-1944)

9:15AM ► (693) *An intuitively appealing axiomatization of the median procedure on median graphs.*
Beth A Novick*, Clemson University, and **Henry Martyn Mulder**, Econometrisch Instituut, Erasmus Universiteit (1067-05-1713)

9:30AM (694) *Decomposition of sparse graphs using forests and a graph with bounded degree.*
Seog-Jin Kim, Konkuk University, South Korea, **Alexandr V. Kostochka**, **Douglas B. West**, **Hehui Wu***, University of Illinois at Urbana-Champaign, and **Xuding Zhu**, Zhejiang Normal University, China (1067-05-1114)

9:45AM (695) *A Characterization of the Centers of Chordal Graphs.*
James Michael Shook* and **Bing Wei**, University of Mississippi (1067-05-957)

10:00AM (696) *Spherical Tiling by 12 Congruent Pentagons.*
Min Yan*, **Honghao Gao** and **Nan Shi**, Hong Kong University of Science and Technology (1067-05-801)

10:15AM (697) *Oriented Hypergraphs and the Structure of Rational Matrices.*
Lucas J. Rusnak, Binghamton University (1067-05-32)

10:30AM (698) *Bicircular Matroids with Circuits of a Single Size.*
Torina Deachune Lewis*, **Talmage James Reid** and **Laura Sheppardson**, The University of Mississippi (1067-05-2297)

10:45AM ► (699) *L(2,1) Labeling of Graphs of Bounded Bandwidth and Permutation Graphs.* Preliminary report.
Ellen Panofsky*, Cabrini College, and **Garth Isaak**, Lehigh University (1067-05-1597)

11:00AM ► (700) *Edge switching on colored degree sequences.*
Hannah Alpert*, University of Chicago, **Amariah Becker**, Carleton College, **James Hilbert**, Lafayette College, **Jennifer Iglesias**, Harvey Mudd College, and **Garth Isaak**, Lehigh University (1067-05-591)

11:15AM ► (701) *A Variation on Kundu's Theorem.*
Hannah Alpert, University of Chicago, **Amariah Becker**, Carleton College, **James Hilbert**, Lafayette College, **Jennifer Iglesias***, Harvey Mudd College, and **Garth Issak**, Lehigh University (1067-05-615)

11:30AM ► (702) *Obstacle Numbers of Graphs.*
Hannah Alpert, University of Chicago, **Christina Koch**, Academy of Hope, and **Joshua D Laison***, Willamette University (1067-05-1359)

11:45AM ► (703) *"Graphic" Degree Sequences for Edge-Colored Graphs.*
Amariah D. Becker*, Carleton College, **Hannah Alpert**, University of Chicago, **James Hilbert**, Lafayette College, and **Jenny Iglesias**, Harvey Mudd College (1067-05-704)

MAA Session on Alternative Approaches to Traditional Introductory Statistics Courses, I

8:00 AM – 11:55 AM

Organizers: **Brian T. Gill**, Seattle Pacific University
Nancy J. Boynton, SUNY Fredonia
Michael A. Posner, Villanova University

8:00AM ► (704) *Confounding the Traditional Introductory Statistics Course.*
Daniel T Kaplan, Macalester College (1067-B1-1002)

8:20AM ► (705) *Online discussions boards: An attempt to foster student interaction and engagement in an online Introductory Statistics course.*
Sheldon H Lee, Viterbo University (1067-B1-2359)

8:40AM ► (706) *Teaching Critical Thinking in a Statistical Literacy Course Using Odysseys2Sense: a Web-Based Discussion Forum.* Preliminary report.
Milo Schield, W. M. Keck Statistical Literacy Project (1067-B1-51)

9:00AM ► (707) *Papers? - in a math class? Using essays and online discussion groups to improve an Introductory Statistics course.* Preliminary report.
Edwin P Herman, University of Wisconsin-Stevens Point (1067-B1-1600)

9:20AM ► (708) *Using group quizzes in an online introductory statistics course.* Preliminary report.
Audbjorg Bjornsdottir* and **Joan Garfield**, University of Minnesota (1067-B1-2057)

9:40AM (709) *Teaching an online Statistics Class for Education Major.*
Kumer Pial Das*, **Md. Shamim Sarker** and **AKM Saiful Islam**, Lamar University (1067-B1-1862)

10:00AM ► (710) *A Biology-Emphasis Elementary Statistics Course in a Small, Liberal Arts College Setting.*
William R Harris, Georgetown College (1067-B1-840)

10:20AM ► (711) *Applied Statistics for Non-Traditional Undergraduate Business Majors (An Introductory Statistics Course).* Preliminary report.
Michael D. Miner, American Public University System (1067-B1-1858)

10:40AM ► (712) *Teaching Introductory Statistics in Thirteen Formats.* Preliminary report.
Anant Godbole, East Tennessee State University (1067-B1-27)

11:00AM (713) *Mathematics and the Law: Beyond People v. Collins.*
Jeff Suzuki, Brooklyn College (1067-B1-376)

11:20AM (714) *Data Visualization in Introductory Statistics.* **Max Buot**, Xavier University (1067-B1-2349)

11:40AM (715) *Statistics for the Millenial Learner.* **Gina F Reed**, Gainesville State College (1067-B1-1025)

MAA Session on Cool Calculus: Lessons Learned Through Innovative and Effective Supplemental Projects, Activities, and Strategies for Teaching Calculus

8:00 AM – 11:35 AM

Organizer: **Jessica M. Deshler**, West Virginia University

8:00AM ► (716) *Sharks, Minnows and Wheelbarrows: Calculus Modeling Projects.* **Michael D Smith**, Hollins University (1067-C1-357)

8:20AM ► (717) *Use of Open-Ended Problems in Multivariable Calculus.* **Sarah L Mabrouk**, Framingham State University (1067-C1-2362)

8:40AM ► (718) *Overcoming Conflicting Imagery in the Development of an Understanding of Taylor Series Convergence.* **Jason H Martin***, Arizona State University, and **Michael C Oehrtman**, University of Northern Colorado (1067-C1-2274)

9:00AM ► (719) *Playing with Multivariable Calculus Concepts Wearing 3D Glasses.* Preliminary report. **Paul E Seeburger**, Monroe Community College (1067-C1-1647)

9:20AM ► (720) *Maplets for Calculus: Effective Teaching and Studying Resources for Calculus Students.* **Philip B Yasskin***, Texas A&M University, and **Douglas B Meade**, University of South Carolina (1067-C1-1457)

9:40AM ► (721) *Using Differentials to Teach Calculus Coherently.* **Tevian Dray**, Oregon State University (1067-C1-2352)

10:00AM (722) *Putting the Cart before the Horse? Teaching Differentiation Rules as "Review" in First Semester Calculus.* **Nathan M Wodarz**, University of Wisconsin - Stevens Point (1067-C1-397)

10:20AM ► (723) *Using Modeling and Differential Equations with a Numerical Solver to Teach First Year Calculus.* Preliminary report. **Brian Birgen*** and **Mariah Birgen**, Wartburg College (1067-C1-251)

10:40AM (724) *Calculus in large lectures: Pedagogy through technology.* Preliminary report. **Amit A Savkar*** and **Fabiana A Cardetti**, University of Connecticut (1067-C1-1662)

11:00AM (725) *Engaging students through the use of the online homework system WeBWorK.* Preliminary report. **Anneke Bart**, Saint Louis University (1067-C1-986)

11:20AM (726) *A Hands-On Approach To Calculus.* **Mike Long**, Shippensburg University (1067-C1-1951)

MAA Session on Modeling in the ODE Driver's Seat

8:00 AM – 10:55 AM

Organizers: **Kurt Bryan**, Rose-Hulman Institute of Technology

Brian J. Winkel, U. S. Military Academy

8:00AM ► (727) *Comparing an Applications-first Approach and an Analytic Techniques-first Approach to Teaching Topics in Differential Equations.* Preliminary report. **Jennifer Ann Czocher**, The Ohio State University (1067-R1-1680)

8:20AM ► (728) *Mathematical Modeling of "hearts and minds" in the Terrorism/Counter-Terrorism Struggle.* **Chris Arney**, United States Military Academy (1067-R1-237)

8:40AM ► (729) *Making Differential Equations More Relevant to Electrical Engineering Technology Students.* **Yajun Yang**, Farmingdale State College of SUNY (1067-R1-1796)

9:00AM ► (730) *Cartilage Regeneration in Cell-Seeded Scaffolds: An ODE Modeling Approach.* Preliminary report. **Janine M Haugh**, University of North Carolina at Asheville (1067-R1-2323)

9:20AM ► (731) *ODE Models in Medicine.* **Lester F Caudill**, University of Richmond (1067-R1-1973)

9:40AM (732) *Calibrating, Simulating, and Evaluating an Exposure-Effects Model for Fish Growth.* **Rachael Miller Neilan**, Louisiana State University (1067-R1-118)

10:00AM ► (733) *Modeling Malaria in Central America.* Preliminary report. **Michael Huber**, Muhlenberg College (1067-R1-380)

10:20AM ► (734) *An Ode to Modeling with ODEs.* **Kimberly R. Swetz**, United States Air Force Academy (1067-R1-1504)

10:40AM ► (735) *A Week in the Life of an Inquiry-Based ODEs Course.* Preliminary report. **Elizabeth Thoren**, University of California, Santa Barbara (1067-R1-1542)

MAA General Contributed Paper Session, V

8:00 AM – 11:55 AM

Organizers: **Kristen Meyer**, Wisconsin Lutheran College

Thomas R. Hagedorn, The College of New Jersey

8:00AM ► (736) *A History of Math Seminar Course for Future Secondary Teachers.* Preliminary report. **Kate G McGivney**, Shippensburg University (1067-Z1-2035)

8:15AM ► (737) *Pre-Service Teachers in the College Classroom-A Mentoring Experience.* **Gary A. Olson**, University of Colorado Denver (1067-Z1-2259)

8:30AM ► (738) *Improving Elementary Teacher Mathematics Preparation at Fitchburg State University.* Preliminary report. **Mary Ann Barbato**, Fitchburg State University (1067-Z1-1488)

8:45AM ► (739) *Improving Student Success on PRAXIS II (Mathematical Content).* **Kenneth J Bernard**, Virginia State University (1067-Z1-1947)

9:00AM ► (740) *An Experiment in Student Centered Learning.* Preliminary report. **Laurie Lenz**, Marymount University (1067-Z1-1949)

9:15AM ► (741) *Project Group Student Selection: Using Prior Academic Performance to Improve Group Dynamics.* **J. Kingsley Fink**, United States Military Academy (1067-Z1-2043)

9:30AM ► (742) *Adventures with Cooperative Learning and standards-based grading in the college classroom (or, how I tried to re-program myself to teach in only one semester).* Preliminary report.
Bret Jordan Benesh, College of St. Benedict/St. John's University (1067-Z1-1449)

9:45AM ► (743) *Proactively Preventing Project Procrastination.* Preliminary report.
James A Jones*, **Elizabeth W Schott**, **Stanley F Florkowski** and **Brian J Lunday**, United States Military Academy (1067-Z1-2033)

10:00AM ► (744) *Maximizing the Benefit of a Review Session Using an Informal Collaborative Group Format.*
A. S. Elkhader, Northern State University (1067-Z1-742)

10:15AM ► (745) *Improving Support for Undergraduate Math Tutors.* Preliminary report.
Rachel Esselstein, California State University, Monterey Bay (1067-Z1-1162)

10:30AM ► (746) *Mentoring Undergraduate Research for All Mathematics Majors.*
Jeffrey W Clark, Elon University (1067-Z1-89)

10:45AM ► (747) *Two Different Approaches to Getting Students Involved in Writing Proofs.* Preliminary report.
Martin E. Flashman, Humboldt State University (1067-Z1-1399)

11:00AM ► (748) *The "More" Method of Teaching Proofs.*
Robert L Brabenec, Wheaton College IL (1067-Z1-292)

11:15AM ► (749) *Teaching Techniques and Activities that Encourage Proof Writing.* Preliminary report.
Violeta Vasilevska, Utah Valley University (1067-Z1-1572)

11:30AM ► (750) *How Do You Get Students Involved in Writing Proofs? One (Method) at a Time.* Preliminary report.
Stan Perrine, Charleston Southern University (1067-Z1-928)

11:45AM ► (751) *Doing It Yourself: Writing Your Own Textbook.*
James E. Hamblin, Shippensburg University (1067-Z1-1300)

SIAM Minisymposium on Combinatorial Optimization, I

8:00 AM – 10:55 AM

Organizers: **David Hartvigsen**, University of Notre Dame
Donald Wagner, Office of Naval Research

8:00AM (752) *A PTAS for matroid matching.*
Jon Lee, IBM TJ Watson Research Center (1067-68-533)

8:30AM (753) *Finding 2-factors covering 3- and 4-edge cuts in bridgeless cubic graphs.*
Sylvia Boyd, University of Ottawa, **Satoru Iwata*** and **Kenjiro Takazawa**, Kyoto University (1067-90-887)

9:00AM (754) *Matching preclusion and conditional matching preclusion problems for regular graphs.*
Eddie Cheng*, **Laszlo Liptak**, Oakland University, **Marc J Lipman**, Indiana University Purdue University - Fort Wayne, **Philip Hu**, Yale University, and **Roger Jia**, University of Michigan (1067-05-333)

9:30AM (755) *Computing Matroidal Branchwidth.*
Illya V. Hicks, Rice University (1067-90-1054)

10:00AM (756) *Primal-Dual Algorithms for Weighted Abstract Flow and Weighted Abstract Cut Packing.*
S. Thomas McCormick*, Sauder School of Business, UBC, Vancouver, **Maren Martens**, ZIB Berlin, and **Britta Peis**, TU Berlin (1067-90-806)

10:30AM (757) *Delta-Wye Reduction of Almost-Planar Graphs.*
Don Wagner, Office of Naval Research (1067-05-920)

Employment Center

8:00 AM – 7:00 PM

AMS Session on Geometry

8:15 AM – 11:55 AM

8:15AM ► (758) *Using Cantor Sets to Study the Connectivity of Sierpiński Relatives.*
Tara D Taylor, St. Francis Xavier University (1067-51-699)

8:30AM ► (759) *On Exceptional Points of Cocompact Fuchsian Groups.* Preliminary report.
Joseph Fera, Wesleyan University (1067-51-948)

8:45AM ► (760) *An Introduction to Generalized Parabolas I.* Preliminary report.
Gregory N Hartman* and **Daniel S Joseph**, Virginia Military Institute (1067-51-975)

9:00AM (761) *An Introduction to Generalized Parabolas II.*
Daniel S Joseph* and **Gregory N Hartman**, Virginia Military Institute (1067-51-976)

9:15AM (762) *On the Generalizations of the Polar Moments of Inertia under the Homothetic Motions.*
Mutlu Akar* and **Salim Yuce**, Yildiz Technical University (1067-51-1616)

9:30AM (763) *Prime Paths in Graph Coverings and a Chebotarev Density-type Result.*
Thomas Anthony Petrillo, University of Toledo (1067-51-1841)

9:45AM (764) *Morley $i_\triangle$, Morley $e_\triangle$, and their Mother Triangle.*
Shing S So, University of Central Missouri (1067-51-1996)

10:00AM (765) *Einstein Submanifolds in a Kahler Space Form.*
Matthew Drury, Indiana University (1067-51-2031)

10:15AM ► (766) *Symmetry Analysis of Howe's Patterns.* Preliminary report.
Dennis Glenn Collins, Winamac, IN (1067-51-2278)

10:30AM ► (767) *Perimeter-Minimizing Tilings with Penalties for Vertices.* Preliminary report.
Michael T Mara*, Williams College, **Yifei Li**, Berea College, **Elena Wikner**, Williams College, and **Isamar Rosa**, University of Puerto Rico at Mayaguez (1067-51-2372)

10:45AM (768) *On closed sets with convex shadows in Hilbert space.*
Stoyu Barov, Bulgarian Academy of Sciences, and **Jan J. Dijkstra***, Vrije Universiteit Amsterdam (1067-52-985)

11:00AM ► (769) *Experiments in monotone kinetic visibility.* Preliminary report.
Lily Du, **Stefanie Wang** and **Yonit Bousany***, Smith College (1067-52-1141)

11:15AM ► (770) *Heesch Numbers of Polyforms with Edge Matching Rules.* Preliminary report.
Casey Mann, The University of Texas at Tyler (1067-52-1772)

11:30AM (771) *Classifying Voronoi Graphs of Hex Spheres.*
Aldo-Hilario Cruz-Cota, Grand Valley State University (1067-54-1349)

11:45AM (772) *Stick Numbers in the Simple Hexagonal Lattice.* **Jennifer McLoud-Mann***, **Casey Mann** and **David Milan**, University of Texas at Tyler (1067-54-1521)

AMS Special Session on Expander Graphs in Pure and Applied Mathematics, II

8:30 AM – 11:15 AM

Organizers: **Alireza Salehi Golsefidy**, Princeton University
Alexander Lubotzky, Hebrew University of Jerusalem

8:30AM (773) *Asymptotic phenomena in geometric group theory.* **Igor Rivin**, Institute for Advanced Study and Temple University (1067-05-1682)

9:00AM (774) *Expander graphs, gonality, and Galois representations.* **Jordan S Ellenberg***, University of Wisconsin, **Christopher J Hall**, University of Wyoming, and **Emmanuel Kowalski**, ETH (1067-14-1182)

9:30AM (775) *Affine sieve and expansion in perfect groups.* **Alireza Salehi Golsefidy***, **Peter Sarnak** and **Peter Varju**, Princeton University (1067-11-678)

10:00AM ► (776) *Pseudorandom Financial Derivatives from Expander Graphs.* **David Zuckerman**, University of Texas at Austin (1067-91-777)

10:30AM (777) *Expanders and K-theory for discrete groups.* **Paul Frank Baum**, Penn State University (1067-19-185)

AMS Session on Rings and Algebras

8:30 AM – 11:55 AM

8:30AM (778) *Constructing Quadratic Quantum $\mathbb{P}^2$s from Graded Skew Clifford Algebras.* **Manizheh Nafari***, **Michaela Vancliff** and **Jun Zhang**, University of Texas at Arlington (1067-16-453)

8:45AM (779) *A Notion of Rank for Noncommutative Quadratic Forms.* **Padmini P Veerapen**, University of Texas, Arlington (1067-16-1068)

9:00AM (780) *Covered Groups and Simple Rings.* **G. Alan Cannon**, Southewastern Louisiana University, **Lucyna Kabza**, Southeastern Louisiana University, **C. J. Maxson**, Texas A&M University, and **Kent M. Neuerburg***, Southeastern Louisiana University (1067-16-1485)

9:15AM (781) *Weak crossed product orders over discrete valuation rings.* Preliminary report. **Christopher J Wilson**, Butler University (1067-16-137)

9:30AM (782) *Category $\mathcal{O}$ for the Rational Cherednik Algebra of G_{12}.* **Christopher R Policastro**, MIT (1067-16-493)

9:45AM (783) *Good Gradings from Relations.* Preliminary report. **Kenneth L Price**, University of Wisconsin Oshkosh (1067-16-989)

10:00AM (784) *The $\mathcal{K}_2$ Property for Face Rings.* Preliminary report. **Andrew Conner**, University of Oregon (1067-16-1815)

10:15AM (785) *Fusion Rules for Abelian Extensions of Hopf Algebras.* **Christopher Goff**, University of the Pacific (1067-16-1743)

10:30AM (786) *Structural results for the Yoneda algebra of a connected-graded algebra.* Preliminary report. **Christopher Lee Phan**, Bucknell University (1067-16-2020)

10:45AM (787) *Two-sided ideals in Leavitt path algebras.* **Pinar Colak**, Simon Fraser University (1067-16-2367)

11:00AM (788) *Minimal Non-Elementary Lie Algebra.* Preliminary report. **Kristen L Stagg*** and **Ernest L Stitzinger**, North Carolina State University (1067-17-902)

11:15AM (789) *Nontrivial Schur Multipliers of Nilpotent Lie Algebras.* **Lindsey R Bosko**, North Carolina State University (1067-17-1804)

11:30AM (790) *On Wakimoto representations of $\hat{sl}_2$ and Z-algebras.* Preliminary report. **Jonathan D Dunbar**, North Carolina State University (1067-17-1808)

11:45AM ► (791) *Automorphisms on Albert-like Semifield Planes.* Preliminary report. **Angela M. Brown**, University of Texas at Arlington (1067-17-1722)

AMS Session on Numerical Analysis, I

8:30 AM – 11:55 AM

8:30AM ► (792) *Linear and Nonlinear Inverse Problems.* Preliminary report. **Antoine V Elabdouni**, University of California, Berkeley (1067-00-1440)

8:45AM (793) *Finding the optimal L2 regularization.* **Zhuojun Magnant***, Emory University, and **Eldad Haber**, UBC (1067-65-80)

9:00AM (794) *Finite Element Approximations of Stochastic Optimal Control Problems Constrained by Stochastic Elliptic PDEs.* **Jangwoon (Leo) Lee***, University of Mary Washington, **L. S. Hou**, Iowa State University, and **H. Manouzi**, Laval University (1067-65-1920)

9:15AM (795) *On correct boundary conditions in numerical schemes for the shallow water equations.* **Andrei Bourchtein*** and **Ludmila Bourchtein**, Pelotas State University, Brazil (1067-65-354)

9:30AM ► (796) *A Numerical Model of Fracture using Curvature Dependent Surface Tension.* **Lauren A. Ferguson**, Texas A&M University (1067-65-396)

9:45AM ► (797) *Stability of equilibria in one dimension for diblock copolymer equation.* Preliminary report. **Olga Stulov***, State University of New York at New Paltz, **Ian C Johnson**, **Evelyn Sander** and **Thomas Wanner**, George Mason University (1067-65-651)

10:00AM ► (798) *A Simple Parallel Implementation of the Finite Element Method Using Linear Geometries.* **Robert D French***, **Casey L McKnight** and **Ben Ntatin**, Austin Peay State University (1067-65-1837)

10:15AM (799) *Local Error Estimates of the LDG Method for One-Dimensional Singularly Perturbed Convection-diffusion Equations.* **Huiqing Zhu***, The University of Southern Mississippi, and **Zhimin Zhang**, Wayne State University (1067-65-827)

10:30AM (800) *Additive Schwarz preconditioners for the local discontinuous Galerkin method.* **Andrew T. Barker***, **Susanne C. Brenner** and **Li-Yeng Sung**, Louisiana State University (1067-65-1016)

10:45AM (801) *Hodge Decomposition and Maxwell's Equations.*
Jintao Cui, Louisiana State University (1067-65-87)

11:00AM ► (802) *Approximate worm blankets using segmented worms.*
James M Rath, Austin, TX (1067-65-1181)

11:15AM (803) *A new junction model for gas flow through a splitting pipe.*
J. B. Collins, North Carolina State University (1067-65-1302)

11:30AM (804) *A Branch and Bound Process for Singular Global Optimization Problems - Preliminary Explorations.* Preliminary report.
Julie Roy*, Metropolitan State College of Denver, and **R. Baker Kearfott**, University of Louisiana at Lafayette (1067-65-2069)

11:45AM ► (805) *A Sequential Operator Splitting Method for Maxwell's Equations in Debye Dispersive Media.* Preliminary report.
Aubrey L Leung* and **Vrushali A Bokil**, Oregon State University (1067-65-2210)

AMS Session on Partial Differential Equations, I

8:30 AM – 10:55 AM

8:30AM (806) *Bifurcation of Internal Transition Layers for Spatially Inhomogeneous reaction-diffusion equation.*
Chaoqun Huang* and **Aaron Nung Kwan Yip**, Purdue University (1067-35-600)

8:45AM (807) *A numerical and analytical study of a variable-type equation.*
M Affouf, Kean University (1067-35-1416)

9:00AM (808) *Finite element approximation of reaction diffusion systems on arbitrary surfaces.*
Necibe Tuncer, University of Florida (1067-35-853)

9:15AM (809) *Positive Solutions for an Elliptic Bi-variate Reaction Systems with Combined Nonlinear Effects.*
Jaffar Ali*, Florida Gulf Coast University, and **Ratnasingham Shivaji**, Mississippi State University (1067-35-450)

9:30AM (810) *Explicit Solutions for Optimal Portfolio and Consumption with Transaction Costs.*
Harumi Hattori and **Zheng Zhang***, West Virginia University (1067-35-869)

9:45AM ► (811) *Nonclassical symmetries of a reaction-diffusion equation with a quadratic nonlinearity.*
Danny Arrigo*, **David Ekrut**, **Long Le** and **Sang Lee**, University of Central Arkansas (1067-35-2191)

10:00AM (812) *A Globally Convergent Numerical Method for Coefficient Inverse Problems with Applications in Thermal Tomography.*
Aubrey Rex Rhoden*, University of Texas in Arlington, and **Natee Pantong**, University of North Carolina in Charlotte (1067-35-2096)

10:15AM (813) *Recovery of an Interface from Boundary Measurement in an Elliptic Differential Equation.*
Weifu Fang and **Suxing Zeng***, Wright State University (1067-35-934)

10:30AM ► (814) *Parameter Estimation for Damped Sine-Gordon Equation with Neumann Boundary Condition.*
Narayan Thapa, Minot State University (1067-35-114)

10:45AM (815) *Global Solvability for the Heat Equation with Boundary Flux Governed By Nonlinear Memory.*
Jeffrey R. Anderson, University of Wisconsin-Stout, **Keng Deng** and **Zhihua Dong***, University of Louisiana at Lafayette (1067-35-956)

AMS Session on Finite Differences and Functional Equations

8:45 AM – 11:55 AM

8:45AM (816) *Formal power series solutions of Schröder's functional equation.*
Ruth D Enoch, Arkansas Tech University (1067-39-1690)

9:00AM (817) *Oscillation of Impulsive Differential Equations with Piecewise Constant Argument.*
Fatma Karakoc*, **Huseyin Bereketoglu** and **Gizem Seyhan**, Ankara University (1067-39-300)

9:15AM (818) *Existence Theorem for Set-Valued Differential Inclusion Using the Pseudo-integral in Pseudo-analysis.* Preliminary report.
Priscilla Supnet Macansantos, University of the Philippines Baguio, Baguio City, Philippines (1067-39-1069)

9:30AM (819) *Nonlinear Discrete Sturm-Liouville Problems with Global Boundary Conditions.*
Jesus Rodriguez and **Zachary Abernathy***, NC State University (1067-39-2341)

9:45AM (820) *Non-local boundary value problems for discrete systems.*
Kristen Abernathy* and **Jesus Rodriguez**, North Carolina State University (1067-39-2141)

10:00AM ► (821) *Systems of Difference Equations, Oscillations, and Sturmian Sequences.* Preliminary report.
Mojtaba Moniri, Western Illinois University (1067-39-195)

10:15AM (822) *Convergence of Solutions of Nonhomogeneous Linear Difference Systems with Delays.*
Huseyin Bereketoglu*, Ankara University, and **Aydin Huseynov**, Institute of Mathematics and Mechanics, Azerbaijan National Academy of Sciences (1067-39-301)

10:30AM (823) *Invariant Manifolds for Competitive Discrete Systems in the Plane - Non-hyperbolic Case.*
M. R. S. Kulenovic, University of Rhode Island (1067-39-1251)

10:45AM (824) *Applications of System of Logistic Difference Equations in agriculture.*
Tamara Yevgenia Awerbuch*, **Richard Levins**, Harvard School of Public Health, **Michael A Radin**, Rochester Institute of Technology, **Candace M Kent**, Virginia Commonwealth University, and **Vlajko Kocic**, Xavier University of Louisiana (1067-39-1617)

11:00AM (825) *Asymptotic behavior of solutions to difference equations involving ratios of elementary symmetric polynomials.*
Austin H Jones* and **Kenneth S Berenhaut**, Wake Forest University (1067-39-2404)

11:15AM (826) *Local data of a Linear Difference Operator.*
Yongjae Cha, Florida State University (1067-39-2064)

11:30AM (827) *Competitive exclusion in a discrete juvenile-adult model with continuous and seasonal reproduction.*
Ross A Chiquet* and **Azmy S Ackleh**, University of Louisiana, Lafayette (1067-39-1634)

11:45AM ► (828) *Modeling Interactions Among Fish, Fishermen and Fish-Eating Bird Populations.*
Robert R. Ferdinand*, **Matthew M. Donica**, **James K. Gordon**, **Laura E. Johnson** and **Jessica L. Pitts**, East Central University (1067-39-16)

MAA Invited Address

9:00 AM – 9:50 AM

(829) *Sea battles, Benjamin Franklin's oil lamp, and jellybellies.*
Katherine Socha, Saint Mary's College of Maryland (1067-A0-40)

MAA Invited Paper Session on The Beauty and Power of Number Theory

9:00 AM – 11:55 AM

Organizers: **Thomas Koshy**, Framingham State University
Shannon Lockard, Bridgewater State College

9:00AM ► (830) *Euler's pentagonal numbers theorem, companions and variations.*
Krishnaswami Alladi, University of Florida (1067-AC-1067)

9:45AM (831) *The Takagi function.*
Jeffrey C. Lagarias, University of Michigan (1067-AC-297)

10:30AM (832) *Using finite fields to prove things about the complex numbers.*
Van H. Vu, Rutgers University, **Melanie Matchett Wood***, American Institute of Mathematics and Stanford University, and **Philip Matchett Wood**, Stanford University (1067-AC-531)

11:15AM (833) *Landau's Class Number Theorem: A Gem That Wasn't.* Preliminary report.
H. M. Stark, UCSD (1067-AC-1058)

MAA Minicourse #12: Part A

9:00 AM – 11:00 AM

Concepts, data, and models: College algebra for the real world.
Organizers: **Sheldon P. Gordon**, Farmingdale State College
Florence S. Gordon, New York Institute of Technology

MAA Minicourse #6: Part A

9:00 AM – 11:00 PM

Green linear optimization.
Organizer: **Glenn H. Hurlbert**, Arizona State University

SIGMAA RUME Session on Research on the Teaching and Learning of Undergraduate Mathematics, I

9:00 AM – 11:55 AM

Organizers: **Sean Larsen**, Portland State University
Natasha M. Speer, University of Maine
Stacy Brown, Pitzer College

9:00AM ► (834) *Enhancing Student Understanding of the Concept of Limit via Instructional Provocations.*
Kyeong Hah Roh and **Aviva Halani***, Arizona State University (1067-Z5-1357)

9:20AM (835) *Creating, Using and Interpreting Vectors and Vector Equation in a Classroom Community of Practice.*
George F. Sweeney, San Diego State University/UCSD (1067-Z5-2017)

9:40AM ► (836) *The Impact of the Spacing Effect and Overlearning on Student Performance in Calculus.*
Nicholas Gorgievski*, Nichols College, and **Thomas C DeFranco**, University of Connecticut (1067-Z5-1007)

10:00AM ► (837) *Set-oriented Thinking and the Evaluation of Alternative Solutions in Counting Problems.* Preliminary report.
Elise Lockwood, Portland State University (1067-Z5-1438)

10:20AM ► (838) *University Calculus Instructors and Students' discourses on the derivative.* Preliminary report.
Jungeun Park*, Michigan State University, and **Sharon Senk**, Michigan State University (1067-Z5-1084)

10:40AM (839) *How mathematicians use diagrams to construct proofs.*
Aron Samkoff*, Rutgers University, **Yvonne Lai**, University of Michigan, and **Keith Weber**, Rutgers University (1067-Z5-1798)

11:00AM ► (840) *Quantitative Reasoning and Student Understandings of Function Composition.*
Stacey A. Bowling, West Virginia University (1067-Z5-1727)

11:20AM (841) *Mathematics Majors' Evaluation of Mathematical Arguments and Their Conception of Proof.*
Keith Weber, Rutgers University (1067-Z5-1339)

MAA-Young Mathematicians' Network Panel Discussion

9:00 AM – 10:20 AM

Career options for undergraduate mathematics majors.
Organizers: **Ralucca Gera**, Naval Postgraduate School
Tom Wakefield, Youngstown State University
Panelists: **Emily Kessler**, Society of Actuaries
Erin E. Corman, National Security Agency
Lee Seitelman, University of Connecticut
David Manderscheid, University of Nebraska-Lincoln
Fred Kluempen, Educational Testing Service

MAA Session for Chairs

9:00 AM – 10:20 AM

The new MAA Curriculum Guide: What should it be?
Organizers: **Daniel Maki**, Indiana University
Catherine M. Murphy, Purdue University Calumet
Panelists: **Carol Schumacher**, Kenyon College
James Sellers, Pennsylvania State University

Student Hospitality Center

9:00 AM – 5:00 PM

AMS Session on Algebraic Geometry, I

9:15 AM – 11:55 AM

9:15AM ► (842) *Visualizing Cubic Algebraic Surfaces.*
Jennifer Elyse Bonsangue*, California State University of Channel Islands, and **Ivona Grzegorczyk**, California State University Channel Islands (1067-14-133)

9:30AM (843) *Genus of rational space curves indicated by μ-bases.*
Xiaoran Shi*, Department of Mathematics, University of Science and Technology of China, Department of Computer Science, Rice University, **Xiaohong Jia**, Department of Computer Science, the University of Hong Kong, and **Ron Goldman**, Department of Computer Science, Rice University (1067-14-1259)

9:45AM (844) *A new look at Verdier specialization.*
Paolo Aluffi, Florida State University (1067-14-1310)

10:00AM (845) *Identities for $\wp$-functions.*
Christopher Athorne, University of Glasgow (1067-14-1453)

10:15AM (846) *The Tate-Shafarevich Group, Flat Cohomology and Visibility.*
Saikat Biswas, Florida State University (1067-14-1558)

10:30AM (847) *Kottwitz's nearby-cycles conjecture for local models associated to unitary groups.* Preliminary report.
Sean Rostami, University of Maryland (1067-14-1641)

10:45AM (848) *Algebraic density property of Danilov-Gizatullin surfaces.* Preliminary report.
Fabrizio Donzelli, Stony Brook University (1067-14-1764)

11:00AM (849) *Motivic integral of K3 surfaces over $\mathbb{C}((t))$.*
Allen J Stewart* and **Vadim Vologodsky**, University of Oregon (1067-14-1786)

11:15AM (850) *Some splice quotient double points.*
Elizabeth A. Sell, Millersville University (1067-14-1889)

11:30AM (851) *Towards a salmon conjecture.*
Luke Oeding*, Universitá degli studi di Firenze, and **Daniel J. Bates**, Colorado State University (1067-14-1922)

11:45AM (852) *Positivity of Chern classes for Schubert varieties in low codimension.*
Judson P. Stryker, Florida State University (1067-14-2190)

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

Exhibits and Book Sales

9:30 AM – 5:30 PM

MAA Committee on Graduate Students Poster Session

10:00 AM – NOON

Professional science masters degrees in the mathematical sciences.

Organizer: **David Manderschied**, University of Nebraska-Lincoln

AWM Emmy Noether Lecture

10:05 AM – 10:55 AM

(853) *Orthogonal Representations: From Groups to Hopf Algebras.*
M. Susan Montgomery, University of Southern California (1067-16-4)

MAA Minicourse: #5: Part A

10:30 AM – 12:30 PM

A Game Theory path to quantitative literacy.

Organizers: **David L. Housman**, Goshen College
Richard A. Gillman, Valparaiso University

SIGMAA Officers Meeting

10:30 AM – NOON

Chair: **Amy Shell-Gellasch**, Beloit College

MAA Panel Discussion

10:35 AM – 11:55 AM

Writing the history of the MAA's first 100 years.

Organizers: **Victor J. Katz**, University of the District of Columbia
Janet Beery, University of Redlands
Warren Page, New York City College of Technology, CUNY

Panelists: **Mary Gray**, American University
David Zitarelli, Temple University
Carol Mead, Archives of American Mathematics

MAA Committee on Graduate Students/Young Mathematicians' Network Panel Discussion

10:35 AM – 11:55 AM

Graduate school: Choosing one, getting in, staying in.

Organizers: **Aaron Luttman**, Clarkson University
Kristi Meyer, Wisconsin Lutheran College

Panelists: **Jessie Lenarz**, Concordia College
Richard McGehee, University of Minnesota
Jennifer McNulty, University of Montana

MAA Panel Discussion

10:35 AM – 11:55 AM

Proposal writing workshop for grant applications to the NSF Division of Undergraduate Education.

Organizers: **Dennis Davenport**, NSF DUE

Stephaine Fitchett, NSF DUE
Lee L. Zia, NSF DUE

SIAM Invited Address

11:10 AM – NOON

(854) *In Pursuit of the Salesman: Mathematics at the Limits of Computation.*
William Cook, Georgia Tech (1067-90-2415)

AMS Colloquium Lectures: Lecture II

1:00 PM – 2:00 PM

► (855) *Expander graphs in pure and applied mathematics, II.* Preliminary report.
Alexander Lubotzky, The Hebrew University of Jerusalem (1067-11-14)

AMS-MAA-SIAM Special Session on Research in Mathematics by Undergraduates and Students in Post-Baccalaureate Programs, IV

1:00 PM – 3:50 PM

Organizers: **Darren A. Narayan**, Rochester Institute of Technology
Bernard Brooks, Rochester Institute of Technology
Jobby Jacob, Rochester Institute of Technology
Jacqueline A. Jensen, Sam Houston State University
Carl V. Lutzer, Rochester Institute of Technology

1:00PM ► (856) *Graphs with large second neighborhood.* Preliminary report.
Brooks E Smith*, Notre Dame, **Chang Mou Lim**, Yale, and **Antonio Blanca**, Georgia Institute of Technology (1067-05-1526)

1:30PM (857) *A Poisson Approximation for the Number of kl-Matches I.*
Katherine A Grzesik*, SUNY Oswego, **Heather Shappell**, Arcadia University, **Michael Donders**, McDaniel College, and **Chelsea Ross**, ETSU (1067-62-1748)

2:00PM (858) *SET® and disjoint complete caps in $AG(4,3)$.*
Michael Follett, Lafayette College, **Catherine Pelland**, Pomona College, **Robert Won**, Duke University, and **Elizabeth McMahon***, Lafayette College (1067-51-1761)

2:30PM ► (859) *Working with Cubic Splines and Neural Data.* Preliminary report.
Jeffrey Liebner*, Lafayette College, **Julie Michelman**, Carleton College, **Micah Pearce**, Texas Tech University, and **Jiaqi Li**, Lafayette College (1067-62-1305)

3:00PM ► (860) *Applications of discrete wavelets.*
P. Laverty*, **S. Alzouma** and **W. Lambdin**, University of Richmond (1067-94-1345)

3:30PM (861) *Recovering a group from its asynchronous automatic structure.*
Maria Monks, University of California, Berkeley

AMS-MAA-MER Special Session on Mathematics and Education Reform, II

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

1:00PM ► (862) *Mathematical Literacy and Quantitative Literacy: Symbiosis or Competition?*
Deborah Hughes Hallett, University of Arizona/Harvard Kennedy School (1067-97-1214)

1:30PM ► (863) *Reorganizing School Mathematics for Quantitative Literacy.*
Rick Gillman, Valparaiso University (1067-97-550)

2:00PM ► (864) *Quantitative Literacy and the "Big Ideas" of High School Mathematics.*
Brian Beaudrie*, Winona State University, **Emily Ricard**, New Hampshire Impact Center, **Greg Superchi**, Lisbon High School, and **David Gilcreast**, Pelham High School (1067-97-1221)

2:30PM ► (865) *Quantitative Literacy and College Readiness.*
Cathy L Seeley, Charles A. Dana Center, University of Texas (1067-97-2385)

3:00PM ► (866) *The Role of QL in the High School Mathematics Curriculum: What Students Need to Know to Be College Ready.*
Corrine H Taylor, QR Program, Wellesley College (1067-97-2139)

3:30PM ► (867) *The Role of QL in the High School Mathematics Curriculum Panel Discussion.*
Eric C Gaze, Bowdoin College (1067-97-1307)

AMS-MAA Special Session on History of Mathematics, IV

1:00 PM – 3:50 PM

Organizers: **Sloan E. Despeaux**, Western Carolina University
Craig G. Fraser, University of Toronto
Deborah Kent, Hillsdale College

1:00PM ► (868) *Mary Cartwright and G.H. Hardy's 1928 Oxford Seminar.*
James J. Tattersall*, Providence College, and **Shawnee L. McMurran**, California State University San Bernardino (1067-01-613)

1:30PM ► (869) *George Whaples: A Novice in Emil Artin's Mathematical Circle.*
Della D. Fenster*, University of Richmond, and **Joachim Schwermer**, University of Vienna (1067-01-1547)

2:00PM ► (870) *Advertising and Patronage in Laplace's Early Writing.* Preliminary report.
Menolly Lysne, IHPST at University of Toronto (1067-01-1012)

2:30PM (871) *Circulating Mathematics and Connecting Mathematicians:* The American Journal of Mathematics, 1878-1930.
Deborah Kent, Hillsdale College (1067-01-2354)

3:00PM ► (872) *Roles of an International Journal: Acta Mathematica and Italian Mathematicians, 1882–1927.* Preliminary report.
Laura E. Turner, Aarhus Universitet (1067-01-2104)

3:30PM ► (873) *On the universalization of matrix decomposition: algebraic practices and their circulations (1830-1930).*
Frédéric Brechenmacher, CNRS - Institut de Mathématiques de Jussieu, Paris, & Laboratoire de Mathématiques Lens. Univ. Lille (1067-01-1433)

AMS-SIAM Special Session on Mathematics of Computation: Algebra and Number Theory, II

1:00 PM – 3:50 PM

Organizers: **Gregor Kemper**, Technische Universität München
Michael J. Mossinghoff, Davidson College
Igor E. Shparlinski, Macquarie University

1:00PM (874) *Lehmer's conjecture and points on elliptic curves that are congruent to torsion points.* Preliminary report.
Joseph H. Silverman, Brown University (1067-11-113)

1:30PM (875) *Minimal polynomials of algebraic numbers with rational parameters.*
Karl Dilcher, **Rob Noble**, Dalhousie University, and **Chris Smyth***, University of Edinburgh, UK (1067-11-495)

2:00PM (876) *Pisot and Salem polynomials dividing Newman polynomials.*
Kevin G. Hare*, University of Waterloo, and **Michael Mossinghoff**, Davidson College (1067-11-348)

2:30PM (877) *Effective solution of Norm-form equations.* Preliminary report.
Michael A. Bennett, University of British Columbia (1067-11-2080)

3:00PM ► (878) *The Smoothed Pólya-Vinogradov Inequality and some Applications.* Preliminary report.
Enrique Trevino, Dartmouth College (1067-11-608)

3:30PM ► (879) *On the density of abundant numbers.* Preliminary report.
Mitsuo Kobayashi, California State Polytechnic University, Pomona (1067-11-214)

AMS-ASL Special Session on Logic and Analysis, II

1:00 PM – 3:50 PM

Organizers: **Jeremy Avigad**, Carnegie Mellon University
Ulrich W. Kohlenbach, Technische Universität Darmstadt
Henry Towsner, University of California Los Angeles

1:00PM (880) *Uniform Bounds from Proofs in Nonlinear Ergodic and Fixed Point Theory.*
Ulrich Kohlenbach, TU Darmstadt (1067-03-391)

1:30PM (881) *Proof mining in nonstandard analysis.* Preliminary report.
Eyvind Martol Briseid, TU Darmstadt (1067-03-727)

2:00PM (882) *Computability and Complexity in Geometric Measure Theory.*
Jack H Lutz, Iowa State University (1067-03-864)

2:30PM (883) *Ramsey's theorem for pairs and program extraction.*
Alexander P. Kreuzer, Technische Universität Darmstadt (1067-03-547)

3:00PM (884) *Applications of Logic to Analysis.*
Vassilios Gregoriades, TU Darmstadt (1067-03-737)

3:30PM (885) *Reverse mathematics and constructive analysis.*
Jeffry L. Hirst*, Appalachian State University, and **Carl Mummert**, Marshall University (1067-03-1581)

AMS Special Session on Birational Geometry and Moduli Spaces (Mathematics Research Communities session), II

1:00 PM – 3:50 PM

Organizers: **Kevin Tucker**, University of Utah
Dawei Chen, University of Illinois at Chicago
Amanda Knecht, University of Michigan
David Swinarski, University of Georgia

1:00PM (886) *Conformal Blocks Divisors on $\overline{M}_{0,n}$.*
Angela Gibney*, **Valery Alexeev** and **David Swinarski**, University of Georgia (1067-14-656)

1:30PM (887) *Cox rings and pseudoeffective cones of projectivized toric vector bundles.*
Jose Luis Gonzalez, University of Michigan (1067-14-174)

2:00PM (888) *Beyond the Boundary: Log Minimal Models for the Moduli Space of Curves.*
David Jensen, SUNY Stony Brook (1067-14-381)

2:30PM (889) *Spaces of rational curves on hypersurfaces.*
Roya Beheshti* and **Mohan Kumar**, Washington University in St. Louis (1067-14-1189)

3:00PM (890) *The effective cone of the space of parametrized rational curves in Grassmannians.* Preliminary report.
Shin-Yao Jow, University of Pennsylvania (1067-14-458)

3:30PM (891) *The birational geometry of the Hilbert Scheme of points in the plane.*
Izzet Coskun*, University of Illinois at Chicago, **Aaron Bertram**, University of Utah, and **Daniele Arcara**, St Vincent College (1067-14-873)

AMS Special Session on Lie Algebras, Algebraic Groups, and Related Topics, I

1:00 PM – 3:50 PM

Organizers: **Audrey L. Malagon**, Mercer University
Julie C. Beier, Mercer University
Daniel K. Nakano, University of Georgia

1:00PM (892) *Levi factors of linear algebraic groups.*
George J. McNinch, Tufts University (1067-20-1886)

1:30PM (893) *On maximal weights of integrable $\widehat{sl}(n,\mathbb{C})$-modules.* Preliminary report.
Rebecca L. Jayne, North Carolina State University (1067-17-899)

2:00PM (894) *N-point Virasoro algebras and their dense representations.*
Ben L Cox*, College of Charleston, **Xiangqian Guo**, Zhengzhou University, **Rencai Lu**, Suzhou University, and **Kaiming Zhao**, Wilfrid Laurier University (1067-17-1228)

2:30PM (895) *Degeneracy and Decomposability in Abelian Crossed Products.*
Kelly McKinnie, University of Montana (1067-16-1856)

3:00PM (896) *Cohomology rings for quantized enveloping algebras.* Preliminary report.
Christopher Martin Drupieski, University of Georgia (1067-17-1186)

3:30PM (897) *W-constraints for simple singularities.*
Bojko Bakalov*, North Carolina State University, and **Todor Milanov**, IPMU, Japan (1067-17-1801)

AMS Special Session on Wavelets, Tilings, and Iterated Function Systems, II

1:00 PM – 3:50 PM

Organizers: **Palle E. Jorgensen**, University of Iowa
David R. Larson, Texas A&M University
Gestur Olafsson, Louisiana State University

1:00PM (898) *Crossed products in Gabor analysis and Rieffel projections in rotation algebras.* Preliminary report.
Franz Luef, UC Berkeley (1067-47-621)

1:30PM (899) *Matrix Factorization and Lifting.*
Palle E. T. Jorgensen, The University of Iowa, and **Myung-Sin Song***, Southern Illinois University Edwardsville (1067-42-1298)

2:00PM (900) *Filtering Directional Bias and the Construction of Artifact-free Synthetic Tubular Structures in 3D.* Preliminary report.
Manos Papadakis, University of Houston (1067-42-1410)

2:30PM (901) *p-Adic Wavelets: Quincunx MRA and Biorthogonal Systems.*
Emily J. King*, National Institutes of Health / Norbert Wiener Center UMD, and **Maria A. Skopina**, St. Petersburg State University, Russia (1067-43-1253)

3:00PM (902) *Sparsity of the fusion frame operator and nonorthogonal fusion frames.*
Jameson Cahill, **Pete Casazza**, University of Missouri, and **Shidong Li***, San Francisco State University (1067-41-1613)

3:30PM (903) *Simple wavelet sets for multiwavelets in $\mathbb{R}^2$ and $\mathbb{R}^3$.* Preliminary report.
Kathy D. Merrill, Colorado College (1067-42-1517)

AMS Special Session on Stochastic Analysis and Random Phenomena, II

1:00 PM – 3:50 PM

Organizers: **Ambar N. Sengupta**, Louisiana State University
P. Sundar, Louisiana State University

1:00PM ► (904) *Emissions Option Pricing and Singular BSDEs.* Preliminary report.
Rene Carmona, Princeton University (1067-60-2409)

1:30PM (905) *Drawdowns and drawups.*
Olympia Hadjiliadis, City University of New York (1067-60-1707)

2:00PM (906) *Sensitivity Analysis of Expected Values.*
Victor Goodman, Indiana University (1067-60-1963)

2:30PM (907) *Option Pricing With Transaction Costs And Stochastic Volatility.*
Maria C. Mariani*, The University of Texas at El Paso, **Emmanuel Ncheuguim**, NMSU, **Ionut Florescu**, Stevens Institute of Technology, and **Indranil Sen Gupta**, The University of Texas at El Paso (1067-91-1304)

3:00PM (908) *Cooperative dynamics of kinesin and dynein type molecular motors.*
Avanti Athreya, Duke University, **John Fricks**, Penn State University, **Peter R Kramer**, Rensselaer Polytechnic Institute, and **Scott A McKinley***, University of Florida (1067-60-2138)

3:30PM ► (909) *Statistical Modeling of Methylation Patterns in Ovarian Carcinomas.*
Michelle R Lacey, Tulane University (1067-60-1618)

AMS Special Session on Model Theory of Fields and Applications (Mathematics Research Communities session), II

1:00 PM – 3:50 PM

Organizers: **Benjamin A. Hutz**, CUNY Graduate Center
Jana Marikova, Western Illinois University
Jerome Poineau, University of Strasbourg
Yimu Yin, University of Pittsburgh

1:00PM ► (910) *Model theory of multiplicative valued difference fields.*
Koushik Pal, University of California Berkeley (1067-03-1880)

1:30PM (911) *Solutions of linear equations in a model complete theory of valued D-fields.*
Meghan B Anderson, University of California, Berkeley (1067-03-1867)

2:00PM (912) *Model theory of fields with operators and dynamics.*
Thomas Warren Scanlon, University of California, Berkeley (1067-03-2055)

3:00PM (913) *Further applications of ACFA to polynomial dynamics.* Preliminary report.
Alice Medvedev* and **Thomas Scanlon**, University of California, Berkeley (1067-12-2371)

3:30PM (914) *Rings Arising in a Stable Context.*
Paul Baginski, Universite Lyon 1 (1067-03-1487)

AMS Special Session on Commutative Algebra (Mathematics Research Communities session), II

1:00 PM – 3:50 PM

Organizers: **Christine Berkesch**, Stockholm University
Bhargav Bhatt, University of Michigan, Ann Arbor
Jason McCullough, University of California, Riverside
Javid Validashti, University of Kansas

1:00PM (915) *Finite free resolutions of varieties with symmetries.* Preliminary report.
Witold Kraskiewicz, N. Copernicus University, Torun, Poland, and **Jerzy Weyman***, Northeastern University (1067-13-1777)

1:30PM ► (916) *Bounds on the degrees of generators of Bruns ideals.* Preliminary report.
Douglas A Torrance, University of Idaho (1067-13-407)

2:00PM ► (917) *Bounds for arithmetic rank.*
Manoj Kummini* and **Uli Walther**, Purdue University (1067-13-1210)

2:30PM (918) *Cartier Modules on Toric Varieties.*
Jen-Chieh Hsiao, Purdue University, **Karl Schwede**, Pennsylvania State University, and **Wenliang Zhang***, University of Michigan (1067-13-395)

3:00PM (919) *F-pure thresholds of hypersurfaces over fields of positive characteristic.*
Daniel Jesús Hernández, University of Michigan, Ann Arbor (1067-13-392)

3:30PM (920) *On parameter F-jumping numbers.*
Craig Huneke, University of Kansas, **Shunsuke Takagi***, Kyushu University/Massachusetts Institute of Technology, and **Kei-ichi Watanabe**, Nihon University (1067-13-1341)

AMS Special Session on Knots, Links, 3-Manifolds, and Physics, I

1:00 PM – 3:50 PM

Organizers: **Robert Kusner**, University of Massachusetts, Amherst
Rafal Komendarczyk, Tulane University

1:00PM (921) *Virtual Knots, Khovanov Homology and Quantum Information.*
Louis H. Kauffman, University of Illinois at Chicago (1067-57-1589)

2:00PM (922) *Categorification in knot and graph theory.*
Radmila Sazdanovic, University of Pennsylvania (1067-57-1825)

2:30PM (923) *Commensurability classes of hyperbolic knot complements and hidden symmetries.*
Neil R Hoffman, University of Texas at Austin (1067-57-296)

3:00PM (924) *Two-fold branched covers.*
Dave Auckly, Mathematical Sciences Research Institute (1067-57-924)

3:30PM (925) *Tightness in contact metric manifolds.*
John Etnyre*, Georgia Institute of Technology, **Rafal Komendarczyk**, Tulane University, and **Patrick Massot**, Universite Paris Sud, Orsay (1067-57-1146)

AMS Special Session on Structured Models in Ecology, Evolution, and Epidemiology: Periodicity, Extinction, and Chaos, II

1:00 PM – 3:50 PM

Organizers: **Sophia R.-J. Jang**, Texas Tech University
Linda J. S. Allen, Texas Tech University
Lih-Ing W. Roeger, Texas Tech University

1:00PM (926) *Attenuance and Resonance of Periodic Cycles in Periodically Forced Population Models.* Preliminary report.
Vlajko L Kocic, Xavier University of Louisiana (1067-39-486)

1:30PM (927) *Evolution and competitive coexistence in food chains.*
Rosalyn C. Rael*, University of Michigan, and **J. M. Cushing**, University of Arizona (1067-92-2350)

2:00PM (928) *An Exactly Solveable SIR Model Having Population Dynamics.*
Ronald Mickens, Clark Atlanta University (1067-35-1962)

2:30PM ► (929) *On a Fractional Order Epidemic Model.*
Elif Demirci* and **Nuri Ozalp**, Ankara University (1067-37-1121)

3:00PM (930) *Interactions among virulence, coinfection and drug resistance in a complex life-cycle parasite.*
Dashun Xu*, Southern Illinois University Carbondale, **Gregory J Sandland**, Department of Biology, University of Wisconsin, **Dennis J Minchella**, Department of Biological Sciences, Purdue University (West Lafayette), and **Zhilan Feng**, Purdue University (West Lafayette) (1067-45-1953)

3:30PM (931) *Competitive exclusion and coexistence in a Leslie-Gower competition model with Allee effects.* Preliminary report.
Sophia R.-J. Jang, Texas Tech University (1067-92-2111)

AMS Special Session on Interactions of Inverse Problems, Signal Processing, and Imaging, II

1:00 PM – 3:50 PM

Organizer: **Zuhair Nashed**, University of Central Florida

1:00PM (932) *Sparse Regularization of Geophysical Inverse Problems by a Greedy Algorithm.*
Volker Michel, Geomathematics Group, University of Siegen (1067-65-1199)

1:30PM (933) *On the multi-parameter regularization for ill-posed problems.*
Sergei Pereverzyev*, **Sivananthan Sampath** and **Valeriya Naumova**, Johann Radon Institute for Computational and Applied Mathematics (1067-65-226)

2:00PM (934) *Four kinds of expressing solution smoothness and their consequences for ill-posed problems.*
Bernd Hofmann, Chemnitz University of Technology (1067-65-517)

2:30PM (935) *On the problem of parameter estimation in exponential sums.*
Frank Filbir, Institute of Biomathematics and Biometry, Helmholtz Center Munich, Germany, **Hrushikesh N. Mhaskar**, California State University, Los Angeles, and **Jürgen Prestin***, University of Lübeck, Germany (1067-42-1200)

3:00PM (936) *Non-linear signal representations, subspace clustering and some applications.*
Akram Aldroubi, Vanderbilt University (1067-68-584)

3:30PM (937) *Sampling theorems associated with Singular Basic Sturm Liouville Problems.*
Mahmoud H. Annaby*, Qatar University, **Hassan A. Hassan**, Faculty of Basic Education, Kuwait, and **Zeinab S. Mansour**, King Saud University (1067-39-1154)

MAA Invited Paper Session on Topics in Hopf Algebras

1:00 PM – 3:50 PM

Organizers: **Serban Raianu**, California State University, Dominguez Hills
Davida Fischman, California State University, San Bernardino

1:00PM (938) *Hopf algebras- a unifying theory.* Preliminary report.
Miriam Cohen*, Ben Gurion University, and **Sara Westreich**, Bar Ilan University (1067-AD-509)

1:30PM ► (939) *Knots and Algebra Intertwined.*
David E Radford, U. of Illinois at Chicago (1067-AD-1185)

2:00PM ► (940) *Frobenius-Schur indicators: from groups to Hopf algebras.*
Andrea Jedwab, University of Southern California (1067-AD-1066)

2:30PM (941) *Hopf Algebras from Graphs.* Preliminary report.
Miodrag Cristian Iovanov, University of Southern California; U Bucharest (1067-AD-1696)

3:00PM (942) *Corings and descent theory.*
Stefaan Caenepeel, Vrije Universiteit Brussel (1067-AD-1314)

3:30PM ► (943) *On the classification of fusion categories in small dimensions.*
David A Jordan*, Massachusetts Institute of Technology, and **Eric Larson**, Harvard University (1067-AD-405)

MAA Minicourse #10: Part A

1:00 PM – 3:00 PM

Teaching introductory statistics (for instructors new to teaching intro stats).

Organizers: **Michael A. Posner**, Villanova University
Carolyn K. Cuff, Westminster College

MAA Minicourse #13: Part A

1:00 PM – 3:00 PM

Creating demonstrations and guided explorations for multivariable calculus using CalcPlot3D.

Organizer: **Paul Seelburger**, Monroe Community College

MAA Minicourse #1: Part A

1:00 PM – 3:00 PM

Special relativity through a linear algebraic lens.

Organizer: **John de Pillis**, Unversity of California Riverside

AMS Session on Algebraic Geometry, II

1:00 PM – 3:25 PM

1:00PM (944) *On Weierstrass semigroups of m-tuples of places on function fields associated with linearized polynomials.*
Gretchen L. Matthews and **Justin D. Peachey***, Clemson University (1067-14-1656)

1:15PM (945) *Some new results on invariants of F-crystals.*
Xiao Xiao, Binghamton University (1067-14-42)

1:30PM ► (946) *Toric Symmetry in Gromov-Witten Theory and Enumerative Geometry: Blowups of Complex Projective Space.*
Dagan Karp, **Dhruv Ranganathan*** and **Paul L Riggins**, Harvey Mudd College (1067-14-169)

1:45PM (947) *Picard-Fuchs Equations for a Family of K3 Hypersurfaces.*
Daniel Moore* and **Dmitri Skjorshammer**, Harvey Mudd College (1067-14-177)

2:00PM ► (948) *Classification of Tops in Five Dimensions.*
Dmitri Skjorshammer, Harvey Mudd College (1067-14-178)

2:15PM (949) *Vector bundles of conformal blocks.* Preliminary report.
David J Swinarski, University of Georgia (1067-14-634)

2:30PM ► (950) *Counting Generating Invariants for the Action of a Semisimple Group.*
Harlan Kadish, University of Michigan (1067-14-848)

2:45PM (951) *Exact Sums-of-Squares Certificates in Numeric Algebraic Geometry.*
Sharon Elizabeth Hutton*, **Erich L. Kaltofen**, North Carolina State University, and **Lihong Zhi**, KLMM, Academy of Math and System Sciences (1067-14-2189)

3:00PM (952) *On the Number of Erdös' Consistent 5-tuples.*
Hongbo Li, Chinese Academy of Sciences (1067-14-658)

3:15PM (953) *Polynomials Nonnegative on Half-strips and Multiple Strips.*
Ha N Nguyen, Wesleyan College (1067-14-293)

AMS Session on Numerical Analysis, II

1:00 PM – 3:55 PM

1:00PM (954) *Commuting Smoothed Projectors in Weighted Spaces.*
Minah Oh*, James Madison University, and **Jay Gopalakrishnan**, University of Florida (1067-65-1099)

1:15PM (955) *L_q error estimates and superconvergence analysis for finite element methods for compressible miscible displacement.*
Kening Wang*, University of North Florida, and **Shuang Li**, Ernst & Young LLP (1067-65-2357)

1:30PM ► (956) *Oscillation-Free Operator Splitting Method for Semilinear Diffusion Equations.*
R. Corban Harwood*, **Likun K. Zhang**, **T. Zaki Jubery**, Washington State University, **Greg M. Vogel**, Utah State University, **W. Gitau Munge**, **Joe J. Theisen** and **V. S. Manoranjan**, Washington State University (1067-65-612)

1:45PM (957) *Spectral Collocation/p-Version Finite Element Methods for Hamiltonian Dynamical Systems.*
Zhimin Zhang* and **Nairat Kanyamee**, Wayne State University (1067-65-457)

2:00PM (958) *Domain Decomposition Solvers for Nonlinear Multiharmonic Finite Element Equations.*
Dylan M Copeland*, Texas A&M University, and **Ulrich Langer**, Johannes Kepler University (1067-65-252)

2:15PM (959) *A two domain discontinuous solution to chemical transport in a small artery and arterial wall.*
Shelly M McGee*, University of Findlay, and **Padmanabhan Seshaiyer**, George Mason University (1067-65-2212)

2:30PM (960) *Numerical solution for parabolic equations by a hybrid method.*
Samuel N. Jator, Austin Peay State University (1067-65-1081)

2:45PM (961) *A discontinuous Galerkin method for solving a modified Leakeas-Larsen equation.*
Weimin Han, **Joseph A Eichholz***, University of Iowa, **Xiaoliang Cheng**, Zhejiang University, and **Ge Wang**, Virginia Tech-Wake Forest University (1067-65-2145)

3:00PM (962) *An Evaluation of Solution Algorithms and Numerical Approximation Methods for Modeling an Ion Exchange Process.*
Sunyoung Bu*, **Jingfang Huang**, University of North Carolina at chapel hill, **Treavor H Boyer**, University of Florida, and **Cass T Miller**, University of North Carolina at Chapel Hill (1067-65-1809)

3:15PM (963) *The Alignment of Manifold Sections for Manifold Learning.* Preliminary report.
Weifeng Zhi, University of Kentucky (1067-65-1599)

3:30PM (964) *On the convergence of iterative refinement/improvement of the solution to an ill conditioned linear system.*
Abdramane Serme* and **Jean W. Richard**, BMCC/CUNY-The City University of New York (1067-65-2366)

3:45PM (965) *Numerical solution for nonlinear differential equations via combined block-pulse and orthogonal functions.*
Mohsen Razzaghi, Mississippi State University (1067-49-564)

AMS Session on Partial Differential Equations, II

1:00 PM – 3:55 PM

1:00PM (966) *On the Multi-dimensional Controller-and-stopper Games.*
Yu-Jui Huang* and **Erhan Bayraktar**, University of Michigan, Ann Arbor (1067-35-463)

1:15PM (967) *A new boundary closure scheme for the multiresolution time-domain(MRTD) calculations.*
Pengfei Yao* and **Shan Zhao**, University of Alabama (1067-35-254)

► 1:30PM (968) *Galerkin boundary integral analysis of the Grad-Shafranov equation.*
U Pablo Suarez, Delaware State University (1067-35-1931)

1:45PM (969) *A direct method for solving an ill-posed inhomogeneous elliptic problem.*
Haiyan Tian*, The University of Southern Mississippi, and **Andreas Grunewald**, Bonn Graduate School of Economics (1067-35-2384)

► 2:00PM (970) *A Round Peg in a Square Hole? Application of Non-uniform Rectangular Grid Schemes to Circular Domains.*
Vincent J van Joolen, United States Naval Academy (1067-35-2048)

2:15PM (971) *New Numerical Results on the Surface Quasi-Geosgrophic Equations.* Preliminary report.
Ramjee P Sharma* and **Jiahong Wu**, Oklahoma State University (1067-35-366)

2:30PM (972) *Finite Difference Methods for Solving the Coupled Non-Linear Euler-Bernoulli Beam Equations, with applications to modeling the wing of a Micro Air Vehicle.*
James Francis Hickman, Shippensburg University (1067-35-2204)

2:45PM (973) *Dual Interpolants for Finite Element Methods.*
Andrew K. Gillette* and **Chandrajit Bajaj**, University of Texas at Austin (1067-35-173)

3:00PM (974) *An Explicit Super-Time-Stepping Scheme for Non-Symmetric Parabolic Differential Equations.*
Katharine F. Gurski*, Howard University, and **Stephen O'Sullivan**, Dublin City University (1067-35-165)

3:15PM (975) *Spectrum of Constrained Gradient Flows of Functionalized Energies.* Preliminary report.
Gurgen Hayrapetyan* and **Keith Promislow**, Michigan State University (1067-35-2360)

3:30PM (976) *Local Solvability on $\mathbb{H}_1$: Non-homogeneous operators.* Preliminary report.
Christopher J. Winfield, Madison Area Science and Technology (1067-35-601)

3:45PM (977) *Solutions of Fractional Order Partial Differential Equations.*
Lokenath Debnath, University of Texas-Pan American (1067-35-1046)

AMS Session on Mathematical Biology and Ecology, II

1:00 PM – 3:25 PM

1:00PM (978) *Optimized Scoring Function to Predict Solubility Mutagenesis.*
Ye (Alice) Tian*, Washington State University, **Christopher Deutsch**, Portland State University, and **Bala Krishnamoorthy**, Washington State University (1067-92-471)

1:15PM (979) *An Heterogenous Adaptive Sparse Grid Method For Representing High Dimensional Free Energy Landscape in Proteins.*
Chuanbin Du*, **Hui Wang**, **Dennis Livesay** and **Donald Jacobs**, University of North Carolina at Charlotte (1067-92-2377)

1:30PM (980) *The degree of phase locking observed in hybrid neural circuits can be explained using maps based on the phase resetting curve.*
Srisairam Achuthan*, Neuroscience Center of Excellence, LSU Health Sciences Center, **Jianxia Cui**, BioCircuits Institute, University of California, San Diego, **Robert J. Butera**, Laboratory for Neuroengineering, School of Electrical and Computer Engineering, Georgia Institute of Technology, and **Carmen C. Canavier**, Neuroscience Center of Excellence, LSU Health Sciences Center (1067-92-2335)

1:45PM (981) *Stability of two cluster solutions in pulse coupled networks of neural oscillators.*
Lakshmi Chandrasekaran, Louisiana State University Health Sciences Center (1067-92-275)

► 2:00PM (982) *Chord groups associated with DNA recombination in Ciliates.* Preliminary report.
Muche A Tilahun, University of South Florida (1067-92-1148)

2:15PM (983) *Dynamics Of The Drosophila Circadian Clock: Theoretical Anti-Jitter Network And Controlled Chaos.*
Hassan M Fathallah-Shaykh, The University of Alabama at Birningham (1067-92-1236)

► 2:30PM (984) *Boundaries of Sustainability in Simple and Elaborate Models of Agricultural Pest Control with a Pesticide and a Nontoxic Refuge.* Preliminary report.
Jemal S Mohammed-Awel*, Valdosta State University, **John Bantle**, **Aaron Festinger**, **Ryan Klafehn**, **Hee-Joon Jo** and **John Ringland**, University at Buffalo (1067-92-307)

2:45PM (985) *Optimal Control of a Cholera Model by Vaccination.*
Peng Zhong*, **Suzanne Lenhart**, University of Tennessee, and **Elsa Schaefer**, Marymount University (1067-92-1975)

3:00PM (986) *How do we measure the response of species interactions to climate change? The use of models and experiments to study myrmecochory.*
Judith E Canner, California State University, Monterey Bay (1067-92-1540)

3:15PM (987) *A mathematical model to highlight the importance of vector demography in malaria dynamics and control.*
Miranda Ijang Teboh-Ewungkem*, Lafayette College, **Gideon Akumah Ngwa**, University of Buea, Cameroon, and **Calistus Ngonghala**, West Virginia University (1067-92-735)

AMS Session on Combinatorics and Graph Theory, VI

1:00 PM – 3:55 PM

1:00PM (988) *Edges in 2-factor Isomorphic Graphs.* **Paul Wrayno*** and **Ronald J. Gould**, Emory University (1067-05-903)

1:15PM ► (989) *How large is your diameter? A quest for the diameter of a Rational Residue Graph.* **Mark Budden**, Western Carolina University, **Nicole Calkins**, **William Nathan Hack***, **Joshua K Lambert** and **Kimberly Thompson**, Armstrong Atlantic State University (1067-05-1272)

1:30PM (990) *Extremal coin graphs on multiple radii.* Preliminary report. **Jill Bigley Dunham**, Hood College (1067-05-253)

1:45PM ► (991) *ϕ-Symmetric Hamilton Cycle Decompositions of Graphs.* Preliminary report. **Michael William Schroeder**, University of Wisconsin - Madison (1067-05-2029)

2:00PM (992) *Distance Labelings of Trees.* Preliminary report. **Joshua Hanes***, Mississippi University for Women, and **Tristan Denley**, Austin Peay State University (1067-05-1853)

2:15PM ► (993) *A new class of hyper-energetic graphs.* Preliminary report. **Nafiseh Jahanbakht**, University of Lethbridge (1067-05-1800)

2:30PM (994) *Top to random shuffles and number of fixed points.* Preliminary report. **Lerna Pehlivan**, Carleton University (1067-05-220)

2:45PM (995) *Permutation Puzzles.* **Evan M. O'Dorney**, Danville, California (1067-05-1175)

3:00PM ► (996) *Exhaustive Random Permutations.* Preliminary report. **Palmer C Mebane**, Harvey Mudd College (1067-05-1751)

3:15PM (997) *Coin set extensions in the greedy change-making problem.* **Tianhui Cai**, Harvard College (1067-05-1667)

3:30PM (998) *Group Divisible Designs with Fixed Block Configuration.* Preliminary report. **Melanie Laffin*** and **Melissa Keranen**, Michigan Technological University (1067-05-1360)

3:45PM (999) *Weak Transversals of Latin Squares.* **J Kyle Pula***, University of Denver, and **Ian Wanless**, Monash University (1067-05-1503)

MAA Session on Effective Teaching of Upper Level Mathematics to Secondary Education Mathematics Majors, I

1:00 PM – 3:15 PM

Organizer: **Joyati Debnath**, Winona State University

1:00PM ► (1000) *The Impact of the Moore Method on Secondary Mathematics Education Majors.* Preliminary report. **Joy Moore**, Xavier University (1067-E1-2410)

1:20PM (1001) *Changing Their Culture: A Multi-Faceted Approach to Improving Math Secondary Education Major's View of Mathematics.* **Scott S Searcy*** and **Jeffrey B Biessman**, Waldorf College (1067-E1-944)

1:40PM ► (1002) *Pre-Algebra Connections with the Chinese Remainder Theorem.* **Elizabeth A Burroughs**, Montana State University (1067-E1-2179)

2:00PM (1003) *Minding the Pre-service Teacher Students in a Discrete Mathematics Class.* Preliminary report. **Feryal Alayont**, Grand Valley State University (1067-E1-1830)

2:20PM ► (1004) *The Calculus Book: A Text for Analysis?* Preliminary report. **Ockle E Johnson**, Keene State College (1067-E1-1244)

2:40PM ► (1005) *"Practicing What We Preach" in Multivariable Calculus.* Preliminary report. **Sharon S. Emerson-Stonnell**, Longwood University (1067-E1-1482)

3:00PM ► (1006) *Making Connections in Real Analysis for Students Interested in Secondary Mathematics Education.* **Sandra Fillebrown**, Saint Joseph's University (1067-E1-830)

MAA Session on The Mathematics of Games and Puzzles, II

1:00 PM – 3:55 PM

Organizers: **Laura Taalman**, James Madison University
Robin L. Blankenship, Morehead State University

1:00PM ► (1007) *Cops and Robbers on Planar Graphs.* **Aaron J Maurer***, Carleton College, **John M McCauley**, Haverford College, and **Silviya D Valeva**, Mount Holyoke College (1067-P1-1717)

1:20PM ► (1008) *Bachet's problem: as few weights to weigh them all.* **Edwin O'Shea**, University College, Cork, Ireland (1067-P1-1697)

1:40PM ► (1009) *Puzzling Groups.* **Thomas Q. Sibley**, St. John's University/College of St. Benedict (1067-P1-474)

2:00PM ► (1010) *Solitaire Mancala.* Preliminary report. **Anthony Tongen***, **Laura Taalman** and **Roger J Thelwell**, James Madison University (1067-P1-2011)

2:20PM ► (1011) *Connection Games and Sperner's Lemma.* **David E Molnar**, Felician College (1067-P1-77)

2:40PM (1012) *Turn the Tide: A Game for Undergraduate Research Projects.* **Catherine Stenson**, Juniata College (1067-P1-2333)

3:00PM ► (1013) *Heartless Poker.* **Dominic Lanphier***, Western Kentucky University, and **Laura Taalman**, James Madison University (1067-P1-1684)

3:20PM ► (1014) *Big Bucks, No Whammies: An Investigation of "Press Your Luck".* Preliminary report. **Anthony DeLegge**, Benedictine University (1067-P1-299)

3:40PM ► (1015) *The Monty Hall Problem, Reconsidered.* **Jason Rosenhouse**, James Madison University (1067-P1-1701)

MAA Session on Treasures from the Past: Using Primary Sources in the Classroom

1:00 PM – 4:15 PM

Organizers: **Amy E. Shell-Gellasch**, Beloit College
Daniel E. Otero, Xavier University
David J. Pengelley, New Mexico State University

1:00PM ► (1016) *Abstract awakenings in algebra: Teaching and learning group theory through the works of Lagrange, Cauchy, and Cayley.* **Janet Heine Barnett**, Colorado State University - Pueblo (1067-W1-1475)

1:20PM (1017) *From Babylonian Table Texts to Abstractions.*
Stuart Anderson, Texas A&M University-Commerce (1067-W1-1531)

1:40PM (1018) *Treasures from the Americas: Two Examples of Arithmetic as It Is No Longer Done.* Preliminary report.
Bruce S. Burdick, Roger Williams University (1067-W1-2153)

2:00PM (1019) *The Mathematics of Albrecht Dürer.*
Andrius Tamulis, Governors State University (1067-W1-2132)

2:20PM (1020) *Reviewing Logs through the Resolution of Two Different Published Algebraic Representations of Napier's Logarithm.*
Andy D. Martin, Kentucky State University (1067-W1-1048)

2:40PM (1021) *Isaac Barrow's Proof of the Fundamental Theorem of Calculus.*
Colin Bryan Powell McKinney, Bradley University (1067-W1-239)

3:00PM (1022) *Newton's subjunctive G-flat opus.*
Andrew Simoson, King College (1067-W1-617)

3:20PM (1023) *Partial Fractions in Euler's Institutiones calculi differentialis.*
William Dunham, Muhlenberg College (1067-W1-659)

3:40PM (1024) *Mathematics of Non-Western Civilizations: A New Course for Majors and Nonmajors Alike.*
Jeff Suzuki, Brooklyn College (1067-W1-375)

4:00PM (1025) *Multiple Paths to Mathematics Practice in al-Kashi's Key to Arithmetic: A Preliminary Report.* Preliminary report.
Osama O. Taani, New Mexico State University (1067-W1-1184)

MAA Session on the Mathematics of Sustainability

1:00 PM – 4:00 PM

Organizers: **Elton Graves**, Rose-Hulman Institute of Technology
Peter T. Otto, Willamette University

1:00PM (1026) *Teaching Non-Science Majors Basic Modeling -A Cluster of Courses Focused on Climate Change.* Preliminary report.
Amy Kelley* and **Julia Metzker**, Georgia College & State University (1067-Q1-579)

1:20PM (1027) *Math and Social Justice: Improving the world with semester projects in a liberal arts math course.*
David Kung, St. Mary's College of Maryland (1067-Q1-2344)

1:40PM (1028) *Global Warming-Based Calculus.* Preliminary report.
Andrew E Long, Northern Kentucky University (1067-Q1-1740)

2:00PM (1029) *Do sustainability problems in mathematics really affect student attitudes?* Preliminary report.
Jeremy Case, Taylor University (1067-Q1-2140)

2:20PM (1030) *Climate change and the mathematics of sustainability of student projects for calculus and statistics courses.*
Lily S. Khadjavi, Loyola Marymount University (1067-Q1-1878)

2:40PM (1031) *Math in the City: A hands-on learning experience with projects on sustainability.* Preliminary report.
Stephen G Hartke* and **Petronela Radu**, Univ of Nebraska-Lincoln (1067-Q1-156)

3:00PM Discussion.

MAA General Contributed Paper Session, VI

1:00 PM – 3:55 PM

Organizers: **Kristen Meyer**, Wisconsin Lutheran College
Thomas R. Hagedorn, The College of New Jersey

1:00PM (1032) *What to Do on Day One in Calculus One.*
Jim Fulmer* and **Tom McMillan**, University of Arkansas at Little Rock (1067-Z1-2061)

1:15PM (1033) *The Alpha and the Omega of 1st Year Calculus.*
Carl V Lutzer, Rochester Institute of Technology (1067-Z1-2411)

1:30PM (1034) *Using Wolfram|Alpha in finite mathematics and applied calculus.* Preliminary report.
Raymond N. Greenwell*, Hofstra University, and **Nathan P. Ritchey**, Youngstown State University (1067-Z1-402)

1:45PM (1035) *Teaching a first semester Calculus class entirely through Inquiry Based Learning.* Preliminary report.
David Crombecque, Gettysburg College (1067-Z1-1763)

2:00PM (1036) *Strategies of Involving Students in Teaching Calculus.*
Jinfeng Wei, Maryville University of St. Louis (1067-Z1-2160)

2:15PM (1037) *Calculus Instructors' Responses to Prior Knowledge Errors.*
Jana R. Talley, Jackson State University (1067-Z1-1649)

2:30PM (1038) *Enhancing Student Learning in Calculus Through Subject-Oriented Projects.* Preliminary report.
Long Wang* and **Kai Qian**, Southern Polytechnic State University (1067-Z1-2329)

2:45PM (1039) *Using Calculus to Model Aspects of the 2010 Gulf Oil Spill.* Preliminary report.
Barbara P Gonzalez and **Melanie A Pivarski***, Roosevelt University (1067-Z1-2238)

3:00PM (1040) *Height variations with change of variables.*
Justin Edward Sukiennik, University of Minnesota (1067-Z1-2314)

3:15PM (1041) *Enhancing Calculus with Technology Labs, and getting your students to like it!*
Stanley F. Florkowski, United States Military Academy (1067-Z1-954)

3:30PM (1042) *Using a data modeling project to enhance the teaching of the derivative.*
Murray H Siegel, Arizona State University (1067-Z1-194)

3:45PM (1043) *Applications of Calculus to Game Theory: The Prisoners' Dilemma.*
Lee J Stemkoski, Adelphi University (1067-Z1-1795)

SIAM Minisymposium on Combinatorial Optimization, II

1:00 PM – 3:55 PM

Organizers: **David Hartvigsen**, University of Notre Dame
Donald Wagner, Office of Naval Research

1:00PM (1044) *Maximum Disjoint Paths and Flow-Cut Gaps.* Preliminary report.
Chandra Chekuri, University of Illinois Urbana-Champagne, **Sanjeev Khanna**, University of Pennsylvania, **Loic Seguin-Charbonneau**, Royal Military College, St Jean sur Richelieu, and **Burce Shepherd***, McGill University (1067-90-1217)

1:30PM (1045) *An $O(n^3)$ algorithm for the weighted stable set problem on claw-free graphs.*
Gianpaolo Oriolo*, **Yuri Faenza**, Universita' di Roma Tor Vergata, and **Gautier Stauffer**, Institut de Mathematiques de Bordeaux, Universite de Bordeaux 1 (1067-90-809)

2:00PM (1046) *Thin spanning trees, conductances, nowhere zero flows, and the traveling salesman problem.*
Michel X. Goemans, Massachusetts Institute of Technology (1067-05-1055)

2:30PM (1047) *The Maximum-weight Stable Matching Problem.*
Xujin Chen, Chinese Academy of Sciences, **Guoli Ding***, LSU, **Xiaodong Hu**, Chinese Academy of Sciences, and **Wenan Zang**, The University of Hong Kong (1067-05-1045)

3:00PM (1048) *Minimizing the sum of weighted completion times in a concurrent open shop.*
Monaldo Mastrolili, IDSIA, **Maurice Queyranne**, University of British Columbia, **Andreas S. Schulz**, Massachusetts Institute of Technology, **Ola Svensson**, KTH Computer Science and Communication, and **Nelson A. Uhan***, Purdue University (1067-90-438)

3:30PM (1049) *Polyhedral and Algorithmic Results for 1-restricted Simple 2-matchings.*
David Hartvigsen*, University of Notre Dame, and **Yanjun Li**, Purdue University (1067-90-998)

SIGMAA RUME Session on Research on the Teaching and Learning of Undergraduate Mathematics, II

1:00 PM – 4:55 PM

Organizers: **Sean Larsen**, Portland State University
Natasha M. Speer, University of Maine
Stacy Brown, Pitzer College

1:00PM (1050) *Blending Inquiry-Based Learning and Computer-Assisted Instruction in Algebra.*
John C Mayer* and **William O. Bond**, University of Alabama at Birmingham (1067-Z5-1376)

1:20PM (1051) *Quantitative Reasoning and Students' Approaches to Solving Novel Problems.*
Kevin C. Moore, University of Georgia (1067-Z5-1677)

1:40PM (1052) *Modeling Mathematical Behaviors; Making Sense of Traditional Teachers of Advanced Mathematics Courses Pedagogical Moves.*
Tim P Fukawa-Connelly, The University of New Hampshire (1067-Z5-1451)

2:20PM (1053) *Reading Online Mathematics Textbooks, A Preliminary Study.* Preliminary report.
Mary D Shepherd* and **Carla van de Sande**, Arizona State University (1067-Z5-2194)

2:40PM (1054) *Individual and Collective Analysis of the Genesis of Student Reasoning regarding the Invertible Matrix Theorem in Linear Algebra.*
Megan J Wawro, San Diego State University & University of California, San Diego (1067-Z5-1337)

3:00PM (1055) *Frameworks for Understanding Undergraduate Students' Conceptions of the Equals Sign.*
Aaron Weinberg, Ithaca College (1067-Z5-952)

3:40PM (1056) *An Exploration of the Transition to Graduate School in Mathematics.* Preliminary report.
Sarah L. Marsh, University of Oklahoma (1067-Z5-1245)

4:00PM (1057) *Differences in Beliefs and Teaching Practices between International and U.S. Domestic Mathematics Teaching Assistants.* Preliminary report.
Minsu Kim, The University of Oklahoma (1067-Z5-1119)

4:20PM (1058) *Improving Pass Rates in Mathematics using Interactive Software - Revisited.*
Michelle DeDeo, Univ. of North Florida (1067-Z5-60)

4:40PM (1059) *Reasoning about Functions of Two-Variables: A Case Study.*
Eric D Weber, Arizona State University (1067-Z5-343)

Joint Committee on Women in the Mathematical Sciences Panel Discussion

1:00 PM – 2:30 PM

Women in the mathematical sciences: Looking back, looking forward.

Organizers: **Terrell Hodge**, Western Michigan University
Maura Mast, University of Massachusetts Boston
Moderator: **Terrell Hodge**
Panelists: **Mary Gray**, American University
Jim Lewis, University of Nebraska-Lincoln
Jill Pipher, Brown University
Jean Taylor, Rutgers University
Marie Vitulli, University of Oregon

AMS Panel Discussion

1:00 PM – 2:15 PM

Proving Hardy wrong: Math research with social justice applications.

Organizer: **Eva Curry**, Acadia University
Moderator: **Eva Curry**
Panelists: **Gizem Karaali**, Pomona College
Lili Khadjavi, Loyola Marymount University
Judith Sunley, National Science Foundation

AMS Conversation on Nonacademic Employment

1:00 PM – 2:30 PM

Moderator: **C. Allen Butler**, Daniel H. Wagner Associates, Inc.

MAA Panel Dicussion

1:00 PM – 3:00 PM

Good intentions are necessary but not sufficient: Steps toward best practices in mentoring underrepresented students.

Organizer: **James H. Curry**, Arizona State University
Panelists: **Carlos Castillo-Chavez**, Arizona State University

A. G. (Loek) Helminck, North Carolina State University
Rhonda Hughes, Bryn Mawr College
Philip Kutzko, The University of Iowa
M. Helena Noronha, California State University, Northridge

MAA Panel Discussion

1:00 PM – 2:20 PM

This could be YOUR graduate research!
Organizer: **Aaron Luttman**, Clarkson University
Moderator: **Ralucca Gera**, Naval Postgraduate School
Panelists: **Timothy Chartier**, Davidson College
Steven Horton, U. S. Military Academy at West Point
Keri Kornelson, University of Oklahoma

MAA Panel Discussion

1:00 PM – 3:00 PM

Mathematical culture and mathematical life.
Organizers: **Reuben Hersh**, University of New Mexico
Vera John-Steiner, University of New Mexico
Panelists: **Lenore Blum**, Carnegie-Mellon University
Philip J. Davis, Brown University
Nathaniel Dean, Texas State University, San Marcos
Reuben Hersh
Gizem Karaali, Pomona College

SIGMAA on Statistics Education/ASA-MAA Joint Committee on Undergraduate Statistics Panel Discussion

1:00 PM – 2:20 PM

Report from the International Conference on Teaching Statistics: A world view of statistics education.
Organizers: **John McKenzie**, Babson College
Michael A. Posner, Villanova University
Panelists: **Rob Carver**, Stonehill College
Katherine Halvorsen, Smith College
John McKenzie
Milo Schield, Augusburg College
Gail Burrill, Michigan State University

MAA Committee on Technologies in Mathematics and Education/WEB SIGMAA Panel Discussion

1:00 PM – 2:20 PM

Assessment of learning in an age of technology.
Organizers: **Michael B. Scott**, California State University Monterery Bay
Jason Aubrey, University of Missouri
Panelists: **Andrew G. Bennett**, Kansas State University
Gavin LaRose, University of Michigan
Alison Marble Ahlgren, University of Illinois at Urbana-Champaign

Summer Program for Women in Mathematics (SPWM) Reunion

1:00 PM – 4:00 PM

Organizer: **Murli M. Gupta**, The George Washington University

AMS Session on Fluid Mechanics, II, and Geophysics

1:15 PM – 3:55 PM

1:15PM (1060) *Numerical Simulation of Oblique and Head-on Collision.*
Leon Kaganovskiy*, New College of Florida, and **Robert Krasny**, University of Michigan, Ann Arbor (1067-76-243)

1:30PM (1061) *An Integrative Model of Hyperactivated Sperm Motility.*
Sarah D Olson*, Tulane University, **Susan Suarez**, Cornell University, and **Lisa Fauci**, Tulane University (1067-76-216)

► 1:45PM (1062) *Deposition Patterns of Nanoparticles in Human Nasal Passages.* Preliminary report.
Rebecca A Segal, Virginia Commonwealth University (1067-76-1928)

2:00PM (1063) *New Minimal Representation of Self Propelled Swimmers in Stokes Flow Using Regularized Fundamental Solutions.*
Priya Shilpa Boindala, Georgia Gwinnett College (1067-76-250)

► 2:15PM (1064) *Modeling the Evaporation of a Tear Film over a Contact Lens.*
Kevin Talbott, George Mason University (1067-76-1374)

► 2:30PM (1065) *Numerical Simulation of Fiber Spinning Including Flow-Induced Crystallization.*
David C Szurley, Francis Marion University (1067-76-1655)

2:45PM (1066) *Mathematical model of a liquid jet breakup containing solid particles.*
M. Hameed*, University of South Carolina Upstate, and **J. Morris**, Department of Chemical Engineering, City College of New York (1067-76-1364)

► 3:00PM (1067) *Preliminary Report on the Modeling of Surface Velocities and Fault Rotations.* Preliminary report.
Danielle Nicole Gannon*, **Natalie Domelle**, Saint Mary's College, and **Lucy Flesch**, Purdue University (1067-86-150)

3:15PM (1068) *Evolution of a Mushy Zone on a Finite Domain.* Preliminary report.
Nicholas R Gewecke* and **Tim P Schulze**, University of Tennessee, Knoxville (1067-86-346)

3:30PM (1069) *Estimation of Near Surface Wind Structures in Tornadic Vortices.*
Sean M Crowell*, **Luther White**, University of Oklahoma, and **Louis Wicker**, National Severe Storms Laboratory (1067-86-950)

3:45PM (1070) *A one dimensional algorithm for seismic imaging and inversion: theoretical development and numerical tests.*
Bogdan G. Nita*, **Ashley Ciesla**, Montclair State University, and **Christopher Smith**, The College of New Jersey (1067-86-1887)

MAA Poster Session on Projects Supported by the NSF Division of Undergraduate Education

2:00 PM – 4:00 PM

Organizer: **Jon Scott**, Montgomery College

2:00PM (1071) *Workshops That Improve Undergraduate Teaching of Mathematics.*
Alex Heidenberg*, **Jerry Kobylski** and **Hilary Fletcher**, United States Military Academy

2:00PM (1072) *Distributome-An Interactive Web-based Resource for Probability Distributions.*
Kyle Siegrist*, University of Alabama in Huntsville, **Ivo Dinov**, University of California, Los Angeles, and **Dennis Pearl**, The Ohio State University

2:00PM (1073) *Mathematics and Social Advocacy.*
Sandra Kingan and **Jeff Suzuki***, Brooklyn College of CUNY

2:00PM (1074) *The HBCU Retreat and Follow-On Program.*
Don Small*, United States Military Academy, and **Laurette Foster**, Prairie View A&M University

2:00PM (1075) *Teaching Abstract Algebra for Understanding.*
Estrella Johnson* and **Sean Larsen**, Portland State University

2:00PM (1076) *Math in the City.*
Petronela Radu* and **Stephen Hartke**, University of Nebraska-Lincoln

2:00PM (1077) *Lurch, Educational Software for Writing Proofs.*
Kenneth G. Monks*, University of Scranton, and **Nathan Carter**, Bentley University

2:00PM (1078) *DIY Modeling–Do It Yourself Modeling and Simulation for STEM Learning.*
Frank Wattenberg*, United States 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 (1079) *Discovering the Art of Mathematics.*
Julian F. Fleron*, **Philip K. Hotchkiss**, **Volker Ecke** and **Christine von Renesse**, Westfield State College

2:00PM (1080) *Quantitative Reasoning in the Contemporary World.*
Caren Diefenderfer*, Hollins University, **Bernard L. Madison**, University of Arkansas, **Stuart Boersma**, Central Washington University, and **Shannon Dingman**, University of Arkansas

2:00PM (1081) *College Ready in Mathematics and Physics Partnership.*
Gay Stewart, **Bernard L. Madison*** and **Shannon Dingman**, University of Arkansas

2:00PM (1082) *Biology and Mathematics in Population Studies–BioMaPS I and BioMaPS II.*
Donald Adongo*, **K. Renee Fister**, **Terry Derting**, **Chris Mecklin**, **Claire Fuller**, **Kate He**, **Emily Croteau**, **Maeve McCarthy** and **Howard Whiteman**, Murray State University

2:00PM (1083) *Dynamic Visualization Tools for Multivariable Calculus.*
Paul Seeburger, Monroe Community College

2:00PM (1084) *Enabling Computer Algebra Use in the Undergraduate Abstract Algebra Curriculum.*
Alexander Hulpke, Colorado State University

2:00PM (1085) *STEM Real World Applications of Mathematics.*
Darren Narayan* and **William Basener**, Rochester Institute of Technology

2:00PM (1086) *Analysis of Stress in Biological Systems.*
Ben G. Fitzpatrick*, **Thomas Zachariah**, **Wendy Binder**, **Kam Dahlquist** and **Gary Kuleck**, Loyola Marymount University

2:00PM (1087) *Paradigms in Physics: Interactive Electromagnetism Curricular Materials.*
Tevian Dray*, **Corinne A. Manogue** and **Emily H. van Zee**, Oregon State University

2:00PM (1088) *Project MOSAIC: Integrating Modeling, Statistics, Calculus and Computation in the Early Undergraduate Curriculum.*
Daniel Kaplan, Macalester College

2:00PM (1089) *Undertaking a Purposeful and Effective Departmental Review.*
Nancy Baxter Hastings, Dickinson College

2:00PM (1090) *Flash Applets for WeBWork Online Homework System.*
Barbara Margolius* and **Yuping Wu**, Cleveland State University

2:00PM (1091) *Research-Based Video for Teaching Undergraduate Proof.*
Jim Sandefur, Georgetown University, **Kay Somers**, Moravian College, and **Connie Campbell***, Millsaps College

2:00PM (1092) *An Integrative Analysis of Human Cancer: Exploiting the Synergy of Mathematical and Molecular Biological Approaches in Studying a Complex Problem.*
Jeffrey Forrester* and **Michael P. Roberts**, Dickinson College

2:00PM (1093) *WeBWorK: Improving Student Success in Mathematics.*
Arnold Pizer*, **Mike Gage**, **Vicki Roth**, University of Rochester, and **Michael Pearson**, Mathematical Association of America

2:00PM (1094) *MathVote: Teaching Mathematics with Classroom Voting.*
Jean McGivney-Burelle*, University of Hartford, **Kathy Shay**, Middlesex County College, **Ann Stewart**, Hood College, **Lahna VonEpps**, Columbia College, **Kelly Cline**, **Holly Zullo**, Carroll College, and **Christopher Storm**, Adelphi University

2:00PM (1095) *Maplets for Calculus.*
Douglas B. Meade*, University of South Carolina, **Philip B. Yasskin** and **Matthew Barry**, Texas A & M University

2:00PM (1096) *UTMOST: Undergraduate Teaching of Mathematics with Open Software and Textbooks.*
Robert Beezer*, University of Puget Sound, **Jason Grout**, Drake University, **Marja-Liisa Hassi**, University of Colorado at Boulder, **Thomas Judson**, Stephen F. Austin State University, **Kiran Kedlaya**, Massachusetts Institute of Technology, **Sandra Laursen**, University of Colorado at Boulder, and **William Stein**, University of Washington, Seattle

2:00PM (1097) *Discovery Learning Projects in Introductory Statistics.*
Brad Bailey* and **Dianna Spence**, North Georgia College & State University

2:00PM (1098) *Mathematics Partnering with Computer Sciences to Improve Calculus Instruction and Learning.*
Calvin L. Williams*, **Marilyn Reba**, **Roy Pargas** and **Allen Guest**, Clemson University

2:00PM (1099) *Supplying Undergraduate Biology and Mathematics Education and Research Group Experiences (SUBMERGE) to Students at the University of Michigan: Understanding Diseases with Math Biology.*
Patrick Nelson, **Trachette Jackson**, **Michael Simonov*** and **Helen Shi**, University of Michigan

2:00PM (1100) *The Integrative Biomathematics Learning and Engagement Network for Diversity (iBLEND) Project at North Carolina A&T State University.*
Gregory D. Goins*, **Mingxiang Chen**, **C. Dinitra White**, **Dominic P. Clemence** and **Thomas C. Redd**, North Carolina A&T State University

2:00PM (1101) *Problems of the Week as Teacher Education Resources.*
Jason Silverman*, Drexel University, and **Chrystal Dean**, Appalachian State University

2:00PM (1102) *The Math Forum's Virtual Fieldwork Sequence.*
Wesley Shumar*, **Jason Silverman**, Drexel University, **Stephen Weimar** and **Ellen Clay**, The Math Forum at Drexel

2:00PM (1103) *Preservice Teachers' Learning and Motivation in Working with The Math Forum's Virtual Fieldwork Sequence.*
K. Ann Renninger*, **Mark Chin**, **Dennis Fan** and **Ming Cai**, Swarthmore College

2:00PM (1104) *Assessing Open-ended Mathematics Writing: The Math Image Wiki Page Coding Scheme (MI-CS).*
Anna M. Phillips*, **Abram Lipman** and **K. Ann Renninger**, Swarthmore College

► 2:00PM (1105) *MBUR (Mathematical Biology and Undergraduate Research): Modeling the Dynamics of Riparian Forests and Landforms.*
Lindsay Blazsek, **Lisa M. Curll**, **Thomas P. Diggins** and **George T. Yates***, Youngstown State University

2:00PM (1106) *Texas A&M UBM: Student research experience is the key.*
Jay Walton, **May Boggess***, **Masami Fujiwara**, Texas A&M University, **Kaibin Fu** and **Harriette Block**, Prairie View A&M University

2:00PM (1107) *Texas A&M Math REU: The 3 X 5 Model.*
Jay Walton and **Al Boggess***, Texas A&M University

2:00PM (1108) *Interdisciplinary Training in Mathematical Biology Through Team-based Undergraduate Research and Courses.*
Jason Miller* and **Pamela Ryan**, Truman State University

2:00PM (1109) *Broadening Participation in STEM Through Integrative Experiences For First-Year Students.*
Jason Miller, Truman State University

2:00PM (1110) *University Scholars in STEM.*
Leah Gold*, **Barbara K. Modney**, **Daniel Simon**, **Lauren Davis**, **Carol Hodanbosi** and **Mark Tumeo**, Cleveland State University

2:00PM (1111) *Quantitative Skills in Biology through Scientific Inquiry at James Madison University.*
Brian Walton*, **Anthony Tongen**, **Nusrat Jahan** and **Reid Harris**, James Madison University

2:00PM (1112) *Mathematical Methods for Biology and Medicine.*
Glenn Ledder, University of Nebraska Lincoln

2:00PM (1113) *Research, Dissemination, and Faculty Development of Inquiry-Based Learning (IBL) Methods in the Teaching and Learning of Mathematics.*
Michael Starbird*, The University of Texas at Austin, **Paul J. Sally**, **John Boller**, University of Chicago, **Ralf Spatzier**, University of Michigan, **Sandra Laursen**, University of Colorado at Boulder, **John D. Moore** and **William B. Jacob**, University of California, Santa Barbara

2:00PM (1114) *GeoGebra Applets for Elementary Statistics.*
David Gurney, Southeastern Louisiana University

2:00PM (1115) *Motivation and Learning in an Online Unmoderated Mathematics Workshop for Teachers.*
K. Ann Renninger*, **Ming Cai**, **M. C. Lewis**, **M. Adams**, Swarthmore College, and **K. Ernst**, Drexel University

2:00PM (1116) *CELTIC: Calculus for Elementary Teachers: An Innovative Context.*
Karen Keene*, **Alina Duca** and **Paola Szatjn**, North Carolina State University

2:00PM (1117) *MINDSET: Mathematics Instruciton using Decision Science and Engineering Tools.*
Robert Young, **Karen Keene***, North Carolina State University, **Kenneth Chelst**, **Thomas Edwards**, Wayne State University, and **David Pugalee**, The University of North Carolina at Charlotte

2:00PM (1118) *An Accessible Online Resource for Mathematics Students and Instructors.*
Lila F. Roberts, Clayton State University

2:00PM (1119) *Online Statistics Education: An Interactive Multimedia Course of Study II.*
David M. Lane*, Rice University, and **Camille Peres**, University of Houston, Clear Lake Campus

2:00PM (1120) *Biocalculus: Text Development, Dialog, and Assessment.*
Timothy Comar* and **Brenda Alberico**, Benedictine University

2:00PM (1121) *MAA's Interactive Online Calculus Text.*
David Smith* and **Lang Moore**, Duke University

2:00PM (1122) *Resources for Courses: MathDL's New Collection of Online Materials.*
Lang Moore*, Duke University, and **Tom Leathrum**, Jacksonville State University

2:00PM (1123) *Empowering Student Learning in Mathematical Analysis.*
Barbara A. Shipman, The University of Texas at Arlington

2:00PM (1124) *PREP: MAA's Professional Development Program.*
J. Michael Pearson, Mathematical Association of America, **Nancy Baxter Hastings**, Dickinson College, **Barbara Edwards**, Oregon State University, **Nathaniel Dean**, Texas State University San Marcos, **Virginia Buchanan**, Hiram College, **Mike Brilleslyper**, United States Air Force Academy, and **Jon Scott***, Montgomery College

2:00PM (1125) *Modern Biology, Modern Mathematics, and Modern Solutions: Moving Biomathematics Education Beyond Calculus.*
Raina Robeva*, Sweet Briar College, **Terrell Hodge**, Western Michigan University, **Robin Davies**, Sweet Briar College, and **Alexander Enyedi**, Western Michigan University

► 2:00PM (1126) *The Math S-STEM Program for Attracting and Retaining Scholars in the Mathematical Sciences.*
Alexandra Kurepa, North Carolina A&T State University

► 2:00PM (1127) *The Links Between Smale's Mean Value Conjecture and Convergence.* Preliminary report.
Hayley M Miles-Leighton, University of California, San Diego (1067-30-2386)

► 2:00PM (1128) *Realization Relationships Between Communication Models.* Preliminary report.
Leilani Hendrina Gilpin, University of California, San Diego (1067-90-2390)

AMS Invited Address

2:15 PM – 3:05 PM

(1129) *Self-organization in human, biological, and artificial systems.*
Andrea L. Bertozzi, UCLA (1067-92-9)

AMS Session on Differential Geometry

2:15 PM – 3:55 PM

2:15PM (1130) *Curve Matching Using Integral Invariants.* Preliminary report.
Susan Crook, North Carolina State University (1067-53-1958)

2:30PM ► (1131) *Facial Recognition Using Conformal Geometry.*
Meghan Anne Galiardi, Stonehill College, **Miguel Angel Lugo***, Florida State University, and **Shawn Leo Witte**, Central Michigan University (1067-53-145)

2:45PM (1132) *Moving Frames and The Equivalence of Homogeneous Polynomials.* Preliminary report.
Thomas H. Wears, North Carolina State University (1067-53-166)

3:00PM (1133) *A dense G-delta of Riemannian metrics without the finite blocking property.*
Wah-Kwan Ku* and **Marlies Gerber**, Indiana University (1067-53-1156)

3:15PM ► (1134) *Distance comparison and the Dirichlet problem for curve shortening flow in convex domains.* Preliminary report.
Paul T Allen, **Adam Layne** and **Katharine Tsukahara***, Lewis & Clark College, Portland, Oregon (1067-53-193)

3:30PM (1135) *Remarks on some Non-Linear Heat Flows in Kähler Geometry.*
Donovan C McFeron, Ramapo College of New Jersey (1067-53-1232)

3:45PM (1136) *The Geometry of Simple Singularities.* Preliminary report.
Joanna K Nelson, University of Wisconsin-Madison (1067-53-2183)

MAA Committee on the Teaching of Undergraduate Mathematics Panel Discussion

2:35 PM – 3:55 PM

Calculus reform: 25 years later.
Organizers: **Steve Benson**, Lesley University
Joe Yanik, Emporia State University
Marilyn Carlson, Arizona State University
Ellen Kirkman, Wake Forest University
Panelists: **Steve Benson**
Tom Dick, Oregon State University
Deborah Hughes Hallett, University of Arizona
Judy Holdner, Kenyon College
Paul Zorn, St. Olaf College

MAA Panel Discussion

2:35 PM – 3:55 PM

Mathematicians and teachers: Professional development and outreach groups.
Organizers: **James King**, University of Washington
Gail Burrill, Michigan State University
Panelists: **Darryl Yong**, Harvey Mudd University
Brian Hopkins, St. Peters College
James King
Harvey Keynes, University of Minnesota
Brynja Kohler, Utah State University

SIGMAA on Mathematical and Computational Biology-SIGMAA on Statistics Education-ASA/MAA Joint Committee on Undergraduate Statistics Panel Discussion

2:35 PM – 3:55 PM

Creating/improving the biomathematics/biostatistics course.
Organizers: **Michael A. Posner**, Villanova University
Raina Robeva, Sweet Briar College
Holly Gaff, Old Dominion University
Panelists: **Pam Ryan**, Truman University
Fred Adler
Laurie Heyer, Davidson College
Deborah Nolan, University of California, Berkeley

AMS Committee on the Profession Panel Discussion

2:45 PM – 4:15 PM

What I wish I had known before applying for a job.

AMS Invited Address

3:20 PM – 4:10 PM

(1137) *Potential Theory meets Geometric Measure Theory.*
Tatiana Toro, University of Washington (1067-31-5)

MAA Session on Journals and Portfolios: Tools in Learning Mathematics?

3:20 PM – 4:15 PM

Organizer: **Sarah L. Mabrouk**, Framingham State University

3:20PM ► (1138) *Learning Logs in College Algebra: A Window to Student Perceptions of Learning Progress and Student Engagement.*
Carrie A Campbell, Lincoln, NE (1067-M1-1916)

3:40PM ► (1139) *Using Journals and Portfolios in a Modern Geometry Course.* Preliminary report.
G Maria Fung, Worcester State University (1067-M1-2263)

4:00PM ► (1140) *Proof Writing and Portfolios in a Bridge Course.*
Penelope Dunham, Muhlenberg College (1067-M1-520)

Joint Prize Session

4:25 PM – 5:25 PM

SIGMAA on Environmental Mathematics Guest Lecture and Business Meeting

5:30 PM – 6:30 PM

5:30PM (1141) *Startling Parallels: Macondo/BP in 2011 and Bhopal/UC in 1984.*
Charles Hadlock, Bentley College

6:00PM Business Meeting.

Joint Prize Session Reception

5:30 PM – 6:30 PM

MAA Reunion for Those Interested in Refocusing College Algebra

5:30 PM – 7:30 PM

Organizer: **Donald B. Small**, U. S. Military Academy

SIGMAA on Research in Undergraduate Mathematics Education Business Meeting

5:45 PM – 6:30 PM

SIGMAA Statistics Education Business Meeting and Reception

5:45 PM – 7:15 PM

MAA Two-Year College Reception

5:45 PM – 7:00 PM

SIGMAA on Mathematical and Computational Biology Business Meeting

6:00 PM – 7:00 PM

SIGMAA on Teaching Advanced High School Mathematics Business Meeting

6:00 PM – 7:00 PM

SIGMAA on Mathematical and Computational Biology Guest Lecture

7:00 PM – 7:45 PM

7:00PM (1142) *The biofluiddynamics of swimming and pumping: Recent insights.*
Lisa Fauci, Tulane University (1067-A0-2432)

Young Mathematicians' Network Open Forum

7:30 PM – 8:30 PM

All meeting participants, including undergraduates and graduate students, are welcome to discuss topics and issues affecting young mathematicians.

Saturday, January 8

Minority Chairs Breakfast

7:00 AM – 8:45 AM

Joint Meetings Registration

7:30 AM – 4:00 PM

AMS-SIAM Special Session on Mathematics of Computation: Algebra and Number Theory, III

8:00 AM – 10:50 AM

Organizers: **Gregor Kemper**, Technische Universität München
Michael J. Mossinghoff, Davidson College
Igor E. Shparlinski, Macquarie University

8:00AM (1143) *Four dimensional algebraic tori.* Preliminary report.
Nicole Marie Lemire, University of Western Ontario (1067-14-1594)

8:30AM (1144) *Families of free hyperplane arrangements.* Preliminary report.
Will Traves* and **Max Wakefield**, U.S. Naval Academy (1067-14-711)

9:00AM ► (1145) *Computations with basic algebras.* Preliminary report.
Jon F. Carlson, University of Georgia (1067-16-372)

9:30AM (1146) *Computing Conjugacy Classes of Elements and Subgroups in Matrix Groups.*
Alexander Joerg Hulpke, Colorado State University (1067-20-147)

10:00AM (1147) *Computing isometry groups of Hermitian maps.*
James B Wilson*, The Ohio State University, and **Peter A Brooksbank**, Bucknell University (1067-20-119)

10:30AM (1148) *Toward Numerical Primary Decomposition.*
Anton Leykin, Georgia Tech (1067-14-1180)

AMS-AWM Special Session on Hopf Algebras and Their Representations, I

8:00 AM – 10:50 AM

Organizers: **M. Susan Montgomery**, University of Southern California
Siu-Hung Ng, Iowa State University
Sarah J. Witherspoon, Texas A&M University

8:00AM (1149) *Right coideal subalgebras of Nichols algebras and the Duflo order of the Weyl groupoid.*
Hans-Juergen Schneider*, Ludwig-Maximilians-Universitaet Muenchen, and **Istvan Heckenberger**, Philipps-Universitaet Marburg (1067-20-1153)

8:30AM (1150) *Conjugacy classes for Hopf algebras.*
Miriam Cohen*, Ben Gurion University, and **Sara Westreich**, Bar Ilan University (1067-16-422)

9:00AM (1151) *Secondary cohomology for Hopf algebras.*
Mihai D. Staic, DePaul University (1067-16-618)

9:30AM (1152) *Classification of isomorphism types of a class of abelian extensions.*
Leonid Krop* and **Yevgenia Kashina**, DePaul University (1067-16-429)

10:00AM (1153) *On classification of certain abelian extensions.* Preliminary report.
Yevgenia Kashina* and **Leonid Krop**, DePaul University (1067-16-2356)

10:30AM (1154) *On Multigraded combinatorial Hopf algebras.*
Samuel K Hsiao, Bard College, and **Gizem Karaali***, Pomona College (1067-16-793)

AMS Special Session on Formal Mathematics for Mathematicians: Developing Large Repositories of Advanced Mathematics, I

8:00 AM – 10:50 AM

Organizers: **Krystyna M. Kuperberg**, Auburn University
Andrzej Trybulec, University of Bialystok
Artur Kornilowicz, University of Bialystok
Adam Naumowicz, University of Bialystok

8:00AM (1155) *The GOEDEL Program.*
Johan G. F. Belinfante, Georgia Institute of Technology (1067-03-724)

8:30AM (1156) *Modules for a Large Library of Formalized Mathematics.* Preliminary report.
William M Farmer, McMaster University (1067-03-1782)

9:00AM (1157) *Automated Reasoning for Mizar.*
Josef Urban, Radboud University Nijmegen (1067-03-860)

9:30AM (1158) *The HOL Light formalization of Euclidean space.*
John R Harrison, Intel Corporation (1067-03-1711)

10:00AM (1159) *Formalization of Lattice Theory in Mizar.*
Adam Grabowski, University of Bialystok, Poland (1067-06-1493)

10:30AM ► (1160) *The Kepler Conjecture after 400 years: from conjecture to formal proof.*
Thomas C. Hales, University of Pittsburgh (1067-03-854)

AMS Special Session on Multivariable Operator Theory, I

8:00 AM – 10:50 AM

Organizers: **Ronald G. Douglas**, Texas A&M University
Gelu F. Popescu, University of Texas at San Antonio

8:00AM (1161) *Canonical Models for Quasi-Free Hilbert Modules.*
Ronald G. Douglas*, Texas A & M University, **Yun-Su Kim**, University of Toledo, **Hyun Kwon**, Seoul National University, and **Jaydeb Sarkar**, University of Texas at San Antonio (1067-47-593)

8:30AM (1162) *Function Theory from Tensor Algebras.* Preliminary report.
Paul S. Muhly*, University of Iowa, and **Baruch Solel**, Technion (1067-47-580)

9:00AM (1163) *Joint Similarity to Operators in Noncommutative Varieties.*
Gelu F Popescu, The University of Texas at San Antonio (1067-47-352)

9:30AM (1164) *BMO Estimates for the $H^\infty(\mathbb{B}_n)$ Corona Problem.*
Serban Costea, Timisoara, Romania, **Eric T. Sawyer**, McMaster University, and **Brett D. Wick***, Georgia Institute of Technology (1067-32-538)

10:00AM (1165) *The c*-envelope of a tensor algebra revisited.* Preliminary report.
Elias Katsoulis, University of Athens, Greece and East Carolina University (1067-47-692)

10:30AM (1166) *Hilbert modules and dilation theory.*
Ronald G. Douglas, Texas A&M university, **Gadadhar Misra**, Indian Institute of Science, India, and **Jaydeb Sarkar***, The University of Texas at San Antonio (1067-47-539)

AMS Special Session on Stochastic Analysis and Mathematical Physics: A Session in Honor of the 80th Birthday of Len Gross, I

8:00 AM – 10:50 AM

Organizers: **Bruce K. Driver**, University of California at San Diego
Maria Gordina, University of Connecticut
Todd Kemp, Massachusetts Institute of Technology and University of California at San Diego

8:00AM (1167) *The space of harmonic sections on noncompact manifolds.*
Nelia Charalambous, Instituto Tecnologico Autonomo de Mexico (1067-58-673)

8:30AM (1168) *Stochastic Completeness and Escape Rate of Brownian Motion on a Riemannian Manifold.*
Elton P Hsu, Northwestern University (1067-60-1648)

9:00AM (1169) *Vanishing of L^2 harmonic one-forms on based path spaces of Riemannian manifolds.*
K. D. Elworthy, University of Warwick. (1067-58-1088)

9:30AM (1170) *A Brownian Motion on the Group of Diffeomorphisms of the Circle.*
Mang Wu, University of California, Riverside (1067-60-1009)

10:00AM (1171) *Another approach to Lie's third theorem in infinite dimensions.*
Maria Gordina, University of Connecticut, **Leonard Gross***, Cornell University, and **S. G. Rajeev**, University of Rochester, Physics (1067-22-1404)

10:30AM (1172) *Heat kernel measures and critical limits.*
Douglas M Pickrell, University of Arizona (1067-46-622)

AMS Special Session on Mathematics Related to Feynman Diagrams, I

8:00 AM – 10:45 AM

Organizers: **Victor H. Moll**, Tulane University
Olivier Espinosa, Universidad Santa Maria, Valparaiso

8:00AM ► (1173) *A symbolic summation approach to Feynman integral calculus.*
Flavia Stan, Tulane University (1067-40-1231)

9:00AM (1174) *Geometrical approach to the evaluation of Feynman diagrams and its application to the epsilon-expansion.* Preliminary report.
Andrei I. Davydychev, Moscow State University (1067-33-2430)

10:00AM (1175) *Patterns in denominators of Feynman integrals.*
Karen A Yeats, Simon Fraser University (1067-05-1274)

AMS Special Session on Completely Integrable Systems, Random Matrices, and the Bispectral Problem, I

8:00 AM – 10:50 AM

Organizers: **Bojko Bakalov**, North Carolina State University
Michael Gekhtman, University of Notre Dame
Plamen Iliev, Georgia Institute of Technology
Milen T. Yakimov, Louisiana State University

8:00AM (1176) *Cluster Expansions, Caustics and Counting Graphs.*
Nicholas M. Ercolani, University of Arizona (1067-05-885)

8:30AM (1177) *Toda lattice hierarchy and noncommutative geometry.*
Thomas Nevins*, University of Illinois at Urbana-Champaign, and **David Ben-Zvi**, University of Texas-Austin (1067-14-875)

9:00AM (1178) *Drinfeld-Sokolov reduction and algebras of chiral differential operators.*
Fyodor Malikov, USC (1067-14-2112)

9:30AM (1179) *Norms of eigenfunctions to trigonometric KZB operators.*
Erik J. Jensen* and **Alexander Varchenko**, University of North Carolina - Chapel Hill (1067-82-1229)

10:00AM (1180) *Liouville integrability of a class of integrable spin Calogero-Moser systems and exponents of simple Lie algebras.*
Luen-Chau Li*, Pennsylvania State University, University Park, and **Zhaohu Nie**, Pennsylvania State University , Altoona Campus (1067-58-1284)

10:30AM (1181) *Bethe subalgebras of the group algebra of the symmetric group.*
Vitaly Tarasov, Indiana University – Purdue University Indianapolis (1067-17-2266)

AMS Special Session on Nonlinear Evolution Equations, Analysis, and Geometry, I

8:00 AM – 10:50 AM

Organizers: **Ralph Saxton**, University of New Orleans
Feride Tiglay, Fields Institute

8:00AM (1182) *On the global solutions of the Higgs boson equation.*
Karen Yagdjian, University of Texas-Pan American (1067-35-786)

8:30AM (1183) *On the well-posedness of Camassa-Holm type equations.*
Alex A. Himonas, University of Notre Dame (1067-35-1778)

9:00AM (1184) *Existence, uniqueness and stability for some models of complex fluids.*
Peter Constantin* and **Weiran Sun**, The University of Chicago (1067-35-962)

9:30AM (1185) *Boundary value problems for the stationary axisymmetric Einstein equations.*
Jonatan Lenells, Baylor University (1067-35-551)

10:00AM (1186) *On the Loss of Regularity for the Three-Dimensional Euler Equations.*
Claude Bardos, Laboratory J.L.Lions, University of Pierre and Marie Curie, and **Edriss S Titi***, The Weizmann Institute of Science and The University of California - Irvine (1067-35-1086)

10:30AM (1187) *On the optimality of two isoperimetrical inequalities for the p-Laplacian.*
Ana Maria Matei, Loyola University New Orleans (1067-58-487)

AMS Special Session on Knots, Links, 3-Manifolds, and Physics, II

8:00 AM – 10:45 AM

Organizers: **Robert Kusner**, University of Massachusetts, Amherst
Rafal Komendarczyk, Tulane University

8:00AM (1188) *Helicity and Energy Bounds For Vector Fields.*
Jason H Cantarella*, University of Georgia, and **Jason Parsley**, Wake Forest University (1067-57-2065)

8:30AM (1189) *New perspectives on helicity.*
Jason Cantarella, University of Georgia, and **Jason Parsley***, Wake Forest University (1067-57-2260)

9:00AM (1190) *The Search for Higher Helicities.*
Clayton Shonkwiler*, Haverford College, **Dennis DeTurck**, **Herman Gluck**, University of Pennsylvania, **Rafal Komendarczyk**, Tulane University, **Paul Melvin**, Bryn Mawr College, and **David Shea Vela-Vick**, Columbia University (1067-57-1502)

9:30AM (1191) *Optimally Immersed Planar Curves under Möbius Energy.*
Ryan P Dunning, St. Mary's University (1067-49-937)

10:00AM (1192) *Self-organization resulting from conservation of magnetic helicity, a distributed form of linkages; applications to lab and solar phenomena.*
Paul M Bellan, Caltech (1067-78-1149)

AMS Special Session on Boundary Control and Moving Interface in Coupled Systems of Partial Differential Equations, II

8:00 AM – 10:50 AM

Organizers: **Lorena Bociu**, University of Nebraska-Lincoln
Jean-Paul Zolesio, CNRS-INLN and INRIA, Sophia Antipolis, France

8:00AM (1193) *Finite-dimensional attractor for a structural-acoustic system with a localized feedback control.*
Daniel Y Toundykov, University of Nebraska-Lincoln (1067-35-852)

8:30AM (1194) *Nonhomogeneous boundary value problems for non-stationary compressible Navier-Stokes equations and work minimization.*
Jan Sokolowski*, Institut Elie Cartan, UMR 7502, and **P.I. Plotnikov**, Lavryentyev Institute of Hydrodynamics, Siberian Division of Russian Academy of Sciences (1067-35-1590)

9:00AM (1195) *Morrey regularity for almost minimizers of nonconvex functionals with $p(x)$ growth.*
Kyle W. Fey* and **Mikil Foss**, University of Nebraska - Lincoln (1067-49-858)

9:30AM (1196) *Electrical impedance tonography: From topology to shape.*
Michael Hintermueller, University of Graz, Austria (1067-35-2159)

10:00AM (1197) *Global Well-posedness for Systems of Nonlinear Wave Equations with Supercritical Boundary and Interior Sources.*
Mohammad A. Rammaha* and **Yanqiu Guo**, University of Nebraska- Lincoln (1067-35-1041)

10:30AM (1198) *The Optimal Interior Regularity for the Critical Case of a Clamped Thermoelastic System with Point Control.*
Catherine G Lebiedzik, Wayne State University (1067-35-1511)

AMS Special Session on Self-Organization in Human, Biological, and Artificial Systems, I

8:00 AM – 10:50 AM

Organizer: **Andrea L. Bertozzi**, University of California Los Angeles

8:00AM (1199) *Explicit results for the swarm aggregation model in any dimension.*
Theodore Kolokolnikov, Dalhousie University (1067-00-1397)

► 8:30AM (1200) *Limiting PDEs for Social Dynamics.* Preliminary report.
Alethea Barbaro, UCLA (1067-92-655)

9:00AM (1201) *Local Well-Posedness and Blow-up Results for an Aggregation Equations and Patlak-Keller-Segel Models with Degenerate Diffusion.*
Nancy Rodriguez, UCLA (1067-35-620)

9:30AM (1202) *Global existence for aggregation equations and Patlak-Keller-Segel models with degenerate diffusion.*
Jacob Philip Bedrossian, University of California, Los Angeles (1067-35-1393)

10:00AM (1203) *Nonlocal PDE models for self-organization of biological groups.*
Razvan C. Fetecau*, Simon Fraser University, and **Raluca Eftimie**, McMaster University (1067-35-604)

10:30AM (1204) *Characterization of radially symmetric finite time blowup in multidimensional aggregation equations.*
Andrea Bertozzi, **John Garnett**, UCLA, and **Thomas Laurent***, University of California, Riverside (1067-35-606)

AMS Special Session on Harmonic Analysis and Partial Differential Equations, I

8:00 AM – 10:50 AM

Organizers: **Svitlana Mayboroda**, Purdue University
Tatiana Toro, University of Washington

8:00AM (1205) *Topics in quasi-metric geometry.*
Irina Mitrea, Institute for Mathematics and its Applications, University of Minnesota (1067-00-1866)

8:30AM (1206) *Sharp weighted norm inequalities for classical operators.*
David V. Cruz-Uribe*, Trinity College, **José María Martell**, Instituto de Ciencias Matematicas CSIC-UAM-UC3M-UCM, and **Carlos Pérez**, Universidad de Sevilla (1067-42-2102)

9:00AM (1207) *The linear bound in A_2 characteristic for Calderon-Zygmund operators.*
Michael T. Lacey, Georgia Institute of Technology (1067-42-475)

9:30AM (1208) *On Muckenhoupt-Wheeden Conjecture.*
Maria Carmen Reguera, Georgia Institute of Technology (1067-42-1668)

10:00AM (1209) *Geometric discrepancy and lattice constructions.*
Dmitriy Bilyk, U. of South Carolina, **Xiaomin Ma**, **Jill Pipher***, Brown University, and **Craig Spencer**, Kansas State University (1067-42-1759)

10:30AM (1210) *Sobolev estimates for an FIO calculus associated to marine seismic imaging.*
Raluca Felea, Rochester Institute of Technology, New York, **Allan Greenleaf**, University of Rochester, New York, and **Malabika Pramanik***, University of British Columbia, Vancouver (1067-26-1725)

AMS Special Session on Groups, Geometry, and Applications, II

8:00 AM – 10:50 AM

Organizer: **Delaram Kahrobaei**, City University of New York

8:00AM ► (1211) *Generating random braids.*
Juan Gonzalez-Meneses, Universidad de Sevilla (1067-20-462)

8:30AM (1212) *Dehn functions and finiteness properties of subgroups of CAT(0) groups.*
Noel P. Brady*, **Dan P. Guralnik** and **Sang Rae Lee**, University of Oklahoma (1067-20-1640)

9:30AM (1213) *Divergence in right-angled Artin groups.*
Jason Behrstock, Lehman College, CUNY, and **Ruth Charney***, Brandeis University (1067-20-1127)

10:30AM (1214) *Enumerating Primitives and Palindromes in Rank Two Free Groups.*
Jane Gilman*, Rutgers University, Newark, and **Linda Keen**, Lehman College, CUNY and Graduate Center (1067-20-338)

AMS Special Session on New Topics in Graph Theory, I

8:00 AM – 10:50 AM

Organizers: **Ralucca Gera**, Naval Postgraduate School
Eunjeong Yi, Texas A&M University at Galveston

8:00AM ► (1215) *Functigraphs: A Generalization of Permutation Graphs.*
Ralucca M Gera*, Naval Postgraduate School, **Andrew Chen**, Minnesota State University Moorhead, **Daniela Ferrero**, Texas State University, San Marcos, and **Eunjeong Yi**, Texas A&M University at Galveston (1067-05-2007)

8:30AM ► (1216) *Toward a language theoretic proof of the four color theorem.*
Bobbe J. Cooper, University of Minnesota, **Eric S. Rowland***, Tulane University, and **Doron Zeilberger**, Rutgers University (1067-05-84)

9:00AM (1217) *The Independence and Annihilation Numbers.*
Craig Eric Larson*, Virginia Commonwealth University, and **Ryan Pepper**, University of Houston - Downtown (1067-05-1010)

9:30AM ► (1218) *Steinberg's Conjecture on Higher Surfaces.*
Carl R Yerger*, Davidson College, and **Robin Thomas**, Georgia Institute of Technology (1067-05-687)

10:00AM ► (1219) *Large 1-factorizable subgraphs.*
Tyler Seacrest* and **Stephen G. Hartke**, University of Nebraska - Lincoln (1067-05-43)

10:30AM ► (1220) *On extremal graphs with a given number of perfect matchings.* Preliminary report.
Stephen G Hartke, **Derrick Stolee***, University of Nebraska-Lincoln, **Douglas B West** and **Matthew Yancey**, University of Illinois Urbana-Champaign (1067-05-917)

AMS Session on Algebraic Topology and Global Analysis

8:00 AM – 10:55 AM

8:00AM (1221) *The role of free Lie algebras in the Taylor tower of Γ-modules.* Preliminary report.
Dan Lior, University of Illinois (1067-55-2325)

8:15AM (1222) *Applications of our generalized result of C. T. C Wall´s suspension theorem.*
Mokhtar Aouina, Jackson State University (1067-55-1365)

8:30AM ► (1223) *The fundamental group as topological group.*
Jeremy T Brazas, University of New Hampshire (1067-55-1394)

8:45AM (1224) *Mixed Coxeter Systems.*
J Kyle Armstrong, Florida State University (1067-55-2133)

9:00AM (1225) *The homotopy type of the complement of an arrangement of hyperplanes.*
Kris J Williams, University of Iowa (1067-55-1030)

9:15AM (1226) *A Finite Dimensional L_∞ Module.*
Michael P Allocca, University of Scranton (1067-55-1664)

9:30AM (1227) *Asymptotics of minimal dilatation pseudo-Anosov mapping classes on rays in the gn-plane.* **Aaron David Valdivia**, Florida State University (1067-55-1342)

9:45AM (1228) *Comparing Kac-Moody Groups over $\mathbb{C}$ and Finite Fields via Homotopy Theory.* **John D Foley**, University of California at San Diego (1067-22-2171)

10:00AM (1229) *Bi-Lipschitz embeddability of the Grushin plane into Euclidean space.* **Jeehyeon Seo**, University of Illinois at Urbana Champaign (1067-58-558)

10:15AM (1230) *String structures and loop spaces.* Preliminary report. **Corbett Redden**, Michigan State University (1067-58-953)

10:30AM (1231) *A Generalization of the Fujisawa-Kuh Global Inversion Theorem.* Preliminary report. **E Cabral Balreira**, Trinity University (1067-58-1113)

10:45AM (1232) *Definition of the Cycle Space of Orbits of Semi-simple Lie Groups acting on Flag Manifolds.* **B. Ntatin**, Austin Peay State University (1067-58-1518)

AMS Session on Mathematical Biology and Ecology, III

8:00 AM – 10:55 AM

8:00AM (1233) *The effect of co-colonization with community-acquired and hospital-acquired methicillin-resistant* Staphylococcus aureus strains on competitive exclusion. **Joanna Pressley***, Vanderbilt University, **Erika M. C. D'Agata**, Beth Israel Deaconess Medical Center, and **Glenn F. Webb**, Vanderbilt University (1067-92-1388)

8:15AM (1234) *An Optimal Control Mathematical Model for Photoreceptor Interactions.* **E. T. Camacho**, Arizona State University, **L. A. Melara***, Shippensburg University, **M. C. Villalobos**, The University of Texas - Pan American, and **S. Wirkus**, Arizona State University (1067-92-1814)

8:30AM (1235) *Blood Vessel Segmentation in Volumetric Ultrasound.* **Jue Wang***, Union College, and **Yongjian Yu**, InfiMed Inc. (1067-92-1810)

8:45AM (1236) *Prelens Tear Film Evaporation from a Porous Layer.* **Amber C Xu**, Carnegie Mellon University (1067-92-2332)

9:00AM ► (1237) *Modeling, Analysis and Outbreak Risk of Vancomycin-Resistant Enterococci.* Preliminary report. **Mohammed Yahdi***, **Sara Abdelmageed**, Ursinus College, **Jon Lowden**, California University of Pennsylvania, and **Lloyd Tannenbaum**, Ursinus College (1067-92-2381)

9:15AM ► (1238) *Predictions of tumor morphological stability and evaluation against experimental observations.* **Kara T Pham***, **Hermann B Frieboes**, University of California, Irvine, **Vittorio Cristini**, University of Texas, Austin, and **John Lowengrub**, University of California, Irvine (1067-92-2303)

9:30AM (1239) *Computational fluid dynamic simulation to assess flow characteristics of an in vitro aneurysm model.* **Dawn Alisha Lott***, Delaware State University, **Charles J Prestigiacomo**, University of Medicine and Dentistry of New Jersey, **Hans R Chaudhry**, War-Related Illness and Injury Center and New Jersey Institute of Technology, and **Michael Siegel**, New Jersey Institute of Technology (1067-92-748)

9:45AM ► (1240) *Effect of Arterial Geometry on Stresses in Intracranial Aneurysms.* Preliminary report. **Lisa Melanson**, Northwestern University (1067-92-1683)

10:00AM ► (1241) *Model and Simulation of Red Blood Cell Dynamics in Patients with Chronic Kidney Disease.* Preliminary report. **Karen M. Bliss**, North Carolina State University (1067-92-1163)

10:15AM ► (1242) *A Mathematical Model for Active Transport of Gag Protein in the Cytoplasm.* Preliminary report. **Roberto Munoz-Alicea**, Colorado State University, Fort Collins (1067-92-365)

10:30AM (1243) *General stability analysis 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 (1067-92-1474)

10:45AM ► (1244) *A Mathematical Model of the Effects of Antioxidants on Atherosclerotic Lesion Growth.* **Hayley M Belli***, University of Oregon, **Jay R Walton** and **May Boggess**, Texas A&M University (1067-92-141)

MAA Session on New and Continuing Connections between Math and the Arts, I

8:00 AM – 10:55 AM

Organizer: **Douglas E. Norton**, Villanova University

8:00AM ► (1245) *Sequences, Series, Combinatorics, and Probability in the Early Plate Work of Jennifer Bartlett.* **Mary L Garner**, Kennesaw State University (1067-S1-2302)

8:20AM ► (1246) *Hyperbolic Planes Take Off!* **Vi Hart**, vihart.com (1067-S1-1164)

8:40AM ► (1247) *Tilings of hyperbolic space and their visualization.* Preliminary report. **Vladimir L Bulatov**, Corvallis, OR (1067-S1-1691)

9:00AM ► (1248) *Glide Reflections as a Cultural and Artistic Value.* Preliminary report. **Darrah P. Chavey**, Beloit College (1067-S1-2347)

9:20AM ► (1249) *Flash-y Pictures: Go with the Flow.* Preliminary report. **Anne Burns**, Long Island University, C.W. Post Campus (1067-S1-508)

9:40AM ► (1250) *A Workshop in Geometric Constructions of Mosaic Designs.* **Reza Sarhangi**, Towson University (1067-S1-219)

10:00AM ► (1251) *Islamic decorations and wallpaper groups.* **Frode Ronning**, Sor-Trondelag University College (1067-S1-247)

10:20AM ► (1252) *Art at the Museum of Mathematics.* **George W. Hart**, Museum of Mathematics (1067-S1-2228)

10:40AM ► (1253) *Photographic Fractal Trees.* **Robert W. Fathauer**, Tessellations Company (1067-S1-1692)

MAA Session on Mathematics Experiences in Business, Industry, and Government

8:00 AM – 10:55 AM

Organizers: **Carla D. Martin**, James Madison University
Philip E. Gustafson, Mesa State College

Michael Monticino, University of North Texas

8:00AM ► (1254) *Bayesian Inference for Rapid Social Networking Analysis.*
Timothy D Andersen* and **C Allen Butler**, Daniel H. Wagner Associates Inc. (1067-O1-2022)

8:20AM ► (1255) *Updates on a New Green's Function Code for Radiation Transport.*
Candice Rockell Gerstner* and **John Tweed**, Old Dominion University (1067-O1-713)

8:40AM ► (1256) *Patterns in criminal offender distance decay.*
Mike P O'Leary, Towson University (1067-O1-1318)

9:00AM ► (1257) *The US blood supply, bioterrorism and mathematics.*
Sonja Sandberg*, Framingham State University, and **Steven Anderson**, FDA (1067-O1-2087)

9:20AM (1258) *Building Models and a Methodology for Using Technologies to Detect Suicide Bombers.*
William P. Fox*, **Michael Minutas** and **John Binstock**, Naval Postgraduate School (1067-O1-562)

9:40AM ► (1259) *Estimation of Black Globe Temperature for Calculation of the WBGT Index.* Preliminary report.
Vincent E Dimiceli*, Oral Roberts University, and **Steven F Piltz**, National Weather Service, Tulsa, OK (1067-O1-1401)

10:00AM ► (1260) *The Strategic Use of Analytics in Government Is A Powerful Resource In Achieving Federal Missions.*
Carl L Moravitz, IBM Global Business Services, Performance Management and Analytics (1067-O1-1407)

10:20AM ► (1261) *Improving the performance of open-ended mathematics questions.*
James H Fife, Educational Testing Service (1067-O1-439)

10:40AM (1262) *Math in the City: A hands-on learning experience in mathematical modeling.*
Petronela Radu* and **Stephen Hartke**, University of Nebraska-Lincoln (1067-O1-129)

MAA Session on Fostering, Supporting, and Propagating Math Circles for Students and Teachers, II

8:00 AM – 10:55 AM

Organizers: **Tatiana Shubin**, San Jose State University
Elgin H. Johnston, Iowa State University
James Tanton, St. Mark's Institute of Mathematics

8:00AM ► (1263) *Texas A&M Summer Educational Enrichment (SEE-Math) for Middle School Students: Organization and Technology.*
Philip B Yasskin, Texas A&M University (1067-F1-2003)

8:20AM ► (1264) *A Tale of Two Circles.*
Nathan A. Carlson, California Lutheran University (1067-F1-1363)

8:40AM ► (1265) *Gnomons at the Teacher Circle.*
Jeffery T. McLean, University of St. Thomas (1067-F1-973)

9:00AM Discussion.

9:20AM ► (1266) *Math Circles along the Hudson River: from New York City to Albany.*
Japheth Wood, Bard College (1067-F1-2353)

9:40AM ► (1267) *San Francisco Math Circle (SFMC) Mathematics and Community Attitudes Survey and Evaluation Tool.* Preliminary report.
Brandy S Wiegers*, Mathematical Sciences Research Institute, and **Yuan-Juang Yvonne Lai**, University of Michigan, Ann Arbor (1067-F1-2399)

10:00AM ► (1268) *Yielding the Floor: Student-Driven Math Circles.*
Sam Vandervelde, St. Lawrence University (1067-F1-1658)

10:20AM ► (1269) *Problem solving paradigms for mathematical research.* Preliminary report.
Ted Theodosopoulos, Saint Ann's School (1067-F1-2188)

10:40AM ► (1270) *Math Circles Library.* Preliminary report.
Tatiana Shubin, San Jose State University (1067-F1-2251)

MAA General Contributed Paper Session, VII

8:00 AM – 10:55 AM

Organizers: **Kristen Meyer**, Wisconsin Lutheran College
Thomas R. Hagedorn, The College of New Jersey

8:00AM ► (1271) *Paper Homework or Online Homework?* Preliminary report.
Dai Jialing, The University of the Pacific (1067-Z1-2200)

8:15AM ► (1272) *Closing the Gap Between Learners' and Instructors' Expectations.* Preliminary report.
Laura J Schmidt* and **Joy L Becker**, University of Wisconsin-Stout (1067-Z1-1353)

8:30AM (1273) *Improving College Mathematics Teaching Through Faculty Development.*
Hilary Fletcher*, **Alex Heidenberg** and **Gerald Kobylski**, United States Military Academy (1067-Z1-1551)

8:45AM ► (1274) *The Quill Chart: Sensitizing Faculty to End-of-Term Stresses.*
E. Lee May, Jr., Salisbury University (1067-Z1-319)

9:00AM (1275) *Getting Back Home: Student Meaning-Making in Linear Algebra.*
George F. Sweeney, San Diego State University/UCSD (1067-Z1-2008)

9:15AM ► (1276) *An investigation of student discovery of the concept of eigenvector in the context of 2-D linear vector fields.* Preliminary report.
Robert L. Sachs, George Mason University (1067-Z1-1642)

9:30AM ► (1277) *An Introductory Computational Thinking Sequence for Science Majors.* Preliminary report.
Christopher M Kuster* and **John C Symms**, Carroll University (1067-Z1-535)

9:45AM ► (1278) *Assessing the Effects of Application of Cognitive Load Theory in the Teaching and Learning of Undergraduate Mathematics.*
Jerry C. Obiekwe, The University of Akron-Wayne College (1067-Z1-644)

10:00AM ► (1279) *Mental Mathematics as a Game: Historical Foundations Applied to Today's Classroom.*
Elizabeth C. Rogers*, **A Poole James** and **Elizabeth L. Poole**, Piedmont College (1067-Z1-2418)

10:15AM ► (1280) *Can Mathematics Be Taught? Revisiting Carl Linderholm's "Mathematics Made Difficult".*
John C Mayer, University of Alabama at Birmingham (1067-Z1-1371)

10:30AM ► (1281) *Explorations that enhance student understanding of limits and derivatives.*
Ken M Collins, Charlotte Latin School (1067-Z1-401)

10:45AM ► (1282) *Redesign of Calculus 2.* Preliminary report.
Kyle Riley, South Dakota School of Mines & Technology (1067-Z1-1893)

MAA General Contributed Paper Session, VIII

8:00 AM – 10:55 AM

Organizers: **Kristen Meyer**, Wisconsin Lutheran College
Thomas R. Hagedorn, The College of New Jersey

8:00AM (1283) *Using Steiner designs to construct entanglement-assisted quantum error-correcting codes.*
David Clark, Michigan Technological University (1067-Z1-1635)

8:15AM ► (1284) *Cryptology with Mathematica.* Preliminary report.
Thawda Aung, Randolph College (1067-Z1-2187)

8:30AM ► (1285) *Simulating a Verbal Translation of the Navajo Code; a Completed Version.* Preliminary report.
Rick E. Klima*, Appalachian State University, and **Neil P. Sigmon**, Radford University (1067-Z1-648)

8:45AM ► (1286) *Braid group cryptography and some related computational problems.*
Imre Tuba*, San Diego State University, Imperial Valley, and **Jonathan Boiser**, University of California, Merced (1067-Z1-2402)

9:00AM (1287) *An Infinite Collection of Quasi-Isometrically Distinct Graph Braid Groups.*
Praphat Xavier Fernandes, Emory University (1067-Z1-1508)

9:15AM ► (1288) *Families of proofs that the prime numbers are infinite.* Preliminary report.
J Marshall Ash* and **T. Kyle Petersen**, DePaul University (1067-Z1-862)

9:30AM ► (1289) *Some Prime Curiosities.* Preliminary report.
Jay L. Schiffman, Rowan University (1067-Z1-46)

9:45AM ► (1290) *Permutations and Ladders.*
Jennifer Franko Vasquez* and **Steven T. Dougherty**, The University of Scranton (1067-Z1-2090)

10:00AM (1291) *Patterns for Permutations with Fixed Points.*
Amy Mihnea, Florida Atlantic University (1067-Z1-1807)

10:15AM ► (1292) *Palindromic Curiosities.* Preliminary report.
G. Joseph Wimbish, Daytona State College (1067-Z1-69)

10:30AM (1293) *Introduction to Abstract Algebra Based on Computational Algebra with Applications Drawn from Biology.*
Kapila Rohan Attele*, **Dan Hrozencik** and **Victor Akatsa**, Chicago State University (1067-Z1-1073)

10:45AM ► (1294) *Interpolation and remainders: two formulas that are really the same.*
Ezra A. Brown, Virginia Tech (1067-Z1-482)

AWM Hay Minisymposium

8:00 AM – 11:00 AM

Organizers: **Cathy Kessel**, Education Consultant
W. James Lewis, University of Nebraska-Lincoln

8:00AM ► (1295) *Mathematics, Educational Research, and STEM Education Policy: Challenges and Opportunities in the Intersection.*
Joan Ferrini-Mundy, National Science Foundation and Michigan State University (1067-97-2203)

8:30AM ► (1296) *Addressing Challenges in the Common Core: Mathematics Specialists in Elementary and Middle Schools.* Preliminary report.
Patricia F Campbell, University of Maryland (1067-97-1622)

9:00AM ► (1297) *The Role of Logic in the K-12 Mathematics Curriculum.*
Susanna S Epp, DePaul University (1067-97-2152)

9:30AM ► (1298) *The Power of Interdisciplinary Bridges: Throwing the Net Widely.*
Deborah Hughes Hallett, University of Arizona/Harvard Kennedy School (1067-97-1237)

10:00AM Panel Discussion: The Mathematical Education of Teachers and the Common Core.

PME Council Meeting

8:00 AM – 11:00 AM

Employment Center

8:00 AM – 7:00 PM

AMS Session on General Topology

8:30 AM – 10:55 AM

8:30AM (1299) *The period set of a map from the Cantor set to itself.*
James Cannon, Brigham Young University, **Mark Meilstrup***, University of Leoben, and **Andreas Zastrow**, University of Gdansk (1067-37-1881)

8:45AM (1300) *Inversible Fibrations.* Preliminary report.
Nigar Tuncer, Okan University (1067-54-1895)

9:00AM (1301) *The Uniform Box Product Problem.*
Scott W Williams* and **Jocelyn R Bell**, SUNY at Buffalo (1067-54-760)

9:15AM (1302) *Normality of Uniform Box Products.*
Jocelyn R Bell, SUNY at Buffalo (1067-54-982)

9:30AM (1303) *A Generalization of Scattered spaces.*
Mehrdad Namdari, Shahid Chamran University (1067-54-1854)

9:45AM (1304) *Extensions of Tychonoff theorem in Hausdorff compactifications and generalized Stone-Weierstrass theorem.*
Hueytzen J Wu*, Texas A & M University - Kingsville, and **Wan-Hong Wu**, UT Health Science Center - San Antonio, Texas (1067-54-574)

10:00AM (1305) *The Number of Minimal Left and Minimal Right Ideals in βS.* Preliminary report.
Neil Hindman, Howard University, Washington, DC, **Lakeshia R. Legette***, Johnson C. Smith University, and **Dona Strauss**, University of Leeds (1067-54-823)

10:15AM (1306) *On nonseparable Erdős type spaces.*
Jan J. Dijkstra, Vrije Universiteit Amsterdam, and **Kirsten I. S. Valkenburg***, University of Saskatchewan (1067-54-901)

10:30AM (1307) *The Topological Structure of the Unit Octonions and the Quantum Theory of Games.*
Aden O Ahmed, Texas A&M University - Kingsville (1067-54-1385)

10:45AM ► (1308) *The Advent of Point-Set Topology.* Preliminary report.
Nick Scoville, Ursinus College (1067-54-598)

AMS Session on History of Mathematics

8:30 AM – 10:40 AM

8:30AM *Relative Accuracy of Quadrilateral Area*
► (1309) *Measurement in the Ancient World.* Preliminary report.
Erik R. Tou, Carthage College (1067-01-1344)

8:45AM *Mathematician's Trio.* Preliminary report.
► (1310) **M. Moazzam**, Salisbury University (1067-01-918)

9:00AM *The mathematics of Al-Biruni.*
► (1311) **Morteza Seddighin**, Indiana University East (1067-01-1109)

9:15AM *Early American Presidents' Mathematical Interests.*
► (1312) **Andrew B Perry**, Springfield College (MA) (1067-01-1366)

9:30AM *Examples of Early 1900 Mathematics Secondary*
(1313) *Mathematics.*
Matthew J Haines, Augsburg College, MN (1067-01-1857)

9:45AM *Euler's Rettung: Euler's anonymous work on the*
► (1314) *limits of mathematics, science, and faith.*
Dominic W Klyve, Central Washington University (1067-01-1471)

10:00AM *Euler's proof that every prime of the form* $4n+1$ *is*
► (1315) *sum of two squares.*
Paul R. Bialek, Trinity International University (1067-01-2392)

10:15AM *Neither Positive nor Negative nor yet Null numbers:*
(1316) *Analogy in William Rowan Hamilton's Argument for imaginary numbers.*
Maritza M. Branker*, Niagara University, and **Joseph J. Little**, Department of English, Niagara University (1067-01-26)

10:30AM *Felix Hausdorff: Mathematician, Poet, and*
► (1317) *Playwright.* Preliminary report.
Charlotte K. Simmons* and **Jesse W. Byrne**, University of Central Oklahoma (1067-01-2343)

SIAM Minisymposium on Education

8:30 AM – 10:55 AM

Organizer: **Peter Turner**, Clarkson University

8:30AM *Applied Mathematics and High School Outreach:*
► (1318) *Opportunities and Resources.*
Peter R Turner, Clarkson University (1067-97-1001)

9:00AM *Outreach Activities in Mathematical Biology.*
► (1319) **Suzanne Lenhart***, University of Tennessee, and **Sarah Duncan**, University of Alabama (1067-92-1140)

9:30AM *Math Modeling for Middle School Students.*
► (1320) **Katie R Fowler*** and **Aaron Luttman**, Clarkson University (1067-97-1278)

10:00AM *Using Disease Models to Develop Teacher's*
(1321) *Understanding of Modeling.*
Tracie McLemore Salinas* and **Rene A. Salinas**, Appalachian State University (1067-92-2056)

10:30AM *Math Modeling for high school students: Moody's*
► (1322) *Mega Math Challenge as educational outreach.*
Michelle J Montgomery, SIAM (1067-97-1548)

AMS-MAA Graduate Student Fair

8:30 AM – 10:30 AM

Undergrads! Take this opportunity to meet representatives from mathematical science graduate programs.

MAA Retiring Presidential Address

9:00 AM – 9:50 AM

(1323) *Issues of the transition to college mathematics.*
David M. Bressoud, Macalester College (1067-A0-36)

ASL Invited Address

9:00 AM – 9:50 AM

(1324) *Final coalgebras: A survey.*
Larry Moss, Indiana University (1067-03-64)

MAA Invited Paper Session on Fish Tales: Stories from Mathematical Fluid Dynamics

9:00 AM – 10:50 AM

Organizer: **Katherine Socha**, St. Mary's College of Maryland

9:00AM *Langmuir Layers: Exploring a (nearly)*
► (1325) *Two-dimensional Fluid Experiment.*
Andrew J. Bernoff, Harvey Mudd College (1067-AE-1602)

9:30AM *An economical micro-submarine testbed for*
► (1326) *validation of 3D cooperative control strategies for underwater robots.*
Rachel Levy* and **Students from DYNAR Research Group**, Harvey Mudd College (1067-AE-1672)

10:00AM *How jellyfish can inspire mathematics: A case study*
(1327) *of the feeding currents generated by upside-down jellyfish.*
Laura A Miller*, **Christina Hamlet**, University of North Carolina at Chapel Hill, and **Arvind Santhanakrishnan**, Georgia Institute of Technology (1067-AE-1022)

10:30AM *Hydrodynamics and pattern formation.* Preliminary
(1328) report.
Keith Mertens, UNC Chapel Hill (1067-AE-2417)

MAA Minicourse #4: Part B

9:00 AM – 11:00 AM

Getting students involved in undergraduate research.

Organizers: **Aparna W. Higgins**, University of Dayton
Joseph A. Gallian, University of Minnesota-Duluth

MAA Minicourse #7: Part B

9:00 AM – 11:00 AM

The mathematics of Islam and its use in the teaching of mathematics.

Organizer: **Victor J. Katz**, University of the District of Columbia

MAA Minicourse: #8: Part B

9:00 AM – 11:00 AM

The ubiquitous Catalan numbers and their applications.

Organizer: **Thomas Koshy**, Framingham State University

MAA Panel Discussion

9:00 AM – 10:20 AM

Utilizing NSF ADVANCE to promote the success of women faculty in mathematics.
Organizer: **Jenna Carpenter**, Louisiana Tech University
Panelists: **Judith Silver**, Marshall University
Brooke Shipley, University of Illinois at Chicago
Brenda Johnson, Union College
Jenna Carpenter

MAA Panel Discussion

9:00 AM – 10:20 AM

The benefits of hosting a regional undergraduate mathematics conference
Organizers: **Doug Faires**, Youngstown State University
Panelists: **Doug Faires**
Kendra Kilpatrick, Pepperdine University
Laura Taalman, James Madison University
Nathan Gibson, Oregon State University

Student Hospitality Center

9:00 AM – 5:00 PM

Exhibits and Book Sales

9:30 AM – 5:30 PM

ASL Invited Address

10:00 AM – 10:50 AM

(1329) *Independence results in the model theory of infinitary logics.*
Monica VanDieren, Robert Morris University (1067-03-68)

AWM Hay Minisymposium Panel Discussion

10:00 AM – 11:00 AM

The mathematical education of teachers and the common core.
Moderator: **W. James Lewis**, University of Nebraska-Lincoln
Panelists: **Phyllis Chinn**, Humboldt State University
Harriet Pollatsek, Mount Holyoke College
Annie Selden, New Mexico State University
Martha Smith, University of Texas at Austin

AMS Invited Address

10:05 AM – 10:55 AM

(1330) *Modular forms and the topology of certain hyperbolic 3-manifolds.*
Akshay Venkatesh, Stanford University (1067-11-11)

AMS-MAA Invited Address

11:10 AM – NOON

(1331) *The Riemann zeta-function and related L-functions: A progress report.*
Kannan Soundararajan, Stanford University

MAA Lecture for Students

1:00 PM – 1:50 PM

► (1332) *Turning theorems into plays.*
Steve Abbott, Middlebury College (1067-A0-34)
2:00PM Come and meet the speaker in the Student Hospitality Lounge, Gallier Room, 4th Floor, Sheraton.

AMS Current Events Bulletin

1:00 PM – 4:45 PM

Organizer: **David Eisenbud**, University of California, Berkeley
1:00PM (1333) *Khot's Unique Games Conjecture: its consequences and the evidence for and against.*
Luca Trevisan, Stanford (1067-68-1706)
2:00PM (1334) *Counting special points: logic, Diophantine geometry and transcendence theory.*
Thomas Warren Scanlon, University of California, Berkeley (1067-03-2144)
3:00PM (1335) *Spaces of graphs and surfaces - On the work of Soren Galatius.*
Ulrike Tillmann, Oxford University (1067-57-2406)
4:00PM (1336) *The Geometric Nature of the Fundamental Lemma.*
David E Nadler, Northwestern (1067-22-434)

AMS-AWM Special Session on Hopf Algebras and Their Representations, II

1:00 PM – 5:50 PM

Organizers: **M. Susan Montgomery**, University of Southern California
Siu-Hung Ng, Iowa State University
Sarah J. Witherspoon, Texas A&M University
1:00PM (1337) *A Freeness Result Revisited.* Preliminary report.
David E. Radford, U. of Illinios at Chicago (1067-16-1849)
1:30PM ► (1338) *Hopf algebras of small dimension.* Preliminary report.
Margaret Beattie, Mount Allison University (1067-16-1322)
2:00PM (1339) *The Central Charge of Factorizable Hopf Algebras coming from Bilinear Forms.* Preliminary report.
Yorck Sommerhaeuser, University of South Alabama (1067-16-2184)
2:30PM (1340) *A q-identity related to a comodule.*
Andrea Jedwab* and **Susan Montgomery**, University of Southern California (1067-16-1064)

3:00PM (1341) *The Lie product in the continuous Lie dual of the Witt algebra.*
Earl J. Taft*, Rutgers University, and **Zhifeng Hao**, South China University of Technology (1067-17-212)

3:30PM (1342) *Indicators for the Drinfel'd doubles of certain groups.*
Marc Keilberg, University of California San Diego (1067-16-1876)

4:00PM (1343) *Drinfeld centers of graded fusion categories.*
Shlomo Gelaki, Technion-Israel Institute of Technology, **Deepak Naidu***, Texas A&M University, and **Dmitri Nikshych**, University of New Hampshire (1067-00-465)

4:30PM ► (1344) *Fusion categories of dimension pq^2.*
David A Jordan*, Massachusetts Institute of Technology, and **Eric Larson**, Harvard University (1067-18-1455)

5:00PM (1345) *Cocycle deformations, calculus, and extensions.*
Mitja Mastnak, Saint Mary's University (1067-16-1258)

5:30PM (1346) *Hopf algebraic approach to Picard-Vessiot theory.* Preliminary report.
Akira Masuoka, University of Tsukuba (1067-16-891)

AMS Special Session on Stochastic Analysis and Mathematical Physics: A Session in Honor of the 80th Birthday of Len Gross, II

1:00 PM – 5:50 PM

Organizers: **Bruce K. Driver**, University of California at San Diego
Maria Gordina, University of Connecticut
Todd Kemp, Massachusetts Institute of Technology and University of California at San Diego

1:00PM (1347) *Boundary conditions for the Ricci flow.*
Artem Pulemotov, The University of Chicago (1067-53-765)

1:30PM (1348) *Smoothness of Density for the Area Process of Fractional Brownian Motion.* Preliminary report.
Patrick R Driscoll, University of California, San Diego (1067-60-1573)

2:00PM (1349) *Hypoelliptic heat kernel inequalities on H-type groups.*
Nathaniel Eldredge, Cornell University (1067-58-1425)

2:30PM (1350) *Dimension-independent results on heat kernels.* Preliminary report.
Brian C. Hall* and **Matt Cecil**, University of Notre Dame (1067-46-1049)

3:00PM (1351) *From Dimension-independent Heat Kernel Estimates to Exceptional Sets.* Preliminary report.
Matthew Cecil* and **Brian Hall**, University of Notre Dame (1067-46-1604)

3:30PM (1352) *Heat kernel measures on a class of infinite dimensional Lie groups.*
Tai Melcher, University of Virginia (1067-60-1587)

4:00PM (1353) *Restriction principles in Segal-Bargmann analysis associated to a Coxeter group.*
Stephen Bruce Sontz, CIMAT, Guanajuato, Mexico (1067-81-707)

4:30PM (1354) *Bargmann–Segal space, generalized functions and Feynman–Kac formula.* Preliminary report.
Martin Grothaus, University of Kaiserslautern (1067-46-736)

5:00PM (1355) *The L^p norm of the Segal-Bargmann Transform.*
William E Gryc*, Muhlenberg College, and **Todd Kemp**, University of California, San Diego (1067-44-340)

5:30PM (1356) *A stochastic integral for adapted and instantly independent stochastic processes.*
Hui-Hsiung Kuo*, **Anuwat Sae-Tang** and **Benedykt Szozda**, Louisiana State University (1067-60-890)

AMS Special Session on Lie Algebras, Algebraic Groups, and Related Topics, II

1:00 PM – 5:50 PM

Organizers: **Audrey L. Malagon**, Mercer University
Julie C. Beier, Mercer University
Daniel K. Nakano, University of Georgia

1:00PM (1357) *Cohomology of Finite Groups of Lie Type and Kostant's Partition Functions.* Preliminary report.
Cornelius Pillen, University of South Alabama (1067-20-1326)

1:30PM (1358) *On geometric realizations of quantum groups.*
Yiqiang Li, Virginia Tech. (1067-16-2321)

2:00PM (1359) *The image of a root system in a Coxeter plane.*
Skip Garibaldi, Emory University (1067-20-983)

2:30PM (1360) *Affine structures for certain E_6 crystals.*
Brant Jones*, James Madison University, and **Anne Schilling**, University of California, Davis (1067-22-1450)

3:00PM (1361) *Triality and Arason invariant for algebras with involution.* Preliminary report.
Anne Quéguiner-Mathieu*, UPEC - Universite Paris 13, and **Jean-Pierre Tignol**, Université Catholique de Louvain (1067-16-1325)

3:30PM (1362) *On cohomology and support varieties for Lie superalgebras.*
Irfan Bagci, University of California, Riverside (1067-17-452)

4:00PM (1363) *Centroids of Jordan Superalgebras over Superscalars.* Preliminary report.
Pamela A Richardson*, Westminster College, and **Jennifer Bowen**, The College of Wooster (1067-17-995)

4:30PM (1364) *Zero Cycles on Principal Homogeneous Spaces over Fields of Virtual Cohomological Dimension at most 2.*
Jodi A. Black, Emory University (1067-11-958)

5:00PM (1365) *Irreducible finite-dimensional representations of equivariant map algebras.*
Prasad Senesi*, Catholic University of America, **Erhard Neher** and **Alistair Savage**, University of Ottawa (1067-17-2014)

5:30PM (1366) *Some results on stability for algebraic groups.*
Brian Parshall, University of Virginia (1067-20-1403)

AMS Special Session on Completely Integrable Systems, Random Matrices, and the Bispectral Problem, II

1:00 PM – 5:50 PM

Organizers: **Bojko Bakalov**, North Carolina State University
Michael Gekhtman, University of Notre Dame
Plamen Iliev, Georgia Institute of Technology

Milen T. Yakimov, Louisiana State University

1:00PM (1367) *Discrete integrability in recursion relations for (q)-characters and fusion coefficients.* Preliminary report.
Philippe Di Francesco, CEA/Saclay, France, and **Rinat Kedem***, University of Illinois Urbana-Champaign (1067-17-1715)

1:30PM (1368) *Representations of quantum toroidal $gl(1)$.*
Evgeny Mukhin, IUPUI (1067-81-2099)

2:00PM (1369) *The charged free boson integrable hierarchy.*
Katie T Liszewski, North Carolina State University (1067-37-1608)

2:30PM (1370) *Intersections of Schubert cells and orbits of real semisimple Lie groups on the flag variety.*
Sam Evens, University of Notre Dame (1067-22-1247)

3:00PM (1371) *Double Lie bialagebra structure on Lie superalgebras.*
Ivan Dimitrov*, Queen's University, Kingston, Canada, and **Milen Yakimov**, Louisiana State University, Baton Rouge, USA (1067-17-1865)

3:30PM (1372) *The Modular Class of Poisson Submersion.* Preliminary report.
Arlo Caine* and **Sam Evens**, University of Notre Dame (1067-53-2114)

4:00PM (1373) *Bicharacter construction for boson-fermion correspondences.* Preliminary report.
Iana I Anguelova, College of Charleston (1067-81-1173)

4:30PM (1374) *Methods for constructing matrix-valued bispectral operators.*
Joel B. Geiger* and **Milen T. Yakimov**, Louisiana State University (1067-33-1861)

5:00PM (1375) *Reflexive and projective D-modules.* Preliminary report.
Greg Muller*, Louisiana State University, and **Yuri Berest**, Cornell University (1067-16-1381)

5:30PM (1376) *A nonlinear Gelfand-Zeitlin integrable system on the Poisson dual Lie group $GL(n,\mathbb{C})^*$.*
Mark Colarusso*, Université de Laval, and **Sam Evens**, University of Notre Dame (1067-22-1498)

AMS Special Session on New Trends in Theory and Applications of Evolution Equations

1:00 PM – 5:50 PM

Organizers: **Guoping Zhang**, Morgan State University
Gaston N'Guerekata, Morgan State University
Wen-Xie Ma, University of South Florida
Yi Li, University of Iowa

1:00PM (1377) *Existence of Pseudo Almost Automorphic Solutions to Some Second-Order Partial Evolution Equations.* Preliminary report.
Toka Diagana, Howard University (1067-34-20)

1:30PM (1378) *Systems of Nonlinear Schrödinger Equations.*
Mihaela Manole, Department of Applied Mathematics, Babes Bolyai University, Cluj-Napoca, Romania (1067-47-53)

2:00PM (1379) *Exact Discretization of Linearized Euler Equations in One Space Dimension.*
Ronald E. Mickens, Clark Atlanta University (1067-35-75)

2:30PM (1380) *Local existence of strong solutions for semilinear wave equation with source and damping type interactions.*
Petronela Radu, University of Nebraska-Lincoln (1067-35-83)

3:00PM (1381) *Multi-peak Solutions to Two Types of Free Boundary Problems.*
Yi Li*, University of Iowa and Xian Jiaotong University, and **Shuangjie Peng**, Central China Normal University (1067-35-1983)

3:30PM (1382) *Quantitative Approximation by Fractional Smooth Poisson Cauchy Singular Operators.* Preliminary report.
George A. Anastassiou and **Razvan A. Mezei***, University of Memphis (1067-35-121)

4:00PM (1383) *Norm inflation for incompressible magneto-hydrodynamic system in $\dot{B}_{\infty}^{-1,\infty}$.*
Mimi Dai*, **Jie Qing** and **Maria Schonbek**, University of California, Santa Cruz (1067-35-466)

4:30PM (1384) *A quenching problem due to a concentrated nonlinear source in an infinite strip.*
Patcharin Tragoonsirisak, Fort Valley State University (1067-35-638)

5:00PM (1385) *Mathematical Methods for Modeling of Lightning and Thunderstorm Electrification.*
Beyza C. Aslan*, University of North Florida, and **William Hager**, University of Florida (1067-86-1669)

5:30PM (1386) *Optimal Control of Fractional Diffusion Equation.*
Gisèle Mophou, Université des Antilles et de la Guyane (1067-49-1643)

AMS Special Session on von Neumann Algebras

1:00 PM – 5:45 PM

Organizers: **Richard D. Burstein**, Vanderbilt University
Remus Nicoara, University of Tennessee, Knoxville

1:00PM (1387) *Subfactors and Planar Algebras.* Preliminary report.
Dietmar Bisch, Vanderbilt University (1067-46-1477)

2:00PM (1388) *Eliminating vines and weeds in the classification of subfactors to index 5.*
David Penneys, UC Berkeley (1067-46-701)

3:00PM (1389) *Applications of multiple operator integration.*
Anna Skripka*, University of Central Florida, **Denis Potapov** and **Fedor Sukochev**, University of New South Wales (1067-47-653)

4:00PM (1390) *Orlicz spaces over real von Neumann Algebras.* Preliminary report.
Genady Grabarnik, St. Johns University (1067-47-2425)

5:00PM (1391) *A Morita theorem for dual operator algebras.*
Upasana Kashyap, The Citadel (1067-46-1496)

AMS Special Session on Local Commutative Algebra

1:00 PM – 5:50 PM

Organizers: **Paul C. Roberts**, University of Utah
Anurag K. Singh, University of Utah
Sandra M. Spiroff, University of Mississippi

1:00PM ► (1392) *Relating Initial Degrees of Symbolic and Regular Powers.* Preliminary report.
Susan Marie Cooper* and **Stephen G Hartke**, University of Nebraska–Lincoln (1067-13-1765)

1:30PM (1393) *Equality of Powers and Symbolic Powers of Ideals.*
Aline Hosry, University of Missouri, **Young Su Kim**, Purdue University, and **Javid Validashti***, University of Kansas (1067-13-1087)

2:00PM (1394) *Lifting Splittings and the Strong Direct Summand Conjecture.*
Jason McCullough, University of California, Riverside (1067-13-856)

2:30PM (1395) *Krull Schmidt Property for Ideals of Reduced Commutative Noetherian Rings.*
Basak Ay, The Ohio State University at Lima (1067-13-455)

3:00PM (1396) *Brauer-Thrall theorems and conjectures for commutative local rings.*
Roger A Wiegand, University of Nebraska (1067-13-1294)

3:30PM (1397) *Matlis Duals of Ext-Modules.* Preliminary report.
Bethany Ann Kubik*, **Sean Sather-Wagstaff**, North Dakota State University, and **Micah J Leamer**, University of Nebraska-Lincoln (1067-13-1152)

4:00PM ► (1398) *Torsion of Cohomology Modules.*
Julian David Chan, University of Utah (1067-13-942)

4:30PM (1399) *F-signature of pairs.*
Manuel Blickle, Johannes Gutenberg-Universität Mainz, **Karl Schwede***, Penn State University, and **Kevin Tucker**, University of Utah (1067-13-1281)

5:00PM (1400) *Asymptotic linearity of regularity and a*-invariant of powers of ideals.*
Tai Ha, Tulane University (1067-13-1177)

5:30PM (1401) *Prime ideals in birational extensions of power series rings.* Preliminary report.
Christina Eubanks-Turner, University of Louisiana at Lafayette, **Melissa Luckas**, Madison, Wisconsin, **A. Serpil Saydam**, University of Louisiana at Monroe, and **Sylvia M Wiegand***, University of Nebraska Lincoln (1067-13-1971)

AMS Special Session on Dirac Operators

1:00 PM – 5:50 PM

Organizers: **Craig A. Nolder**, Florida State University
John Ryan, University of Arkansas

1:00PM (1402) *Multicomplex Spaces: Holomorphicity and Dolbeault Complexes.*
Mihaela B Vajiac*, **Daniele C Struppa** and **Adrian I Vajiac**, Chapman University (1067-32-2098)

1:30PM (1403) *The Hypercomplex Beurling-Ahlfors Transform.*
Craig A. Nolder, Florida State University (1067-30-269)

2:00PM (1404) *Generalized Cauchy-Pompeiu and Bochner-Martinelli-Koppelman Integral Representation Formulas.* Preliminary report.
Mircea Martin, Baker University (1067-35-1089)

2:30PM (1405) *Split Quaternionic Analysis and Representation Theory.*
Matvei Libine, Indiana University (1067-20-994)

3:00PM (1406) *The Infinite Dirac Operator.*
Thomas J. Bieske*, University of South Florida, and **John Ryan**, University of Arkansas (1067-35-1679)

3:30PM (1407) *Some Rarita-Schwinger type operators.*
Junxia Li*, **John Ryan**, University of Arkansas, and **Peter Van Lanker**, University College of Gent (1067-43-715)

4:00PM (1408) *On Dirac type operators.*
John Ryan, University of Arkansas (1067-30-1367)

4:30PM (1409) *An equivalent condition to the existence of an irreducible Seiberg-Witten Monopole on a smooth closed 4-manifold.*
Celso Melchiades Doria, Federal University of Santa Catarina (1067-58-241)

5:00PM (1410) *Dirac operator and K-theory for discrete groups.*
Paul Frank Baum, Penn State University (1067-19-257)

5:30PM (1411) *Complex N-Spin Bordism of Semifree Circle Actions and Elliptic Genera.*
Muhammad N. Ahmad, Kansas State University (1067-55-1437)

AMS Special Session on Set-Valued Optimization and Variational Problems

1:00 PM – 5:50 PM

Organizers: **Akhtar A. Khan**, Rochester Institute of Technology
Miguel Sama, Universidad Nacional de Educacion a Distancia, Madrid

1:00PM (1412) *Set-valued optimization revisited: From minimal points to lattice solutions.*
Andreas H Hamel, Yeshiva University New York (1067-49-2127)

1:30PM (1413) *Variational Analysis of Minimal Time Functions and Applications.*
Nguyen Mau Nam* and **Juan Salinas**, University of Texas-Pan American (1067-49-681)

2:00PM (1414) *Hybrid systems for variational inequalities.*
Monica Gabriela Cojocaru, University of Guelph (1067-49-2316)

2:30PM (1415) *Lagrange necessary conditions for Pareto minimizers in Asplund spaces and applications.*
Bao Quang Truong*, Northern Michigan University, and **Christiane Tammer**, Martin-Luther-University Halle-Wittenberg (1067-90-554)

3:00PM (1416) *A simple proof of Fredholm alternative for A-proper mappings.*
Dan D. Pascali, Courant Institute, New York University (1067-47-1515)

3:30PM (1417) *Second Order Necessary Conditions for Problems with Locally Lipschitz Data via Tangential Directions.*
Elena Constantin, University of Pittsburgh at Johnstown (1067-49-1132)

4:00PM (1418) *A new topological condition for the existence of lagrange multipliers in set-valued optimization.*
Miguel Sama*, Universidad Nacional de Educación a Distancia, and **Akhtar A. Khan**, Rochester Institute of Technology (1067-49-1386)

4:30PM ► (1419) *A Generalized Newton's Method based on Graphical Derivatives.*
Hung Phan, Wayne State University (1067-49-775)

5:00PM (1420) *Discrete Approximations and Optimality Conditions for the Sweeping Process.*
Hoang Dinh Nguyen, Wayne State University (1067-49-773)

5:30PM (1421) *Toward Second-Order Sensitivity Analysis in Set-Valued Optimization.*
Akhtar A Khan*, Rochester Institute of Technology, and **D E Ward**, Miami University (1067-49-1382)

AMS Special Session on Knot Theory, I

1:00 PM – 5:50 PM

Organizers: **Tim D. Cochran**, Rice University
Shelley Harvey, Rice University

1:00PM (1422) *Examples of the head and the tail of the colored Jones polynomial.* Preliminary report.
Oliver Dasbach, Louisiana State University (1067-57-783)

1:30PM (1423) *Walks along Braids and the Colored Jones Polynomial.* Preliminary report.
Cody Armond, Louisiana State University (1067-57-763)

2:00PM (1424) *On Legendrian Graphs.* Preliminary report.
Danielle O'Donnol and **Elena Pavelescu***, Rice University (1067-57-857)

2:30PM (1425) *The (n)-Solvable Filtration of the Link Concordance Group and Milnor's Invariants.*
Carolyn A Otto, Rice University (1067-54-788)

3:00PM (1426) *The knot Floer complex, cabling and concordance.* Preliminary report.
Jennifer Hom, University of Pennsylvania (1067-57-629)

3:30PM (1427) *Genetic infection by string links and new structure of the knot concordance group.* Preliminary report.
John R. Burke, Wesleyan University (1067-57-383)

4:00PM (1428) *Invariants of spatial graphs.*
Danielle S. O'Donnol, Rice University (1067-57-865)

4:30PM (1429) *Concordance within a fixed homotopy class.*
Prudence Heck, Rice University (1067-57-835)

5:00PM (1430) *Filtering smooth concordance classes of topologically slice knots.* Preliminary report.
Tim D Cochran, **Shelly Harvey**, Rice University, and **Peter D Horn***, Columbia University (1067-57-497)

5:30PM (1431) *Legendrian contact homology in Seifert fibered spaces.*
Joan E Licata*, Stanford University, and **Joshua M. Sabloff**, Haverford College (1067-57-675)

AMS Special Session on Self-Organization in Human, Biological, and Artificial Systems, II

1:00 PM – 4:50 PM

Organizer: **Andrea L. Bertozzi**, University of California Los Angeles

1:00PM ► (1432) *Graphs, Dynamical Systems, Fractals: A Heuristic Framework For Modeling the Structure and Dynamics of Complex Interactions Across Multiple Levels of Analysis.* Preliminary report.
Richard E Niemeyer, University of California, Riverside (1067-91-2247)

1:30PM ► (1433) *An Agent-Based Approach to Modeling Gang Rivalries.* Preliminary report.
Laura M. Smith, University of California, Los Angeles (1067-91-235)

2:00PM (1434) *Point process modeling and estimation of near-repeat effects in crime data.*
George O Mohler, Santa Clara University (1067-62-581)

2:30PM (1435) *Self-Exciting Point Process Models of Civilian Deaths in Iraq.*
Erik Lewis*, UCLA, **George Mohler**, Santa Clara University, **P. Jeffrey Brantingham** and **Andrea Bertozzi**, UCLA (1067-60-339)

3:00PM (1436) *Asymptotic dynamics of attractive-repulsive swarms.*
Chad M. Topaz*, Macalester College, and **Andrew J. Bernoff**, Harvey Mudd College (1067-92-317)

3:30PM (1437) *A Primer of Swarm Equilibria.*
Andrew J. Bernoff*, Harvey Mudd College, and **Chad M. Topaz**, Macalester College (1067-35-320)

4:00PM (1438) *Generalized Birkhoff-Rott equation for 2D active scalar problems.*
Hui Sun*, **Uminsky David** and **Bertozzi Andrea**, University of California, Los Angeles (1067-76-1077)

4:30PM (1439) *A theory of complex patterns arising from 2D particle interactions.*
David T. Uminsky*, UCLA, **Theodore Kolokolnikov**, Dalhousie University, **Hui Sun** and **Andrea Bertozzi**, UCLA (1067-70-1042)

AMS Special Session on Harmonic Analysis and Partial Differential Equations, II

1:00 PM – 5:50 PM

Organizers: **Svitlana Mayboroda**, Purdue University
Tatiana Toro, University of Washington

1:00PM (1440) *Harmonic analysis and uniform rectifiability.*
Steven C. Hofmann, University of Missouri (1067-42-799)

1:30PM (1441) *C^α and BMO solvability of Dirichlet problem for divergence form elliptic equations with complex L^∞ coefficients.*
Mihalis Mourgoglou, University of Missouri-Columbia (1067-35-1729)

2:00PM (1442) *Elliptic PDE and Carleson-measure estimates.*
Ariel Elizabeth Barton, Purdue University (1067-35-1224)

2:30PM (1443) *Homogenization of Neumann Boundary Value Problems.* Preliminary report.
Zhongwei Shen, University of Kentucky (1067-35-523)

3:00PM (1444) *Regularity and Free Boundary Regularity for the p-Laplace Operator in Reifenberg Flat and NTA Ahlfors Regular Domains.* Preliminary report.
John L Lewis, University of Kentucky (1067-35-686)

3:30PM (1445) *Free boundary regularity for harmonic measure from two sides.*
Matthew Badger, University of Washington (1067-31-1108)

4:00PM (1446) *Estimates for the dimension of p-harmonic measure in $\mathbb{R}^n$.* Preliminary report.
Björn Bennewitz, Iceland, **John L Lewis**, University of Kentucky, **Kaj Nyström**, Umea University, and **Andrew L Vogel***, Syracuse University (1067-35-1543)

4:30PM (1447) *Asymptotics of positive harmonic functions on paraboloid-type regions.*
Koushik Ramachandran*, Purdue University,West Lafayette, IN, **Alexandre Eremenko** and **Svitlana Mayboroda**, Purdue University (1067-31-2013)

5:00PM (1448) *Estimates for a family of multi-linear forms.*
Zhongyi Nie and **Russell M. Brown***, University of Kentucky (1067-35-1793)

5:30PM (1449) *Convergence of Eigenvalues for Elliptic Systems on Perturbed Domains with Low Regularity.*
Justin L Taylor, University of Kentucky Mathematics Department (1067-35-1607)

AMS Special Session on Difference Equations and Applications

1:00 PM – 5:50 PM

Organizer: **Michael A. Radin**, Rochester Institute of Technology

1:00PM (1450) *Open Problems and Conjectures in Difference Equations.* Preliminary report.
Gerasimos E. Ladas, University of Rhode Island (1067-39-211)

1:30PM (1451) *Global Attractivity of Equilibria and Existence of Prime Period-Two Solutions for a Class of Planar Systems of Difference Equations.*
Sukanya Basu, Midwestern State University (1067-39-627)

2:00PM (1452) *Long-Term Behavior of Solutions of the Difference Equation* $x_{n+1} = x_{n-1}x_{n-2} - 1$.
Candace M. Kent*, Virginia Commonwealth University, **Witold Kosmala**, Appalachian State University, and **Stevo Stevic**, Mathematical Institute of the Serbian Academy of Sciences (1067-39-1375)

2:30PM (1453) *Uncovering fundamental properties of difference equations by semiconjugate factorization.*
H Sedaghat, Virginia Commonwealth University (1067-39-988)

3:00PM (1454) *Global Behavior of Certain Nonautonomous Nonlinear Discrete Population Models Exhibiting Allee Effect.* Preliminary report.
Vlajko L Kocic, Xavier University of Louisiana (1067-39-484)

3:30PM (1455) *On the periodically forced Simoid Beverton-Holt Model.* Preliminary report.
Y Kostrov, Xavier University of Louisiana (1067-39-2066)

4:00PM ► (1456) *Computing recurrences for Mellin-Barnes integrals.*
Flavia Stan, Tulane University (1067-39-997)

4:30PM (1457) *Algebraic Extensions for Summation in Finite Terms.*
Burcin Erocal, Research Institute for Symbolic Computation (RISC), Linz, Austria (1067-40-674)

5:00PM (1458) *Boundary value problems for singular elliptic equations.*
Loc Hoang Nguyen* and **Klaus Schmitt**, University of Utah (1067-35-414)

5:30PM (1459) *Right focal boundary value problems for difference equations.*
Johnny Henderson, Baylor University (1067-39-18)

AMS Special Session on New Topics in Graph Theory, II

1:00 PM – 5:50 PM

Organizers: **Ralucca Gera**, Naval Postgraduate School
Eunjeong Yi, Texas A&M University at Galveston

1:00PM ► (1460) *Two Theorems on Four Colorings.*
Ping Zhang, Western Michigan University (1067-05-1293)

1:30PM ► (1461) *On Hamiltonian-Colored Graphs.*
Kyle Kolasinski, Western Michigan University (1067-05-1340)

2:00PM ► (1462) *On Neighbor-Distinguishing Edge Colorings.*
Ryan C Jones, Western Michigan University (1067-05-1338)

2:30PM (1463) *The G-Shi arrangement, and its relation to G-parking functions.*
Art Duval*, University of Texas at El Paso, **Caroline Klivans**, University of Chicago, and **Jeremy Martin**, University of Kansas (1067-05-963)

3:00PM (1464) *A Matrix Theory Approach to Planar Graphs.*
Jason J Molitierno, Sacred Heart University (1067-15-559)

3:30PM ► (1465) *Iteration index of a zero forcing set in a graph.* Preliminary report.
Kiran Chilakamarri, Texas Southern University, **Nathaniel Dean**, Texas State University, **Cong X Kang*** and **Eunjeong Yi**, Texas A&M University at Galveston (1067-05-1157)

4:00PM (1466) *Common Divisor Graphs of Permutation Groups and IP-graphs of Association Schemes.*
Bangteng Xu, Eastern Kentucky University (1067-05-29)

4:30PM ► (1467) *Two new Graph factorization problems.* Preliminary report.
Dinesh Sarvate*, College of Charleston, **V. Murali**, Rhodes University, and **Hau Chan**, Stony Brook University (1067-05-421)

5:00PM ► (1468) *Screen Size.*
Nathaniel Dean, Texas State University-San Marcos (1067-05-1553)

5:30PM ► (1469) *Chemical Sub-Structural Cluster Expansions.*
Douglas J. Klein, Texas A&M University at Galveston (1067-05-1762)

AMS Session on Ordinary Differential Equations

1:00 PM – 5:55 PM

1:00PM (1470) *Preliminary Investigation on the Properties of the "Leah"-Cosine and -Sine Functions*†.
Joshua Mann*, **Anthony Scrouse**, Morehouse College, and **Ronald E. Mickens**, Clark Atlanta University (1067-34-92)

1:15PM (1471) *Stepanov-like almost automorphy for stochastic processes and applications to stochastic differential equations.*
Gaston M. N'Guerekata, Morgan State University (1067-34-1637)

1:30PM (1472) *Asymptote of orbits of a planar polynomial vector field with the fixed Newton polygon.*
Faina Berezovskaya, Howard University (1067-34-1550)

1:45PM (1473) *Boundary Points of* $P_{n,m}$. Preliminary report.
G. Edgar Parker, James Madison University (1067-34-1586)

2:00PM ► (1474) *Cauchy-Kowalevski and Polynomial ODE.*
Roger Thelwell* and **Paul Warne**, James Madison University (1067-34-1932)

2:15PM ► (1475) *Asymptotic Behavior for Systems of Nonlinear Differential Equations.*
Elizabeth Catsimanes, University of Central Missouri (1067-34-2250)

2:30PM (1476) *On Ordinary Differential Equations with Discontinuous Right Sides.* Preliminary report.
Zhivko S. Athanassov, Bulgarian Academy of Sciences (1067-34-2412)

2:45PM (1477) *Perturbation Analysis of Slow Waves for Periodic Differential-Algebraic Systems of Definite Type.* Preliminary report.
Aaron T. Welters, University of California, Irvine (1067-34-2262)

3:00PM ► (1478) *The existence of Multiple solutions for a fourth order nonhomogeneous boundary value problem.*
Britney Hopkins, University of Central Oklahoma (1067-34-915)

3:15PM (1479) *Comparison of Smallest Eigenvalues.*
Jeffrey T Neugebauer, Baylor University (1067-34-555)

3:30PM (1480) *Nonlocal boundary value problems for nth order differential equations by solution matching.*
Xueyan Sherry Liu, Baylor University (1067-34-437)

3:45PM (1481) *Global Attractivity of Periodic Solutions of First Order Delay Differential Equations with Applications in Population Dynamics.* **Seshadev Padhi***, Birla Institute of Technology, Mesra, Ranchi, **Julio G Dix**, Texas State University at San Marcos, and **Smita Pati**, Birla Institute of Technology (1067-34-2383)

4:00PM (1482) *Existence and Characterization Theorems for Fuzzy Differential Equations.* **Barnabas Bede**, University of Texas- Pan American (1067-34-1654)

4:15PM ► (1483) *An Approximate Method for Obtaining a Polynomial Solution to the Problem of the Unsteady Velocity-Time History of Flow Startup in a Duct.* **William S. Janna*** and **Karyn M Bautista**, University of Memphis (1067-34-1964)

4:30PM ► (1484) *Weak Allee effect, grazing, and S-shaped bifurcation curves.* **Brittany C Stephenson***, Mississippi State University, **Emily K Poole**, University of Arkansas, and **Bonnie J Roberson**, Mississippi State University (1067-34-424)

4:45PM (1485) *Interactions of the CAN and NaP currents yield a novel bursting pattern in a model for a respiratory neuron.* **Justin R. Dunmyre***, University of Pittsburgh, **Christopher A. Del Negro**, College of William and Mary, and **Jonathan E. Rubin**, University of Pittsburgh (1067-34-2230)

5:00PM ► (1486) *Economic Analysis of the Use of Facemasks During Pandemic (H1N1) 2009.* **Samantha M. Tracht***, Los Alamos National Laboratory & University of Tennessee - Knoxville, **Sara Y. Del Valle** and **Brian Edwards**, Los Alamos National Laboratory (1067-34-1663)

5:15PM (1487) *Dynamics of the SAIQR Influenza Model.* **Ana Luz Vivas**, New Mexico State University (1067-34-919)

5:30PM ► (1488) *Models of Antibody responses during HIV viral infections.* **Stanca M. Ciupe***, University of Louisiana at Lafayette, **Patrick DeLeenheer**, University of Florida, and **Thomas Kepler**, Duke University Medical Center (1067-34-1260)

5:45PM ► (1489) *HIV-1 Model with latently infected cells and optimal drug treatment strategy.* Preliminary report. **Maria Leite***, The University of Oklahoma, **Barbara Benitez-Gucciardi**, Houston Baptist University, **Suzanne Lenhart**, University of Tennessee, and **Libin Rong**, Oakland University and Center for Biomedical Research (1067-34-287)

AMS Session on Number Theory, III

1:00 PM – 5:10 PM

1:00PM ► (1490) *Rational self-maps on projective space with automorphisms.* Preliminary report. **Benjamin Hutz***, CUNY Graduate Center, and **Michelle Manes**, University of Hawaii (1067-11-665)

1:15PM (1491) *Congruences Between Spaces of Cuspidal Modular Forms.* **Randy J Heaton**, Florida State University (1067-11-2028)

1:30PM (1492) *Modular forms with non-negative Fourier coefficients and extremal lattices.* **Paul Jenkins**, Brigham Young University, and **Jeremy Rouse***, Wake Forest University (1067-11-1462)

1:45PM (1493) *The representation theory of GSp(4).* **Jeffery E. Breeding**, University of Oklahoma (1067-11-442)

2:00PM (1494) *Differential equations for cubic theta functions.* **Tim Huber**, University of Texas-Pan American (1067-11-1836)

2:15PM ► (1495) *A proof of Ewell's Octuple Product Identity.* Preliminary report. **Zhu Cao**, University of Mississippi, and **Xinyun Zhu***, University of Texas of Permian Basin (1067-11-1131)

2:30PM (1496) *The Connection Between Germain Primes and Twin Primes.* **Thomas J Wright**, Lawrence University (1067-11-1883)

2:45PM (1497) *Infinite class of new sign ambiguities.* **Heon Kim**, Southern University at New Orleans (1067-11-1603)

3:00PM (1498) *An Improved Method for Computing Group Homology of the Congruence Subgroup* $\Gamma_0(2)$ *of* $SL_3(\mathbb{Z})$. **Becky E Hall**, Western Connecticut State University (1067-11-284)

3:15PM (1499) *Minimal Polynomials of Singular Moduli.* Preliminary report. **Eric Errthum**, Winona State University (1067-11-1255)

3:30PM (1500) *The Simplest Cubic Function Fields.* Preliminary report. **Jonathan Webster***, Bates College, and **Pieter Rozenhart**, INRIA Bordeaux Sud-Ouest (1067-11-734)

3:45PM (1501) *Using the* p*-Group Generation Algorithm to Determine Extensions of* D_4 *by* $C_2 \times C_2 \times C_{2^n}$. Preliminary report. **Aliza A Steurer**, Dominican University (1067-11-128)

4:00PM (1502) *Norm-Euclidean Galois cubic fields.* **Kevin J. McGown**, Oregon State University (1067-11-111)

4:15PM (1503) *The Ramification Group Filtrations of Elementary Abelian Extensions and Beyond.* Preliminary report. **Qingquan Wu**, Texas A&M International University (1067-11-1060)

4:30PM (1504) *The Dwork Family and Hypergeometric Functions.* **Adriana Salerno**, Bates College (1067-11-1621)

4:45PM ► (1505) *The classification of curves* $G(X) = H(Y)$ *with infinitely many rational points.* Preliminary report. **Benjamin L Weiss**, University of Michigan (1067-11-1779)

5:00PM ► (1506) *Another look at the GHS Attack on the Elliptic Curve Discrete Logarithm Problem.* **Matthew Musson**, University of Calgary (1067-11-1694)

AMS Session on Mathematical Biology and Ecology, IV

1:00 PM – 5:55 PM

1:00PM ► (1507) *Mathematical models for the effect of transmission-blocking vaccines on malaria.* **Gabriel T Davis***, Carleton College, **Jay Walton** and **May Boggess**, Texas A&M University (1067-92-163)

1:15PM ► (1508) *An Optimal Treatment Strategy for Malaria Infection.* Preliminary report. **Jeremy J. Thibodeaux***, Loyola University New Orleans, and **Timothy Schlittenhardt**, University of Central Oklahoma (1067-92-1021)

1:30PM ► (1509) *Sensitivity Analysis Of a Cholera Epidemic Model.* Preliminary report.
Boloye Gomero, University of Tennessee, Knoxville, TN (1067-92-2264)

1:45PM ► (1510) *A Stochastic Model of Rotavirus Infection and Vaccination.* Preliminary report.
Erica Johnson, **Jennifer Ortiz** and **Omayra Ortega***, Arizona State University (1067-92-2336)

2:00PM ► (1511) *Transmission Dynamics of Kala-azar in Bihar and Impact on Public Health Policies.* Preliminary report.
Anuj Mubayi, Department of Infectious Disease, Cleveland Clinic (1067-92-1063)

2:15PM ► (1512) *Get the News Out Loudly and Quickly: Modeling the Influence of the Media on Limiting Infectious Disease Outbreaks.* Preliminary report.
Anna Mummert*, Marshall University, and **Thembinkosi Mkhatshwa**, Oklahoma State University (1067-92-1105)

2:30PM ► (1513) *Coexistence of competitors in deterministic and stochastic patchy environments.*
Zhilan Feng, Purdue University, **Ronsong Liu**, Dept. of Mathematics and Dept. of Zoology and Physiology, University of Wyoming, **Zhipeng Qiu**, Nanjing University of Science and Technology, **Joaquin Rivera***, Colgate University, and **Abdul-Aziz Yakubu**, Howard University (1067-92-752)

2:45PM (1514) *Mathematical theory of selection and the Principle of minimum discrimination information.*
Georgiy P Karev, Lockheed Martin MSD, National Institute of Health (1067-92-1183)

3:00PM (1515) *A Discrete Stage-Structured Two Species Competition Model.*
Pei Zhang* and **Azmy S. Ackleh**, University of Louisiana at Lafayette (1067-92-1369)

3:15PM ► (1516) *Predator-prey role reversal as bifurcation in a structured model.* Preliminary report.
Christopher Brown, California Lutheran University, and **Sheila K. Miller***, United States Military Academy (1067-92-2370)

3:30PM (1517) *Stochastic juvenile-adult models with application to a green tree frog population.*
Qihua Huang*, **Azmy S. Ackleh** and **Keng Deng**, University of Louisiana at Lafayette (1067-92-1970)

3:45PM ► (1518) *Mathematical Model of Methamphetamine and HIV Epidemics among Men-Seeking-Men Community.* Preliminary report.
Aprillya Lanz, Virginia Military Institute (1067-92-2375)

4:00PM ► (1519) *A Modeling Study of Synaptic Neurotransmission and Independent Signaling of NMDA Receptors.* Preliminary report.
Justin S Blackwell, University of Texas at Arlington (1067-92-1933)

4:15PM ► (1520) *Using matrix analysis to model the spread of an invasive plant, Alternanthera philoxeroides.* Preliminary report.
Samantha H Erwin and **Aron J Huckaba***, Murray State University (1067-92-1426)

4:30PM ► (1521) *Modeling the Effects of Cannibalistic Behavior in Zebra Mussel* Dreissena polymorpha *Populations.*
Patrick Thomas Davis*, Eastern Michigan University, **May Boggess** and **Jay Walton**, Texas A&M University (1067-92-142)

4:45PM (1522) *Quantifying the effects of low dissolved oxygen on the growth, reproduction, and survival of fish.*
Rachael L. Miller Neilan*, **Kenneth Rose**, **Sean Creekmore**, Louisiana State University, **Kevin Craig**, Florida State University, and **Peter Thomas**, University of Texas (1067-92-1230)

5:00PM (1523) *Modeling Energetic and Theoretical Costs of Thermoregulatory Strategy.*
John G. Alford*, Sam Houston State University, and **William I. Lutterschmidt**, Department of Biological Sciences, Sam Houston State University (1067-92-541)

5:15PM ► (1524) *Disease Dynamics in Honeybee Populations.* Preliminary report.
Amalie McKee, Case Western Reserve University and Santa Fe Institute (1067-92-179)

5:30PM (1525) *Asymptotic Herbivory and Optimal Resource Allocation: A Cause for Masting.*
George M. Shakan*, Worcester Polytechnic Institute, **Molly S. Eickholt**, Ohio Northern University, **Laurel A. Ohm**, St. Olaf College, **Kallyn K. Buschkamp**, Briar Cliff University, and **Alyssa G. Kent**, Lewis and Clark College (1067-92-1556)

5:45PM ► (1526) *Modeling Particle Dynamics around Choanoflagellates by the Regularized Stokeslets.* Preliminary report.
Yicong Yong*, University of Florida, and **Xingzhou Yang**, Mississippi State University (1067-92-802)

AMS Session on Topics in Mathematics

1:00 PM – 3:10 PM

1:00PM (1527) *The (l, m)-step competition number of a graph.*
Kim A.S. Factor, Marquette University, **Sarah K. Merz***, University of the Pacific, and **Yoshio Sano**, Pohang Mathematics Institute (1067-05-1373)

1:15PM (1528) *An A-invariant subspace for taut distance-regular graphs.* Preliminary report.
Mark MacLean*, Seattle University, and **Paul Terwilliger**, University of Wisconsin-Madison (1067-05-787)

1:30PM (1529) *Symbolic dynamics from partitions with overlapping elements.* Preliminary report.
David S. Richeson*, Dickinson College, **Jim Wiseman**, Agnes Scott College, and **Fabio Drucker**, Dickinson College (1067-37-1576)

1:45PM (1530) *Killing's equations for invariant metrics on Lie groups.*
Firas Y Hindeleh*, Grand Valley State University, and **Gerard Thompson**, The University of Toledo (1067-22-666)

2:00PM ► (1531) *An introduction to the Kirby Calculator.* Preliminary report.
Frank J Swenton, Middlebury College (1067-57-325)

2:15PM ► (1532) *Efficiency of Maximum Partial Likelihood Estimators with Nested Case Control Sampling and Comparisons to Maximum Likelihood Estimators.* Preliminary report.
Justin W Hansen, University of Vermont, and **Haimeng Zhang***, Mississippi State University (1067-62-1714)

2:30PM (1533) *Sharp Bounds for Multivariate Coherent Risk Measures.*
Li Zhu* and **Haijun Li**, Washington State University (1067-60-1194)

2:45PM (1534) *Poisson Approximation of the Poisson Lindley Distribution.*
Mehdi Razzaghi, Bloomsburg University of Pennsylvania (1067-60-829)

3:00PM (1535) *Expressions with pi and the lemniscate constant expanded as infinite products and continued fractions.*
Thomas J. Osler, Rowan University (1067-40-1193)

MAA Session on Developmental Mathematics Education: Helping Under-Prepared Students Transition to College-Level Mathematics

1:00 PM – 5:35 PM

Organizers: **Kimberly J. Presser**, Shippensburg University
J. Winston Crawley, Shippensburg University

1:00PM (1536) *The Effectiveness of Intensive Workshops in Developmental Mathematics.*
Michael B. Scott* and **Alysia Walther**, Cal State Monterey Bay (1067-D1-2217)

1:20PM (1537) *Improving the Transition from High School to College Mathematics.*
Kathryn T Ernie*, **Erick B Hofacker**, University of Wisconsin - River Falls, and **Sherrie Serros**, University of Wisconsin - Eau Claire (1067-D1-2023)

1:40PM (1538) *Accelerated WARM UPS: Doing more with less time used differently. Remedial Arithmetic in as Little as 20 hours.*
G Michael Guy, Queensborough Community College, CUNY (1067-D1-1938)

2:00PM (1539) *Remedial Math and the Non-Traditional Learner (A Proposed Course Design).*
Darcel Ford, Strayer University (1067-D1-1859)

2:20PM (1540) *Using Arithmetic of Integers as a Bridge to Arithmetic of Polynomials.*
J Bradford Burkman, Louisiana School for Math, Science, and the Arts (1067-D1-1811)

2:40PM (1541) *Teaching Developmental Mathematics in Urban University.*
Zhixiong Chen, New Jersey City University (1067-D1-435)

3:00PM (1542) *Supporting the high school to highly demanding university transition for ESL learners in an environment of strong ethnic and cultural diversity: The case of Carnegie Mellon University in Qatar.*
Dale J Winter, Carnegie Mellon University (1067-D1-1629)

3:20PM (1543) *Leaving the Text Behind and Bringing Real-World Major Based Activities in to the Intermediate Algebra Course on a Weekly Basis.* Preliminary report.
Gary W. Hagerty, Boise State University (1067-D1-1704)

3:40PM (1544) *Mentoring At-Risk Students in a Remedial Mathematics Course.*
Leonid Khazanov* and **Fred Peskoff**, Borough of Manhattan Community College/CUNY (1067-D1-1052)

4:00PM (1545) *Modularized Math Remediation: Completely Overhauling the Broken System.*
Aaron Wong, Nevada State College (1067-D1-504)

4:20PM (1546) *Can Inquiry-Based Learning Augment Computer-Assisted Instruction in Developmental Algebra?*
William O. Bond* and **John C. Mayer**, University of Alabama at Birmingham (1067-D1-1578)

4:40PM (1547) *Tracking and Ability Grouping: Alternative srategies for serving a growing population of students needing developmental mathematics education.* Preliminary report.
Kimberly J Presser, Shippensburg University (1067-D1-768)

5:00PM (1548) *On the Teaching of the Three Methods for Solving a Linear Inequality in Two Variables.* Preliminary report.
Shumei C. Richman, Columbia, SC (1067-D1-255)

5:20PM (1549) *The Mathematical Fitness Center: An Alternative Program for Salvaging Mathematically Suppressed Students and Pre-students, STEM and Otherwise.* Preliminary report.
Clyde L. Greeno, The MALEI Mathematics Institute (1067-D1-2100)

MAA Session on Humanistic Mathematics, I

1:00 PM – 6:00 PM

Organizers: **Gizem Karaali**, Pomona College
Mark Huber, Claremont McKenna College
Dagan Karp, Harvey Mudd College

1:00PM (1550) *Poetry in Sanskrit Mathematics.*
Toke L Knudsen, SUNY Oneonta (1067-I1-1678)

1:20PM (1551) *Jesse Douglas, Norman Levinson, and anti-semitism at MIT in the 1930's.*
Reuben Hersh, University of New Mexico (1067-I1-371)

1:40PM (1552) *Habits of Creative Mathematicians.* Preliminary report.
Marc Chamberland, Grinnell College (1067-I1-1406)

2:00PM (1553) *Making the Connection: Ethnic and Cultural Effects of Mathematics.*
Esther M Pearson, Lasell College (1067-I1-22)

2:20PM (1554) *Humanism, Realism, and Folk Mathematics: the Case of Reticular Geometry.*
Gregory L McColm, University of South Florida (1067-I1-619)

2:40PM (1555) *Tales from the Underground: Polish Mathematics during World War II.*
Emelie A Kenney, Siena College (1067-I1-86)

3:00PM (1556) *Treatment of and trouble with zero in three centuries of American arithmetic.*
Deepak Basyal, New Mexico State University (1067-I1-1279)

3:20PM (1557) *"Beauty is Truth, Truth Beauty": The Aesthetics of Mathematical Arguments.* Preliminary report.
Andrew J. Miller, Belmont University (1067-I1-2348)

3:40PM (1558) *Physical Math for Elementary Teachers: Reconnecting Mathematics with the Body Using Mirror Neurons.*
Susan L. Addington*, California State University, San Bernardino, and **David Dennis**, San Bernardino, CA (1067-I1-2318)

4:00PM (1559) *A Simulation of Evolutionary Psychology Using the Psychology of Personal Constructs.* Preliminary report.
Andrew G. Borden, Palo Alto College, San Antonio, Texas (1067-I1-451)

4:20PM (1560) *Mathematics and Equity, Past and Present, through the Lives and Work of Women Mathematicians.*
Jacqueline M Dewar*, **Lily Khadjavi** and **Alissa Crans**, Loyola Marymount University (1067-I1-368)

4:40PM (1561) *Exploring Mathematical Characters, in Fact and in Fiction.*
Mike Pinter, Belmont University (1067-I1-1283)

5:00PM Poetry reading.

MAA Session on Philosophy of Mathematics in Teaching and Learning

1:00 PM – 5:25 PM

Organizers: **Dan Sloughter**, Furman University

Martin E. Flashman, Humboldt State University

1:00PM ► (1562) *Square Roots: Adding Philosophical Contexts and Issues to Enhance Understanding.* Preliminary report.
Martin E. Flashman, Humboldt State University (1067-T1-1395)

1:30PM ► (1563) *Precalculus from an Ontological Perspective.* Preliminary report.
Whitney Johnson*, University of Maryland, College Park, and **Bill Rosenthal**, LaGuardia Community College, CUNY (1067-T1-2224)

2:00PM ► (1564) *Putting Content into a Fictionalist Account of Mathematics for Non-Mathematicians.* Preliminary report.
Thomas Drucker, University of Wisconsin–Whitewater (1067-T1-1766)

2:30PM ► (1565) *On the Value of Doubt and Discomfort.*
Sheila K. Miller, United States Military Academy, West Point (1067-T1-2223)

3:00PM ► (1566) *Mathematical Understanding and Philosophies of Mathematics.* Preliminary report.
Jeff Buechner, Rutgers University-Newark and Saul Kripke Center, CUNY Graduate Center (1067-T1-712)

3:30PM (1567) *Abstraction and objectivity in mathematics.*
Ruggero Ferro, University of Verona, Italy (1067-T1-1527)

4:00PM ► (1568) *Causation and Explanation in Mathematics.*
James R. Henderson, University of Pittsburgh at Titusville (1067-T1-159)

4:30PM ► (1569) *Claims Become Theorems, but Who Decides?* Preliminary report.
Andy D. Martin, Kentucky State University (1067-T1-2327)

5:00PM ► (1570) *Definitions in Their Developmental Stages: What should we call them?* Preliminary report.
Firooz Khosraviyani*, Texas A&M International University, **Terutake Abe**, South Texas College, and **Juan J Arellano**, Texas A&M International University (1067-T1-2300)

MAA General Contributed Paper Session, X

1:00 PM – 5:10 PM

Organizers: **Kristen Meyer**, Wisconsin Lutheran College
Thomas R. Hagedorn, The College of New Jersey

1:00PM ► (1571) *Exploring Game Theory with SAGE, the open-source competitor to Maple, Mathematica, Matlab and MAGMA.*
Gregory V. Bard, Fordham University (1067-Z1-1891)

1:15PM (1572) *Game Theory and School Choice.*
Alexander A Azzam*, University of Nebraska - Lincoln, and **Gizem Karaali**, Pomona College (1067-Z1-2143)

1:30PM ► (1573) *ACCUV College Football Ranking Model.*
William W Miles*, **Lisa O Coulter**, Stetson University, and **Gary Fowks**, Valencia Community College (1067-Z1-503)

1:45PM ► (1574) *Economic-Based Affirmative Action in College Admissions.*
Bryan Nankervis, Texas State University-San Marcos (1067-Z1-1943)

2:00PM ► (1575) *Video Game Design=Mathematics.*
Paul Raymond Bouthellier, University of Pittsburgh-Titusville (1067-Z1-327)

2:15PM ► (1576) *Application of a chaotic map to digital images.*
Mohamed Allali, Chapman University (1067-Z1-1661)

2:30PM (1577) *Perfecting Solar Greenhouse Design for Hudson Valley Winter Agriculture.*
Abigail L. Stevens* and **Gidon Eshel**, Bard College (1067-Z1-2243)

2:45PM ► (1578) *A Model for Damage to Buried Segmented Pipe.* Preliminary report.
Rachel R Roe-Dale*, Skidmore College, and **Michael O'Rourke**, Rensselaer Polytechnic Institute (1067-Z1-2166)

3:00PM (1579) *Detecting Symmetry in Coupled Droplet Oscillations.*
David M. Slater*, Cornell University, and **Paul H Steen**, Department of Chemical and Biomolecular Engineering / Cornell University (1067-Z1-2074)

3:15PM ► (1580) *Drying Droplets of Colloidal Suspensions: Role of Rheology.* Preliminary report.
Kara L. Maki*, Institute for Mathematics and its Applications, and **Satish Kumar**, University of Minnesota (1067-Z1-1985)

3:30PM (1581) *A Turbulence Model for Ideal Fluids: Analytical and Numerical Results.*
Adam Larios*, University of California, Irvine, and **Edriss S Titi**, University of California, Irvine and Weizmann Institute of Science (1067-Z1-2401)

3:45PM (1582) *Immersed elastic structure dynamics in viscoelastic fluids.*
John C. Chrispell* and **Lisa J. Fauci**, Tulane University (1067-Z1-837)

4:00PM ► (1583) *An Improved Model for Predicting Beta-Cell Insulin Secretion Rate from C-Peptide Data.*
William J Heuett*, Marymount University, **Bernard V Miller** and **Vipul Periwal**, National Institutes of Health (1067-Z1-2071)

4:15PM (1584) *A Multiscale Gene Regulation Model: Mutual Inhibition Network in Epidermal Development.*
Yuyu Peng, University of California, Irvine (1067-Z1-2293)

4:30PM (1585) *Thin Film Evolution over a Thin porous Layer: Modeling a Tear Film on a Contact Lens.*
Kumnit Nong* and **Daniel M Anderson**, George Mason University (1067-Z1-1828)

4:45PM (1586) *Modeling almond pollination by two interacting bee species with cross- and self-diffusion.*
Kamuela E Yong*, **Yi Li** and **Stephen Hendrix**, University of Iowa (1067-Z1-2018)

5:00PM ► (1587) *Singularity of Cubic Bézier Curves and Surfaces.*
Edmond Nadler*, Eastern Michigan University, **Tae-wan Kim**, **Min-jae Oh** and **Sung-ha Park**, Seoul National University (1067-Z1-2054)

MAA General Contributed Paper Session, IX

1:00 PM – 5:55 PM

Organizers: **Kristen Meyer**, Wisconsin Lutheran College
Thomas R. Hagedorn, The College of New Jersey

1:00PM ► (1588) *The war on apathy in a terminal statistics course: Motivating definitions from day one.* Preliminary report.
Gregory M Johnson*, Carnegie Mellon University, and **Christopher S Shaw**, Columbia College Chicago (1067-Z1-1898)

1:15PM ► (1589) *Developing A Successful Actuarial Study Group Without Having A Program In Actuarial Science.*
Chris Lacke, Rowan University (1067-Z1-1897)

1:30PM (1590) *Using Data-Mining to Classify Student Behaviors.* Preliminary report.
Rachel B Manspeaker, Kansas State University (1067-Z1-2113)

1:45PM (1591) *Using Online Survey Tools to Consolidate Game Outcomes.*
Jan O. Case, Jacksonville State University (1067-Z1-590)

2:00PM (1592) *Conditional probability via topics in social justice.* Preliminary report.
Julie A. Belock, Salem State University (1067-Z1-1834)

2:15PM (1593) *Stochastic dynamical model of social conflict and cooperation.*
Salam Md. Mahbubush Khan, Alabama A&M University (1067-Z1-1128)

2:30PM (1594) *Character Estimates, and Random Walks on $SU(n)$.*
Corey M Manack, University of Montana-Western (1067-Z1-657)

2:45PM (1595) *Optimal and Efficient Crossover Designs for Test-Control Study When Subject Effects are Random.*
Samad Hedayat and **Wei Zheng***, University of Illinois at Chicago (1067-Z1-1864)

3:00PM (1596) *Puttering Around with Golf Statistics.* Preliminary report.
Roland Minton, Roanoke College (1067-Z1-1321)

3:15PM (1597) *Estimation of Mode Using Auxiliary Information.*
Stephen A Sedory* and **Sarjinder Singh**, Texas A&M University-Kingsville (1067-Z1-1577)

3:30PM (1598) *Combinations of "combinations of p-values".*
Lan Cheng*, SUNY Fredonia, and **Xuguang Sheng**, American University (1067-Z1-336)

3:45PM (1599) *Sensitivity Analysis of Anaerobic Digestion Model No.1 (ADM1) Using Latin Hypercube Sampling: A case study in dairy manure digestion.*
Mondal Sumona*, Clarkson University, **Bo Zhang**, Civil and Environmental Engineering Department, Clarkson University, **Kathleen R. Fowler**, Clarkson University, and **Stefan Grimberg**, Civil and Environmental Engineering Department, Clarkson University (1067-Z1-2195)

4:00PM (1600) *Optimal points for a probability distribution on Cantor set.* Preliminary report.
Lakshmi Roychowdhury, Texas A&M University (1067-Z1-2253)

4:15PM (1601) *A Generalized Slope Based Scale-Invariant One Sample Nonparametric Test For Bivariate Location Problem.*
Sunil Mathur, University of Mississippi (1067-Z1-25)

4:30PM (1602) *The General, Irreducible Three and Four-State Markov Process.*
Lilinoe M. Harbottle*, California State Polytechnic University, Pomona, **Blake Hunter**, University of California, Davis, and **Alan Krinik**, California State Polytechnic University, Pomona (1067-Z1-1039)

4:45PM (1603) *Central Limit Theorem for Stochastic Flows.* Preliminary report.
William Pachas-Flores* and **Michael Cranston**, University of California, Irvine (1067-Z1-1838)

5:00PM (1604) *Shape Theorems For Evolving Sets on Two Dimensional Lattices.*
Timothy Prescott, University of North Dakota (1067-Z1-795)

5:15PM (1605) *An Exponentially fitted Second Derivative Method for linear singularly perturbed boundary value problems.*
Ramanjit K Sahi* and **Samuel N Jator**, Austin Peay State University (1067-Z1-691)

5:45PM (1606) *Formative Assessment: A Key Strategy for Calculus Teaching.* Preliminary report.
James R Choike*, Oklahoma State University, **Cos Fi**, University of Iowa, and **Vytas Laitusis**, The College Board (1067-Z1-1955)

SIAM Minisymposium on Frontiers in Geomathematics

1:00 PM – 6:25 PM

Organizers: **Willi Freeden**, University of Kaiserslautern
Zuhair Nashed, University of Central Florida
Volker Michel, Universitaet Siegen
Thomas Soner, Technical University of Braunschweig, Germany

1:00PM (1607) *Correlation based imaging.*
George C. Papanicolaou, Stanford University (1067-60-1122)

1:30PM (1608) *Sphere Oriented Wavelets Based on Radial Basis Functions.*
Michael Schreiner, Univ. of Buchs NTB, Institute for Computational Engineering (1067-41-473)

2:00PM (1609) *Role of Computational Science in Protecting the Environment: Geological Storage of CO2.*
Mary Fanett Wheeler, University of Texas at Austin (1067-65-828)

2:30PM (1610) *A Spatially Oriented Approach to Geomagnetic Modeling.*
Christian Gerhards, TU Kaiserslautern (1067-41-512)

3:00PM (1611) *Maximum-likelihood theory for the inversion of gravity and topography data to recover the elastic strength of a planetary lithosphere.*
Frederik J Simons*, Princeton University, and **Sofia C. Olhede**, University College London (1067-86-842)

3:30PM (1612) *3D-Modeling of Heat Transport in Deep Hydrothermal Reservoirs.* Preliminary report.
Isabel Ostermann, Fraunhofer ITWM Kaiserslautern, Germany (1067-86-546)

4:00PM (1613) *Locally mass-conservative Eulerian-Lagrangian methods for multiphase multicomponent transport.*
Thomas F. Russell, National Science Foundation (1067-65-1061)

4:30PM (1614) *Recovering a Tomographic Model of the Earth by Sparse Regularization of a Joint Inversion of Gravitational Data and Normal Mode Anomalies.*
Doreen Fischer, University of Siegen, Geomathematics Group (1067-65-308)

5:00PM (1615) *Moment discretization of ill-posed problems with discrete weakly bounded noise.* Preliminary report.
P. P.B. Eggermont*, **V. N. LaRiccia**, Food and Resource Economics, University of Delaware, and **M. Z. Nashed**, University of Central Florida (1067-45-996)

5:30PM (1616) *Data Analysis for the EOS Aura Microwave Limb Sounder.*
W. Van Snyder, California Institute of Technology Jet Propulsion Laboratory (1067-86-404)

6:00PM (1617) *Delayed Progress in Navigation: The Introduction of Line of Position Navigation in the 19th Century.*
Günther Oestmann, German Maritime Museum, Bremerhaven (1067-01-400)

NAM Granville-Brown-Haynes Session of Presentations by Recent Doctoral Recipients in the Mathematical Sciences

1:00 PM – 3:55 PM

1:00PM ► (1618) *Arithmetic Progressions in the y-coordinates of Certain Elliptic Curves.*
Alejandra Alvarado, University of Arizona (1067-11-358)

1:30PM (1619) *Reflexivity and Grothendieck Space Property for Positive Tensor Products of Banach Lattices.*
Michelle R Craddock, United States Military Academy (1067-46-518)

2:00PM ► (1620) *Super-Sech Solitons in Optical Fibers via the Variational Principle.*
Patrice D. Benson*, US Military Academy West Point, **Anjan Biswas**, **Dawn A. Lott**, Delaware State University, and **Daniala Milovic**, University of Nis (1067-78-1464)

2:30PM (1621) *On Independence Polynomials and Independence Equivalence in Graphs.*
L. Marie Chism, University of Mississippi (1067-05-1750)

3:00PM ► (1622) *In Search of Pythagorean Triples.*
Marcus D. Ashford, University of Alabama - Tuscaloosa, and **Katrina K. A. Cunningham***, Southern University - Baton Rouge (1067-11-1847)

3:30PM ► (1623) *Graphs of arbitrary excessive class.*
Michael E Young*, Iowa State University, and **Giuseppe Mazzuoccolo**, Dipartimento di Scienze e Metodi dell'Ingegneria, Università di Modena e Reggio Emilia (1067-05-1905)

AWM Michler-Mentoring Minisymposium

1:00 PM – 5:30 PM

Organizers: **Georgia Benkart**, University of Wisconsin-Madison
J. Matthew Douglass, University of North Texas

1:00PM (1624) *A Meeting of Algebra and Geometry in Decorated Graphs.*
Rebecca F Goldin, George Mason University, (1067-51-592)

1:30PM (1625) *An optimal metrization theorem for topological groupoids.*
Irina Mitrea, University of Minnesota (1067-00-1870)

2:00PM (1626) *Heat kernel analysis on infinite-dimensional curved spaces.*
Masha Gordina, University of Connecticut (1067-58-660)

2:30PM (1627) *Interplay of Combinatorics and Topology through Posets.*
Patricia L. Hersh, North Carolina State University (1067-05-1124)

3:00PM (1628) *The Evolution of Spatio-Temporal Models of Tumor Angiogenesis.*
Trachette L. Jackson, University of Michigan (1067-92-525)

3:30PM (1629) *Weak and numerical solutions for coupled Navier-Stokes, Darcy and transport equations.*
Beatrice Riviere, Rice University (1067-65-2025)

4:00PM Panel Discussion: Mentors Count!

SIGMAA on Environmental Mathematics Session on the BP Oil Discharge, Energy, and the Environment

1:00 PM – 4:10 PM

Organizer: **Ben Fusaro**, Florida State University

1:00PM (1630) *Modeling Near-Shore and Coastal Processes and Extreme Events.*
Clint Dawson, Institute for Computational Engineering and Sciences, University of Texas at Austin (1067-Z8-2310)

1:50PM ► (1631) *The BP spill, peak oil, and the search for energy.*
John W. Day*, Dept. of Oceanography and Coastal Sciences, Louisiana State University, Baton Rouge, LA 70803, and **Mathew Moerschbaecher**, Department of Oceanography and Coastal Sciences, School of Renewable Natural Resources (1067-Z8-2097)

2:40PM (1632) *The role of mathematics and modeling in cleaning up the BP oil spill.*
James M. Hyman, Tulane University (1067-Z8-2136)

3:30PM ► (1633) *Restoring Gulf Coast habitat after the BP oil spill.*
G. Paul Kemp, National Audubon Society Louisiana Coastal Initiative (1067-Z8-2281)

MAA Committee on the Undergraduate Program in Mathematics Panel Discussion

1:00 PM – 2:20 PM

Preparation and recruitment of future mathematics graduate students.

Organizer: **Amy Cohen**, Rutgers University
Panelists: **Dennis Davenport**, National Science Foundation
Phil Kutzko, University of Iowa
Ruth Haas, Smith College
Ulrica Wilson, Morehouse College

SIGMAA on Statistics Education Panel Discussion

1:00 PM – 2:20 PM

Teaching statistics online.

Organizer: **Brian Gill**, Seattle Pacific University
Panelists: **Michelle Everson**, University of Minnesota
Patricia Humphrey, Georgia Southern University
Michael Miner, American Public University
Sue Schou, Idaho State University

AMS Invited Address

1:10 PM – 2:00 PM

(1634) *Conformal weldings in quantum gravity: Zippers, necklaces, and SLE.*
Scott R. Sheffield, Massachusetts Institute of Technology (1067-60-10)

ASL Invited Address

2:00 PM – 2:50 PM

(1635) *Relational hidden variables and nonlocality.*
Samson Abramsky, University of Oxford (1067-03-62)

MAA Invited Address

2:15 PM – 3:05 PM

(1636) *Binary quadratic forms: From Gauss to algebraic geometry.*
Melanie Matchett Wood, American Institute of Mathematics and Stanford University (1067-A0-41)

MAA Minicourse #11: Part B

2:15 PM – 4:15 PM

Using video case studies in teaching a proof-based gateway course to the mathematics major.
Organizers: **James T. Sandefur**, Georgetown University
Connie M. Campbell, Milllsaps College
Kay Somers, Moravian College

MAA Minicourse #2: Part B

2:15 PM – 4:15 PM

Getting mathematics majors to think outside the book: Course activities that promote exploration, discovery, conjecture, and proof.
Organizers: **Suzanne Dorée**, Augsburg College
Jill Dietz, St. Olaf College
Brian P. Hopkins, St. Peter's College

MAA Minicourse #9: Part B

2:15 PM – 4:15 PM

Learning discrete mathematics via historical projects.
Organizers: **Jerry M. Lodder**, New Mexico State University
Guran Bezhanishvili, New Mexico State University
David J. Pengelley, New Mexico State University
Janet H. Barnett, Colorado State University, Pueblo

Rocky Mountain Mathematics Consortium Board of Directors Meeting

2:15 PM – 4:00 PM

AMS Committee on Science Policy Panel Discussion

2:30 PM – 4:00 PM

A Conversation with Sastry Pantula, the New Director of the Division of Mathematical Sciences at the National Science Foundation.

MAA Panel Discussion

2:35 PM – 3:55 PM

Inquiry-proof instructional techniques.
Organizers: **Tom Roby**, University of Connecticut
Dev Sinha, University of Oregon
Glenn Stevens, Boston University
Ravi Vakil, Stanford University
Panelists: **Keith Conrad**, University of Connecticut
Ken Ono, University of Wisconsin
David Pengelley, New Mexico State University
Margaret Robinson, Mount Holyoke College
Brad Shelton, University of Oregon
Michael Starbird, University of Texas

MAA Committee on Minority Participation-Society for the Advancement of Chicanos and Native Americans in Science-National Association of Mathematicians Panel Discussion

2:35 PM – 3:55 PM

The role of mentoring in undergraduate mathematics: Promising recruitment and retention strategies.
Organizers: **William Velez**, University of Arizona
Sylvia Bozeman, Spelman College
Ken Millett, University of California, Santa Barbara
Panelists: **Sylvia Bozeman**
Michelle Craddock, U. S. Military Academy
Rebecca Garcia, Sam Houston University
William Velez

ASL Invited Address

3:00 PM – 3:50 PM

(1637) *Maximal almost disjoint families.*
Juris Steprans, York University (1067-03-67)

MAA Presentations by Teaching Award Recipients

3:20 PM – 4:40 PM

Organizers: **Barbara Faires**, Westminster College
David Bressoud, Macalester College

3:20PM (1638) *What comes from within... when life serves you lemons.*
Zvezdelina Stankova, Mills College (1067-A0-578)

3:50PM ► (1639) *The problem of how to be a good teacher is undecidable.* Preliminary report.
Erica Flapan, Pomona College (1067-A0-965)

4:20PM (1640) *Most things you worry about never happen...*
Karen Rhea, University of Michigan

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.
Organizers: **Joyati Debnath**, Winona State University
Mike O'Leary, Towson University
Robert Vallin, Slippery Rock University

AWM Michler-Mentoring Minisymposium Panel Discussion

4:00 PM – 5:30 PM

Mentors count!
Moderator: **Marie Vitulli**, University of Oregon

Panelists: **Allan Donsig**, University of Nebraska-Lincoln
Ruth Haas, Smith College
Rhonda Hughes, Bryn Mawr College
Trachette Jackson, University of Michigan
Moira Mc Dermott, Syracuse University

ASL Session for Contributed Papers, I

4:10 PM – 5:45 PM

4:10PM (1641) *Stability in generic graphs with free non-algebraic extensions.*
Justin Brody, Franklin and Marshall College

4:35PM (1642) *Definable choice for a class of weakly o-minimal structures.*
Chris Laskowski, University of Maryland, and **Christopher Shaw***, Columbia College

5:00PM (1643) *Type spaces and Wasserstein spaces.*
Shichang Song, University of Illinois at Urbana-Champaign

5:25PM (1644) *Characterizing infinite cardinals by countable linear orderings.*
Ioannis Souldatos, Minnesota State University

AMS Congressional Fellowship Session

4:30 PM – 6:30 PM

Speakers: **Katherine Crowley**, 2009-2010 AMS Congressional Fellow
Hugh MacMillan, 2010-2011 AMS Congressional Fellow

SIGMAA on Mathematics Instruction Using the Web Business Meeting and Open Discussion

4:30 PM – 6:00 PM

Come share your interests in teaching and learning mathematics online and discuss the direction of future WEB SIGMAA activities.

National Academies/Board on Mathematical Sciences and Their Applications Special Presentation

4:30 PM – 5:20 PM

The Mathematical Sciences in 2025: A study commissioned by the National Science Foundation.
Organizers: **Mark L. Green**, University of California Los Angeles
Scott Weidman, National Academy of Sciences

SIGMAA on Mathematicians in Business, Industry, and Government Guest Lecture

5:00 PM – 5:45 PM

5:00PM (1645) *How mathematics is changing Hollywood.*
Tony DeRose, Pixar Animation Studios (1067-A0-127)

MAA Dramatic Presentation

6:00 PM – 7:00 PM

Derivative vs. Integral: The final showdown.
Organizers: **Colin Adams**, Williams College
Thomas Garrity, Williams College

SIGMAA on the Philosophy of Mathematics Business Meeting

6:00 PM – 6:30 PM

SIGMAA on Mathematics and the Arts Business Meeting

6:00 PM – 7:00 PM

SIGMAA on Environmental Mathematics Dramatic Presentation

6:00 PM – 7:00 PM

The Oil Volcano: Truth and Consequences.

AMS Mathematical Reviews Reception

6:00 PM – 7:00 PM

SIGMAA on Mathematicians in Business, Industry, and Government Reception

6:15 PM – 7:30 PM

SIGMAA on the Philosophy of Mathematics Guest Lecture

6:30 PM – 7:15 PM

► 6:30PM (1646) *Will the real philosophy of mathematics please stand up.* Preliminary report.
Keith Devlin, Stanford University (1067-A0-1172)

NAM Cox-Talbot Address

7:30 PM – 8:15 PM

(1647) *Increasing the pool of underrepresented mathematicians.*
Robert Bozeman, Morehouse College (1067-97-183)

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 Michigan-Duluth
Aparna W. Higgins, University of Dayton
P. Gavin LaRose, University of Michigan

Sunday, January 9

Joint Meetings Registration

7:30 AM – 2:00 PM

AMS-SIAM Special Session on Applications of Stochastic Processes in Neuroscience, I

8:00 AM – 10:50 AM

Organizers: **Peter Thomas**, Case Western Reserve University
Kreso Josic, University of Houston
Carson C. Chow, Institutes of Health

8:00AM (1648) *Correlation shaping in spiking neurons.*
Brent Doiron, University of Pittsburgh (1067-92-1436)

9:00AM (1649) *ON-OFF Episodic Activity: Noisy Oscillator or Noise-Driven Attractor Dynamics.*
John Rinzel, Courant Inst of Mathematical Sciences, New York University (1067-92-714)

► 9:30AM (1650) *Probing intrinsic bistability in neurons with noise: a case of inverse stochastic resonance.* Preliminary report.
Boris S Gutkin, Group for Neural Theory, LNC INSERM U 960, Departement des Etudes Cognitives, Ecole Normale Superieure and CNRS (1067-92-720)

10:00AM (1651) *Synchronization of periodically forced Ornstein Uhlenbeck processes with reset.* Preliminary report.
Peter J. Thomas, Case Western Reserve University (1067-92-498)

10:30AM (1652) *Linear PDE Models of Neurons with Random Excitations*.*
Frederic Y. M. Wan, University of California, Irvine (1067-92-490)

AMS-SIAM Special Session on Control and Inverse Problems for Partial Differential Equations, I

8:00 AM – 10:50 AM

Organizers: **Ana-Maria Croicu**, Kennesaw State University
Michele L. Joyner, East Tennessee State University

► 8:00AM (1653) *New regularity conditions for the minimal time function.* Preliminary report.
Peter R Wolenski, Louisiana State University (1067-35-1924)

8:30AM (1654) *Minimal Norm Control Asymptotics and Numerical Approximations for the Null Controllability of Non-Standard Parabolic-Like PDE Dynamics.*
George Avalos, University of Nebraska-Lincoln (1067-35-782)

9:00AM (1655) *Global uniqueness and stability in determining coefficients for a system of coupled Schrodinger equations.* Preliminary report.
Roberto Triggiani* and **Shitao Liu**, University of Virginia (1067-35-753)

9:30AM (1656) *Recovering a source from the measurments of acceleration of wall vibrations in structural acoustic problems.*
Irena Lasiecka* and **Shitao Liu**, University of Virginia (1067-35-594)

10:00AM (1657) *Electromagnetic Relaxation Time Distribution Inverse Problems in the Time-domain.*
Nathan L. Gibson, Oregon State University (1067-35-807)

10:30AM (1658) *Challenges of Control / Optimization Under Uncertainty.*
Ana-Maria Croicu, Kennesaw State University (1067-49-746)

AMS Special Session on Asymptotic Methods in Analysis with Applications, I

8:00 AM – 10:50 AM

Organizers: **Diego Dominici**, State University of New York at New Paltz
Peter A. McCoy, U.S. Naval Academy

8:00AM (1659) *Two Bessel Function Series in Ramanujan's Lost Notebook.*
Bruce C. Berndt, University of Illinois (1067-33-955)

8:30AM (1660) *Asymptotic Expansions of Certain Partial Theta Functions.*
Bruce C. Berndt, University of Illinois, and **Byungchan Kim***, Seoul national university of science and technology (1067-33-306)

9:00AM (1661) *The Asymptotic Hadamard Conjecture.* Preliminary report.
E. Rodney Canfield, Dept. of Computer Science, Univ. of Georgia (1067-05-1695)

9:30AM (1662) *Γ-convergence of Power-Law Functionals and Applications to Polycrystal Plasticity.*
Cristina Popovici, North Dakota State University (1067-49-85)

10:00AM (1663) *Densities of short uniform random walks.*
Jonathan M Borwein*, CARMA, University of Newcastle NSW Australia, **Armin Straub**, Tulane University, **James Wan** and **Wadim Zudilin**, CARMA (1067-41-298)

10:30AM (1664) *Asymptotic Analysis of Dynamic Storage Allocation Models.*
Charles Knessl*, University of Illinois at Chicago, and **Sohn Eunju**, University of Georgia (1067-41-816)

AMS Special Session on Formal Mathematics for Mathematicians: Developing Large Repositories of Advanced Mathematics, II

8:00 AM – 10:50 AM

Organizers: **Krystyna M. Kuperberg**, Auburn University
Andrzej Trybulec, University of Bialystok
Artur Kornilowicz, University of Bialystok
Adam Naumowicz, University of Bialystok

8:00AM (1665) *Type inference in finite group theory.*
Jeremy Avigad, Department of Philosophy, Carnegie Mellon University (1067-03-910)

8:30AM (1666) *Mechanizing the Odd Order Theorem: Local Analysis.*
Georges Gonthier, Microsoft Research (1067-03-836)

► 9:00AM (1667) *Mizar-supported maths teaching at the university level.*
Adam Naumowicz* and **Artur Kornilowicz**, Institute of Informatics, University of Bialystok, Poland (1067-97-1443)

9:30AM (1668) *Recent achievement of codification on real analysis in Mizar.*
Yasushige Watase*, Shinshu University, Faculty of Engineering, **Noboru Endo**, Gifu National College of Technology, Dept. of Electronic Control Engineering, and **Yasunari Shidama**, Shinshu University, Faculty of Engineering (1067-68-1135)

10:00AM ► (1669) *Computerising Mathematical texts with MathLang.* **Fairouz Kamareddine**, Heriot-Watt University (1067-03-1396)

10:30AM ► (1670) *The language of mathematics in Mizar.* **Artur Kornilowicz*** and **Adam Naumowicz**, Institute of Informatics, University of Bialystok, Poland (1067-68-1444)

AMS Special Session on Multivariable Operator Theory, II

8:00 AM – 10:50 AM

Organizers: **Ronald G. Douglas**, Texas A&M University
Gelu F. Popescu, University of Texas at San Antonio

8:00AM (1671) *Non-commutative Inequalities.* **J William Helton**, UC San Diego (1067-47-636)

8:30AM (1672) *Multivariable Nevanlinna-Pick interpolation and connections with control theory.* **Joseph A. Ball**, Virginia Tech (1067-47-908)

9:00AM (1673) *Ergodic actions of convergent Fuchsian groups on quotients of the noncommutative Hardy algebras.* **Alvaro Arias*** and **Frederic Latremoliere**, University of Denver (1067-47-522)

9:30AM (1674) *Commutative operator algebras and realizations of polynomials on domains in $\mathbb{C}^n$.* Preliminary report. **Michael Jury**, University of Florida (1067-47-693)

10:00AM ► (1675) *Invariant subspaces of nilpotent operators.* **Markus Schmidmeier**, Florida Atlantic University (1067-16-839)

10:30AM (1676) *Operators Cauchy dual to 2-hyperexpansive operators: The multivariable case.* Preliminary report. **Raul E Curto**, The University of Iowa (1067-47-611)

AMS Special Session on Mathematics Related to Feynman Diagrams, II

8:00 AM – 10:45 AM

Organizers: **Victor H. Moll**, Tulane University
Olivier Espinosa, Universidad Santa Maria, Valparaiso

8:00AM (1677) *From Feynman diagrams to Potts models: a motivic approach.* Preliminary report. **Paolo Aluffi**, Florida State University, and **Matilde Marcolli***, Caltech (1067-81-1420)

9:00AM (1678) *On the method of brackets.* **Armin Straub**, Tulane University (1067-33-1720)

10:00AM (1679) *The Hypergeometric Representation of Feynman Diagrams and Construction of the Epsilon Expansion.* **Scott A. Yost***, The Citadel, **Vladimir V. Bytev**, **Mikhail Yu. Kalmykov**, Hamburg Univ. Inst. Theoretical Physics II and J.I.N.R., Dubna, **Bernd A. Kniehl**, Hamburg Univ. Inst. Theoretical Physics II, and **B. F. L. Ward**, Baylor University (1067-81-1500)

AMS Special Session on Analysis of Reaction-Diffusion Models, I

8:00 AM – 10:50 AM

Organizers: **Junping Shi**, College of William and Mary
Xuefeng Wang, Tulane University

8:00AM (1680) *Diffusive logistic equation with non-linear boundary conditions.* **Jerome Goddard II***, Mississippi State University, **Eun Kyoung Lee**, Pusan National University, and **Ratnasingham Shivaji**, Mississippi State University (1067-35-302)

8:30AM (1681) *Positioning the Z-ring near the mid-cell via the spatio-temporal oscillation of the Min system.* **Zhigang Zhang**, University of Houston (1067-35-1948)

9:00AM (1682) *Random dispersal versus fitness-dependent dispersal.* **Robert Stephen Cantrell***, **Chris Cosner**, University of Miami, **Yuan Lou** and **Chao Xie**, Ohio State University (1067-35-776)

9:30AM (1683) *Spatial Spreading Dynamics in Nonlocal Monostable Equations in Spatially Periodic Habitats.* **Wenxian Shen*** and **Aijun Zhang**, Auburn University (1067-35-1267)

10:00AM (1684) *Renormalization Group Method for Semi-Strong Pulse Interactions.* **Thomas Bellsky*** and **Keith Promislow**, Michigan State University (1067-35-131)

10:30AM (1685) *A One-Dimensional Nonlinear Stability Analysis of Vegetative Pattern Formation for an Interaction-Diffusion Plant-Surface Water Model System in an Arid Flat Environment.* **Bonni J Kealy*** and **David J Wollkind**, Washington State University (1067-92-433)

AMS Special Session on Continued Fractions, I

8:00 AM – 10:45 AM

Organizers: **James G. McLaughlin**, West Chester University
Nancy J. Wyshinski, Trinity College

8:00AM (1686) *Biorthogonal Rational Functions and R Fractions.* **Mourad E. H. Ismail**, City University of Hong Kong (1067-33-626)

9:00AM ► (1687) *On periodic Jacobi-Perron algorithm over formal power series field.* Preliminary report. **Amara Chandoul**, Superior Institute of Computer and meltimedia Sfax-Tunisia (1067-11-204)

9:30AM (1688) *Szegő polynomials and para-orthogonal polynomials associated with hypergeometric functions.* Preliminary report. **Dimitar K. Dimitrov** and **Alagacone Sri Ranga***, Universidade Estadual Paulista (1067-33-1452)

10:00AM (1689) *Convergence of continued fractions.* Preliminary report. **Lisa Lorentzen**, Norwegian University of Science and Technology (1067-40-1950)

AMS Special Session on Noncommutative Harmonic Analysis and Dynamic Systems, I

8:00 AM – 10:50 AM

Organizers: **Tao Mei**, Wayne State University
Alan D. Wiggins, University of Michigan at Dearborn

8:00AM (1690) *Entropy and Fuglede-Kadison determinant.* **Hanfeng Li**, SUNY at Buffalo (1067-37-198)

8:30AM (1691) *Entropy and the variational principle for actions of sofic groups.* **David Kerr***, Texas A&M University, and **Hanfeng Li**, SUNY at Buffalo (1067-37-304)

9:00AM (1692) *Cohomology on measure preserving equavalence relations.*
Jesse D. Peterson, Vanderbilt University (1067-46-1519)

9:30AM (1693) *Operator algebras with contractive approximate identities.* Preliminary report.
David P Blecher, University of Houston (1067-47-272)

10:00AM (1694) *Strong solidity for group factors from lattices in* SO(n, 1) *and* SU(n, 1)
Thomas Sinclair, Vanderbilt University (1067-46-932)

10:30AM (1695) *A Lower Bound for the Spectral Radius of Random Walks on the Baumslag-Solitar Group.*
Daniel E. L. Redelmeier* and **Ken Dykema**, Texas A&M University (1067-46-602)

AMS Special Session on Combinatorial Algebraic Geometry, I

8:00 AM – 10:50 AM

Organizers: **Frank Sottile**, Texas A&M University
Alexander T. Yong, University of Illinois, Urbana-Champaign

8:00AM (1696) *Degeneration of Frobenius splittings, and Kazhdan-Lusztig varieties.*
Allen Knutson, Cornell University (1067-14-1698)

8:30AM (1697) *Local complete intersection Schubert varieties.* Preliminary report.
Alexander Woo*, Saint Olaf College, and **Henning Ulfarsson**, Reykjavik University (1067-14-1289)

9:00AM (1698) *Permutation group representations and (equivariant) cohomology of Hessenberg varieties.*
Julianna Tymoczko, University of Iowa (1067-14-2291)

9:30AM (1699) *Positivity in the Symplectic Category.*
Rebecca F Goldin*, George Mason University,, and **Susan Tolman**, University of IL, Champaign-Urbana (1067-51-1688)

10:00AM ► (1700) *Polyhedral Adjunction Theory.*
Sandra Di Rocco, KTH Stockholm, **Christian Haase**, FU Berlin, **Benjamin Nill***, University of Georgia, and **Andreas Paffenholz**, TU Darmstadt (1067-52-647)

10:30AM (1701) *Equivariant methods for hypergeometric systems.*
Christine Berkesch*, Stockholm University, and **Laura Felicia Matusevich**, Texas A&M University (1067-14-819)

AMS Special Session on Nonlinear Evolution Equations, Analysis, and Geometry, II

8:00 AM – 10:50 AM

Organizers: **Ralph Saxton**, University of New Orleans
Feride Tiglay, Fields Institute

8:00AM (1702) *Systems of conservation or balance laws with Lorentz-rotation symmetry.*
Michael Sever, The Hebrew University of Jerusalem (1067-35-282)

8:30AM (1703) *Localization, Smoothness, and Convergence to Equilibrium for a Thin Film Equation.*
Eric A Carlen, Rutgers University, and **Suleyman Ulusoy***, University of Maryland (1067-35-426)

9:00AM (1704) *Newtonian limits of complex fluid models.*
Milton C. Lopes Filho, University of Campinas (1067-76-2313)

9:30AM (1705) *Stability of Solitary-Wave Solutions of the Hirota-Satsuma Equation.*
Jerry L. Bona, University of Illinois at Chicago (1067-35-951)

10:00AM (1706) *Euler-Arnold equations on orbits of diffeomorphism groups.*
Gerard Misiolek, Univ. of Notre Dame (1067-58-1331)

10:30AM (1707) *Two-dimensional incompressible flows as limits of 3D helical flows.* Preliminary report.
Milton C Lopes Filho, IMECC - UNICAMP, **Dongjuan Niu**, Capitol Normal University, Beijing, PRC, **Edriss S Titi**, University of California, Irvine and Weizmann Institute, and **Helena J Nussenzveig Lopes***, IMECC-UNICAMP (University of Campinas) (1067-35-2106)

AMS Special Session on Structure Theory for Matroids and Graphs, I

8:00 AM – 10:50 AM

Organizers: **Bogdan Oporowski**, Louisiana State University
James G. Oxley, Louisiana State University

8:00AM (1708) *Graphs that are Almost Series-Parallel.*
Lisa M Warshauer, Louisiana State University (1067-05-1196)

8:30AM (1709) 3*-connected graphs of path-width at most three.*
Stan Dziobiak* and **Guoli Ding**, Louisiana State University (1067-05-1583)

9:00AM (1710) *Excluding a small minor.*
Guoli Ding, LSU, and **Cheng Liu***, Central South University, China (1067-05-1593)

9:30AM (1711) K_5*-subdivisions in 5-connected nonplanar graphs.*
Xingxing Yu* and **Jie Ma**, Georgia Institute of Technology (1067-05-2416)

10:00AM ► (1712) *2-crossing-critical graphs.*
Drago Bokal, University of Maribor, **Bogdan Oporowski**, Louisiana State University, **R. Bruce Richter***, University of Waterloo, and **Gelasio Salazar**, Universidad Autonoma San Luis Potosi (1067-05-440)

10:30AM ► (1713) *On graph well-quasi-order by topological inclusion.*
Neil Robertson, Ohio State University (1067-05-2373)

AMS Special Session on Knot Theory, II

8:00 AM – 10:50 AM

Organizers: **Tim D. Cochran**, Rice University
Shelley Harvey, Rice University

8:00AM (1714) *Seifert fibered Dehn filling.* Preliminary report.
Cameron McA. Gordon*, University of Texas at Austin, **Steven Boyer**, UQAM, and **Xingru Zhang**, SUNY Buffalo (1067-57-825)

8:30AM (1715) *A Generalization of the Turaev Cobracket and the Minimal Self-Intersection Number.*
Patricia Cahn, Dartmouth College (1067-57-639)

9:00AM (1716) *Cube Number Distinguishes Legendrian Type for Certain Torus Knots.* Preliminary report.
Ben M McCarty, Louisiana State University (1067-57-505)

9:30AM (1717) *Satellites of knots and bordered Heegaard Floer homology.*
Ina Petkova, Columbia University (1067-54-616)

10:00AM (1718) *The topology of Springer varieties.* **Heather M. Russell**, Louisiana State University (1067-57-759)

10:30AM (1719) *Reconstructing* HFK^- *from sutured Floer homology.* **John Etnyre**, Georgia Tech, **David Shea Vela-Vick*** and **Rumen Zarev**, Columbia University (1067-57-744)

AMS Special Session on Time Scales: Theory and Applications, I

8:00 AM – 10:50 AM

Organizers: **Billy Jackson**, Saint Xavier University
Joan Hoffacker, Clemson University

8:00AM (1720) *Fundamentals of Nonlinear Control on Time Scales.* Preliminary report. **Billy Jackson**, St. Xavier University (1067-93-361)

► 8:30AM (1721) *The Laplace Transform in Discrete Fractional Calculus.* **Michael Holm**, University of Nebraska–Lincoln (1067-39-501)

9:00AM (1722) *Asymptotic Equivalence Classes and Regions of Time Scale Exponential Stability.* Preliminary report. **John M Davis**, Baylor University (1067-93-1930)

9:30AM (1723) *Generalized time scales and the Hahn quantum variational calculus.* **Agnieszka B. Malinowska*** and **Delfim F. M. Torres**, University of Aveiro, Portugal (1067-49-449)

10:00AM (1724) *Asymptotic behavior of an n-th order sublinear dynamic equation.* **A Peterson**, University of Nebraska-Lincoln (1067-34-379)

► 10:30AM (1725) *Mean Square Stability of Ito-Volterra Dynamic Equation.* **Suman Sanyal**, Marshall University (1067-00-1610)

AMS Session on Probability, I

8:00 AM – 10:55 AM

8:00AM (1726) *Period-2 behavior and spatial correlations in a probabilistic lattice model of the cardiac cell.* **Robert J Rovetti**, Loyola Marymount University (1067-60-2317)

8:15AM (1727) *Comparing the distributions of various supremums on two-time parameter Wiener space.* Preliminary report. **David L. Skoug**, University of Nebraska-Lincoln (1067-60-1734)

8:30AM (1728) *Reflection principle(s) for the multiple parameter Wiener process?* Preliminary report. **Ian Pierce**, University of Nebraska - Lincoln (1067-60-2046)

8:45AM (1729) *A 'Cousin of Coboundary' Theorem for* $C[0,1]$*-Valued Random Fields with Moment Conditions.* Preliminary report. **Steven T. Morrow**, Indiana University (1067-60-2292)

9:00AM (1730) *A New Asymptotic Expansion for Distributions of Sums of Random Variables.* **Ross P Hilton***, **Kenneth S Berenhaut** and **James W Chernesky**, Wake Forest University (1067-60-1787)

9:15AM (1731) *Tracking communities with a graph-valued Markov process.* **James P Ferry**, Metron, Inc. (1067-60-2041)

9:30AM (1732) *Birth-Death Markov chains Having Hyper-Probability Transitions.* **Mark Burgin**, University of California, Los Angeles, **Mark Dela***, California State Polytechnic University, Pomona, **Alan Krinik**, California State Polytechnic Univ., Pomona, and **David Luu**, California State Polytechnic University, Pomona (1067-60-1710)

9:45AM (1733) *Analogue of Hardy's Inequality for a Renewal Process.* Preliminary report. **Constantine Georgakis**, DePaul University (1067-60-2320)

10:00AM (1734) *A test for testing the equality of covariance operators.* **Krishna Kaphle***, **Frits H. Ruymgaart** and **George Gaines**, Texas Tech University (1067-60-2135)

► 10:15AM (1735) *Weighted and Unweighted Random Walks of Multiple Entities on a Torus-Shaped World.* Preliminary report. **Richard Freedman*** and **Errin Fulp**, Wake Forest University (1067-60-1705)

10:30AM (1736) *Using TPA to count linear extensions.* **Jacqueline Banks**, University of California, Riverside, **Scott Garrabrant**, Pitzer College, **Mark L Huber***, Claremont McKenna College, and **Anne Perizzolo**, Columbia University (1067-60-1358)

► 10:45AM (1737) *Predictive Methods in Coupon Collection.* Preliminary report. **Chelsea R Ross*** and **Brooks E Smith**, East Tennessee State University (1067-60-1785)

AMS Session on Group Theory, I

8:00 AM – 10:55 AM

8:00AM (1738) *An Algorithm to Express Words as Conjugates of Relators.* **Ellen M Ziliak***, Benedictine University, and **Alexander Hulpke**, Colorado State University (1067-20-225)

8:15AM (1739) *An Investigation into an Amalgam between an* $SU_3(q)$ *and an* $SL_3(q)$*: Preliminary Report.* Preliminary report. **Philip Keen**, University of Birmingham (1067-20-373)

► 8:30AM (1740) *On the number of maximal subgroups of a finite solvable group.* Preliminary report. **Benjamin Newton**, Beloit College (1067-20-1096)

8:45AM (1741) *Lower Central Series and Derived Series of the Free Nilpotent Groups of Finite Rank.* Preliminary report. **Mark Pedigo**, Saint Louis University (1067-20-1125)

9:00AM (1742) *Capability of* p*-groups of class* 2 *and exponent* p*.* Preliminary report. **Arturo Magidin***, University of Louisiana at Lafayette, and **Robert Fitzgerald Morse**, University of Evansville (1067-20-1174)

9:15AM (1743) *Injectors in Direct Products of Finite Solvable Groups.* **Joseph Evan**, King's College (1067-20-1454)

9:30AM (1744) *Nonabelian tensor products: the mystery of compatible actions.* Preliminary report. **Luise-Charlotte Kappe**, State University of New York at Binghamton (1067-20-1546)

9:45AM (1745) *The base of a permutational wreath product.* **Elizabeth Wilcox**, Colgate University (1067-20-1650)

10:00AM (1746) *Characterizing Containment of Subgroups in a Direct Product.* Preliminary report. **Dandrielle Lewis**, Binghamton University (1067-20-1960)

10:15AM (1747) *Counting subgroups of S_{n+1} normalized by and coprime to a nonabelian regular subgroup of order n.* Preliminary report.
Stephen M. Gagola, Jr, Kent State University (1067-20-2121)

10:30AM (1748) *IA-automorphisms of wreath products.*
Margaret H Dean, Borough of Manhattan Community College (CUNY), **Gretchen Ostheimer**, Hofstra University, and **Marcos Zyman***, Borough of Manhattan Community College (CUNY) (1067-20-2176)

10:45AM (1749) *The Interassociates of the Bicyclic Semigroup.*
Berit Nilsen Givens* and **Amber Rosin**, Cal Poly Pomona (1067-20-2225)

AMS Session on Topics in Mathematical Physics

8:00 AM – 10:55 AM

8:00AM (1750) *Optimization of an Antenna Structure for a Photovoltaic Nanodevice.*
Emily J Forney, Clemson University (1067-00-1676)

8:15AM (1751) *Electromagnetic Scattering from Large Cavities.*
Weiwei Zhang, King's College (1067-78-1582)

8:30AM ► (1752) *Phase Diagram Calculation via Constrained Optimization.*
Sandra Jeannette Varela, California State University, Scaramento (1067-00-2328)

8:45AM (1753) *Arc-wise connectedness of solution sets of quantum stochastic differential inclusions.*
Ezekiel Olusola Ayoola, University of Ibadan, Nigeria (1067-81-71)

9:00AM ► (1754) *Classification of symmetric states under local unitary action.*
Curt D Cenci, Lebanon Valley College (1067-81-157)

9:15AM ► (1755) *The basic physics of Feynman diagrams.*
Ivan Gonzalez, Departamento de Fisica, Universidad Santa Maria, Chile (1067-81-1421)

9:30AM (1756) *Critical Temperature of Ising Ferromagnets and Spectral Curve of Dimers.*
Zhongyang Li, Brown University (1067-82-44)

9:45AM (1757) *A Cluster Expansion Approach to Renormalization Group Transformations.*
Mei Yin, University of Texas at Austin (1067-82-218)

10:00AM ► (1758) *Distributional Sensitivity in Polycrystalline Grain Growth Simulations.*
Ross Robert Kistler, Loyola University Maryland (1067-82-1732)

10:15AM (1759) *Symmetry breaking in quasi-1D Coulomb systems.*
Paul H Jung*, Sogang University, **Michael Aizenman**, Princeton University, and **Sabine Jansen**, Weierstrass Institute (1067-82-1833)

10:30AM ► (1760) *Orbifolds, the A, D, E Family of Caustic Singularities, and Gravitational Lensing.*
Amir Babak Aazami, Duke University (1067-83-1984)

10:45AM ► (1761) *Geometry of the Random Time Delay Surface and the Expected Number of Lensed Images in Microlensing.* Preliminary report.
Alberto M. Teguia* and **Arlie Petters**, Duke University (1067-83-2211)

AMS Session on Complex Analysis

8:00 AM – 10:55 AM

8:00AM (1762) *Interpolation Sequence for the Spaces $H^q_+(\varphi)(q \geq 1)$.*
Maher M.H. Marzuq, Plymouth, Massachusetts (1067-30-59)

8:15AM (1763) *Regularity of Solutions to Extremal Problems in Bergman Spaces.*
Tim Ferguson, University of Michigan, Ann Arbor (1067-30-217)

8:30AM (1764) *On a refinement of Sendov's conjecture (part 2).* Preliminary report.
Michael J Miller, Le Moyne College (1067-30-1422)

8:45AM (1765) *Iceberg-type Problems: Estimating Hidden Parts of a Convex Continuum from the Visible Parts.*
Matthew H Lochman*, **Roger W Barnard** and **Alexander Yu Solynin**, Texas Tech University (1067-30-1591)

9:00AM (1766) *Construction of Complex-Valued Harmonic Mappings Convex in One or Every Direction.* Preliminary report.
Stacey Muir, University of Scranton (1067-30-1563)

9:15AM (1767) *Hypergeometric functions and subclasses of Harmonic Mappings.*
R. M. Ali, **See Keong Lee***, **Chandrashekar R.** and **K. G. Subramanian**, Universiti Sains Malaysia (1067-30-2305)

9:30AM (1768) *Porosity and limit sets.*
Andrew Lazowski, Sacred Heart University (1067-00-1299)

9:45AM (1769) *Comparison of Conformal Metrics.*
Kourosh Tavakoli, City University of New York (1067-30-1803)

10:00AM (1770) *Riemann-Hilbert families of Schwarzian equations on the punctured torus.*
David J Pinchbeck, St. Joseph's College of Maine (1067-30-1544)

10:15AM (1771) *Thomae formula for general cyclic covers of $\mathbb{CP}^1$.*
Yaacov Kopeliovich, Meag, NY (1067-32-513)

10:30AM (1772) *The Roles Played by Order of Convexity or Starlikeness and the Bloch Condition in the Extension of Mappings from the Disk to the Ball.* Preliminary report.
Jerry R. Muir, Jr., University of Scranton (1067-32-1554)

10:45AM (1773) *Classifying Homogeneous Trees and Lattices.*
Lucio M-G Prado, BMCC-The City University of New York (1067-31-2218)

MAA Session on New and Continuing Connections between Math and the Arts, II

8:00 AM – 10:55 AM

Organizer: **Douglas E. Norton**, Villanova University

8:00AM (1774) *Using Art to Inspire Conceptual Understanding of Fractions.*
Rachel B Manspeaker*, **Andrew Bennett**, **Hien Nguyen** and **Peter Nguyen**, Kansas State University (1067-S1-1520)

8:20AM ► (1775) *Student-Written Plays in a History of Mathematics Class.*
Harrison W. Straley, Wheaton College (1067-S1-344)

8:40AM (1776) *Math and the art of M.C. Escher.*
Anneke Bart, Saint Louis University (1067-S1-1004)

9:00AM ► (1777) *Mathematics, Excel, and Graphic Design in Multicultural Alphabet Books for Papua New Guinea.*
Deane E Arganbright* and **Susan C Arganbright**, Divine Word University (Papua New Guinea) (1067-S1-233)

9:20AM ► (1778) *Teaching Mathematics Through Music for a Liberal Arts Audience.* Preliminary report.
Kurt E Ludwick, Salisbury University (1067-S1-1827)

9:40AM ► (1779) *Inversions and the Dihedral Group in Music.* Preliminary report.
Craig M. Johnson, Marywood University (1067-S1-2216)

10:00AM (1780) *What Does That Picture Sound Like? Calculus and Photosounder.*
Phil Gustafson, Mesa State College (1067-S1-888)

10:20AM ► (1781) *How to cook up a math poem in n easy steps.* Preliminary report.
Caleb Emmons, Pacific University (1067-S1-791)

10:40AM ► (1782) *Decoding DaVinci.*
Susan McBurney, Western Springs, IL (1067-S1-384)

MAA Session on Trends in Undergraduate Mathematical Biology Education

8:00 AM – 10:55 AM

Organizers: **Timothy D. Comar**, Benedictine University
Raina Robeva, Sweet Briar College
Mike Martin, Johnson County Community College

8:00AM (1783) *What do we mean when we say we "want students to understand exponential growth?".*
Carlos W Castillo-Garsow, Kansas State University (1067-X1-2047)

8:20AM (1784) *An ethnographic case study of precision taught bio-calculus.*
Brian Arthur Christopher* and **Rebecca-Anne Dibbs**, University of Northern Colorado (1067-X1-1675)

8:40AM ► (1785) *Motivating the Biology in Biocalculus Courses.*
Timothy D Comar, Benedictine University (1067-X1-700)

9:00AM ► (1786) *Undergraduate Mathematical Biology Research at Truman State University.* Preliminary report.
Pam J Ryan, Truman State University (1067-X1-1689)

9:20AM (1787) *Biomath is more than theorems with biological examples: an integrative framework.*
Dmitry A Kondrashov, University of Chicago (1067-X1-2165)

9:40AM ► (1788) *Title of paper: Biology and Mathematics: The Exciting Nexus for the Advancement of Sciences.* Preliminary report.
Sumona Mondal, Clarkson University (1067-X1-1968)

10:00AM (1789) *Undergraduate Student Mentoring – Minority Participation, Retention, Motivation for Higher Studies.* Preliminary report.
Urmi Ghosh-Dastidar, NYCCT, CUNY (1067-X1-2268)

10:20AM ► (1790) *Development and Implementation of an Undergraduate Honors Course on Mathematical Ecology.* Preliminary report.
Vrushali A Bokil* and **Julia A Jones**, Oregon State University (1067-X1-2241)

10:40AM (1791) *An Intro to Mathematical Biology Course for Biology Majors.*
Sarah A Hews, Swarthmore College (1067-X1-1979)

MAA Session on Effective Teaching of Upper Level Mathematics to Secondary Education Mathematics Majors, II

8:00 AM – 10:55 AM

Organizer: **Joyati Debnath**, Winona State University

8:00AM ► (1792) *Lines and circles: A range of viewpoints.* Preliminary report.
Kevin Hartshorn, Moravian College (1067-E1-2161)

8:20AM ► (1793) *Differing views on assessment: Two instructors' strategies for modeling assessment techniques for prospective secondary mathematics teachers in an upper level team-taught geometry course.* Preliminary report.
Sarah K. Bleiler*, **Gladis Kersaint** and **Milé Krajcevski**, University of South Florida (1067-E1-1674)

8:40AM ► (1794) *Geometry for Prospective Mathematics Teachers.*
Vesna Kilibarda, Indiana University Northwest (1067-E1-1249)

9:00AM ► (1795) *Revisiting College Geometry: Making it Relevant for Math, Math Education and Elementary Education Majors.*
Talitha M. Washington, University of Evansville (1067-E1-1240)

9:20AM ► (1796) *Geometry then and now: Making room for Euclid in the 21st century mathematics curriculum.*
Mark A Miller, Marietta College (1067-E1-305)

9:40AM (1797) *Experiencing the history of mathematics in a capstone course for prospective teachers.* Preliminary report.
Jennifer A Bergner, Salisbury University (1067-E1-1147)

10:00AM ► (1798) *History of Mathematics for Prospective Secondary Teachers.*
Kenneth J Bernard, Virginia State University (1067-E1-1466)

10:20AM ► (1799) *Research-Based Methods for Improving Learning and Assessment.*
Amy Mihnea, Florida Atlantic University (1067-E1-1822)

10:40AM (1800) *Helping Pre-service Teachers Recognize Continuity in the Secondary Curriculum.*
Kristin A. Camenga* and **Rebekah Yates**, Houghton College (1067-E1-731)

MAA Session on Influences of the Calculus Reform Movement on the Teaching of Mathematics, I

8:00 AM – 10:55 AM

Organizers: **Steven R. Benson**, Lesley University
Marilyn Carlson, Arizona State University
Ellen E. Kirkman, Wake Forest University
Joe Yanik, Emporia State University

8:00AM ► (1801) *Twenty Years of Calculus Reform at Duke University.* Preliminary report.
Jack Bookman, Duke University (1067-J1-1150)

8:20AM (1802) *Comparing Calculus classes before the start of Calculus Reform and Calculus classes today.*
Stephen R. Hilbert, Ithaca College (1067-J1-2078)

8:40AM ► (1803) *Teaching College Mathematics Before, During and after the Calculus Reform Movement: A Retrospective Prospective.* Preliminary report.
Ann E Moskol, Rhode Island College (1067-J1-1788)

9:00AM ► (1804) *Reflections on Calculus Reform: How I Was Taught vs. How I Teach.*
Sarah L Mabrouk, Framingham State University (1067-J1-2315)

9:20AM (1805) *21st Century Calculus Reform: Don't Just Paint the Walls and Rearrange the Furniture.*
Mariah Birgen* and **Brian Birgen**, Wartburg College (1067-J1-246)

9:40AM ► (1806) *Calculus reform: What next?*
Patricia Baggett*, New Mexico State University, and **Andrzej Ehrenfeucht**, University of Colorado (1067-J1-1139)

10:00AM ► (1807) *Calculus Reform and AP Calculus.*
Michael E Boardman*, Pacific University, and **Stephen L Davis**, Davidson College (1067-J1-1368)

10:20AM ► (1808) *Have a Good Conclusion: The Value of Ending a Year-Long Calculus Course with an Introduction to Differential Equations.* Preliminary report.
Patti Frazer Lock, St. Lawrence University (1067-J1-2070)

10:40AM (1809) *Calculus Reform and Discrete Mathematics.*
Bill Marion, Valparaiso University (1067-J1-73)

MAA General Contributed Paper Session, XII

8:00 AM – 10:55 AM

Organizers: **Kristen Meyer**, Wisconsin Lutheran College
Thomas R. Hagedorn, The College of New Jersey

8:00AM ► (1810) *A. Horn's result on matrices with prescribed singular values and eigenvalues.* Preliminary report.
Tin-Yau Tam, Auburn University (1067-Z1-1409)

8:15AM ► (1811) *A range associated with skew symmetric matrix.*
Dawit Gezahegn Tadesse*, **Xuhua Liu** and **Tin-Yau Tam**, Auburn University (1067-Z1-1945)

8:30AM ► (1812) *Examples of Highly Frustrated Matrices.*
Garry S Bowlin, Binghamton University (1067-Z1-1505)

8:45AM (1813) *Multiplicities and generalized numerical range.*
Xuhua Liu, Auburn University (1067-Z1-2248)

9:00AM ► (1814) *Using Mathematica to Teach Linear Differential Operators and the Method of Undetermined Coefficients.*
Itai Seggev, Knox College / Wolfram Research (1067-Z1-2117)

9:15AM ► (1815) *Undetermined Coefficients – Not Just for Constant-Coefficient Equations Anymore.* Preliminary report.
Doreen De Leon, California State University, Fresno (1067-Z1-870)

9:30AM ► (1816) *Imaging Science For Undergraduate Projects Using ODEs and PDEs.*
Emek Kose Can, Loyola Marymount University (1067-Z1-2298)

9:45AM ► (1817) *A Differential Equation With Many Faces.*
Mohammad K. Azarian, University of Evansville (1067-Z1-229)

10:00AM (1818) *Partial Regularity for Parabolic Systems with Subquadratic Growth.* Preliminary report.
Mikil Foss and **Joe Geisbauer***, University of Nebraska-Lincoln (1067-Z1-1744)

10:15AM ► (1819) *Second derivative Adams-type methods for boundary value problems.*
Noureen A. Khan*, University of North Texas Dallas, **Ramanjit Sahi** and **S N Jator**, Austin Peay State University (1067-Z1-464)

10:30AM (1820) *D-Optimal Designs for Models Described by Ordinary Differential Equations.*
Adam F Childers, Roanoke College (1067-Z1-732)

10:45AM (1821) *Classification of Automorphism Groups of Rational Elliptic Surfaces.* Preliminary report.
Tolga Karayayla, University of Pennsylvania (1067-Z1-1879)

SIAM Minisymposium on Vistas in Applied Mathematics

8:00 AM – 10:45 AM

Organizers: **Maria-Carme Calderer**, University of Minnesota
Zuhair Nashed, University of Central Florida

8:00AM ► (1822) *Did Mathematics Cause the Subprime Mortgage Disaster?*
Steven E. Shreve, Carnegie Mellon University (1067-60-1000)

9:00AM ► (1823) *Recent Progress in Sparse Signal Recovery and Processing.*
G Richard Baraniuk, Rice University (1067-41-1817)

10:00AM (1824) *Modeling Fluids with Microstructure.*
Noel J Walkington, Carnegie Mellon University (1067-65-1212)

AWM Workshop

8:00 AM – 4:00 PM

This session has several parts that will be listed separately by time in this program. All presentations are open to all JMM participants.

Organizer: **Cammey Cole Manning**, Meredith College

AWM Workshop: Research Presentations by Recent Ph.D.s, I

8:00 AM – 10:20 AM

Chair: **Rachelle DeCoste**, Wheaton College

8:00AM (1825) *Tensor category of integrable modules over $\mathfrak{sl}_\infty$, $\mathfrak{so}_\infty$, and $\mathfrak{sp}_\infty$.*
Elizabeth Dan-Cohen*, **Ivan Penkov**, Jacobs University Bremen, and **Vera Serganova**, U.C. Berkeley (1067-17-244)

8:30AM (1826) *Prime Ideals in Birational Extensions of Two-Dimensional Power Series Rings.* Preliminary report.
Christina L. Eubanks-Turner*, University of Louisiana at Lafayette, **Serpil Saydam**, University of Louisiana at Monroe, and **Melissa Luckas**, University of Nebraska-Lincoln (1067-13-230)

9:00AM (1827) *Freeness of Arrangement Bundles.*
Amanda C Hager, USMA West Point (1067-55-273)

9:30AM (1828) *Divisibility properties and recursions for the Hilbert series of Macdonald polynomials.*
Elizabeth M Niese* and **Nicholas Loehr**, Virginia Tech (1067-05-227)

10:00AM ► (1829) *Fourier-Jacobi coefficients of Eisenstein series on unitary group and the application in Iwasawa main conjecture.*
Bei Zhang, Northwestern University (1067-11-260)

AMS Session on Number Theory, IV

8:15 AM – 10:55 AM

8:15AM (1830) *Improving Abundancy Bounds.*
Elizabeth McCaslin* and **Fenghao Wang**, McDaniel College (1067-11-2396)

8:30AM (1831) *On Periodicity of some Fibonacci-like Sequences.*
Trevor E McGuire, Louisiana State University (1067-11-1946)

8:45AM (1832) *From Fibonacci Numbers to Central Limit Type Theorems.*
Yinghui Wang*, MIT, and **Steven J Miller**, Williams College (1067-11-428)

9:00AM (1833) *Extensions of Eulerian Numbers to More General Triangular Arrays.*
Hung-ping Tsao, Novato, CA, and **Tingyao Xiong***, Radford University (1067-11-628)

9:15AM (1834) *The distribution of the number of Farey fraction in residue classes.* Preliminary report.
M.Tip E Phaovibul, University of Illinois: Champaign-Urbana (1067-11-2272)

9:30AM (1835) *Sociable numbers, or How I messed with perfection and lived to write papers about it.*
Paul Pollack, University of Illinois at Urbana-Champaign (1067-11-2101)

9:45AM (1836) *Differential Operators and Weighted Isobaric Polynomials.*
Trueman MacHenry*, York University, Toronto, and **Geanina Tudose**, Bucharest, Romania (1067-11-1145)

10:00AM (1837) *A Bezoutian algorithm for Egyptian Fractions.* Preliminary report.
Robert Erra, ESIEA - PARIS Equipe SI&S (1067-11-2326)

10:15AM (1838) *Appending Digits to Generate an Infinite Sequence of Composite Numbers I.*
Lenny Jones, Shippensburg University (1067-11-921)

10:30AM (1839) *Appending Digits to Generate an Infinite Sequence of Composite Numbers II.* Preliminary report.
Lenny Jones and **Dan White***, Shippensburg University (1067-11-923)

10:45AM (1840) *Theory and Applications of Benford's Law of Leading Digits.* Preliminary report.
Allison L. Lewis*, University of Portland, **Steven J. Miller**, Williams College, and **Victoria Cuff**, Clemson University (1067-11-1431)

AMS Session on Combinatorics and Graph Theory, VII

8:15 AM – 10:40 AM

8:15AM (1841) *Exponential Domination in Grid Graphs.* Preliminary report.
Emily Hale-Sills*, **Kim Lockrow**, **Emily Merrill** and **Samantha Lowe**, Smith College (1067-05-1142)

8:30AM (1842) *On extremal graphs with a given number of perfect matchings.*
Matthew Price Yancey, University of Illinois at Urbana-Champaign (1067-05-1633)

8:45AM (1843) *Vertices Belonging to All Maximum Independent Sets.* Preliminary report.
Taylor M Short, Virginia Commonwealth University (1067-05-1652)

9:00AM (1844) *Distances in Kneser Graphs.*
Darin Johnson, Delaware State University (1067-05-2155)

9:15AM (1845) *On Cyclic G-designs, where G is the one-point union of two cycles.*
Christian Pawlak*, Illinois State University, **Krystal Brewington**, **Jessica Lynn Smith**, Morehead State University, and **Stephanie Zeppetello**, Illinois State University (1067-05-2227)

9:30AM (1846) *Minimum P_k-total weights of graphs.* Preliminary report.
Ji Young Choi, Shippensburg University / DIMACS, Rutgers University (1067-05-2294)

9:45AM (1847) *Reconstruction of graphs from metric balls of their vertices.*
Andrew B Ray, University of Nebraska - Lincoln (1067-05-1632)

10:00AM (1848) *Hyperspace Graph of Connected Subgraphs.*
Likin C. Simon Romero, Rochester Institute of Technology (1067-05-1555)

10:15AM (1849) *Longest Cycles in k-connected Graphs with Given Independence Number.*
Suil O*, **Douglas B. West** and **Hehui Wu**, University of Illinois at Urbana-Champaign (1067-05-420)

10:30AM (1850) *Paths as m-step Competition Graphs.*
Eva K. Belmont, Harvard University (1067-05-359)

MAA General Contributed Paper Session, XI

8:15 AM – 10:55 AM

Organizers: **Kristen Meyer**, Wisconsin Lutheran College
Thomas R. Hagedorn, The College of New Jersey

8:15AM (1851) *Sugar Ditch Revisited.* Preliminary report.
Leslie M. Horton, Delta State University (1067-Z1-2257)

8:30AM (1852) *Concept Maps: What are they and what can we learn from them about students' understanding of mathematics?*
Rebecca C Metcalf, Bridgewater State University (1067-Z1-2063)

8:45AM (1853) *Classifying Students by Conceptual Understanding in Real-Time.*
Andrew J Cousino, Kansas State University (1067-Z1-2123)

9:00AM (1854) *Designing a parenting seminar to address the national shortage of mathematicians.*
Jessica M Mikhaylov*, US Military Academy, West Point, Center for Leadership and Diversity in STEM, and **Nancy S Libertini**, The Tidewater School, Huntingtown, Maryland (1067-Z1-2081)

9:15AM (1855) *Report on the NSF PRISM project at Truman State University.* Preliminary report.
Jason E Miller, Truman State University (1067-Z1-1754)

9:30AM (1856) *Bridging Policy and Practice with Ethnomathematics.*
Linda Furuto, University of Hawai'i - West O'ahu (1067-Z1-17)

9:45AM (1857) *Mathematics Performance of Boys Correlates with Gender Equity.*
Jonathan Kane, University of Wisconsin – Whitewater, and **Janet Mertz***, University of Wisconsin – Madison (1067-Z1-931)

10:00AM (1858) *Language, Gender, and Number.*
Rebecca Boone, retired (from UCB as an editorial assistant for Science Magazine) (1067-Z1-867)

10:15AM (1859) *Math Mistakes in the Media.* Preliminary report.
Heather A. Lewis, Nazareth College (Rochester, NY) (1067-Z1-2122)

10:30AM *Let's Read the News.*
► (1860) **Leonard J Lipkin**, University of North Florida (1067-Z1-2308)

10:45AM *Teaching Basic Number Theory from the Sieve of*
► (1861) *Eratosthenes.*
Jacqueline Anderson Hall, Longwood University (1067-Z1-1271)

AMS Session on Partial Differential Equations, III

8:30 AM – 10:55 AM

8:30AM (1862) *Global regularity results for the 2D Boussinesq equations with vertical dissipation.* Preliminary report.
Dhanapati Adhikari*, Oklahoma State University, **Chongsheng Cao**, Florida International University, and **Jiahong Wu**, Oklahoma State University (1067-35-1840)

8:45AM (1863) *The axiomatic approach to Harnack's inequality in doubling quasi-metric spaces.* Preliminary report.
Sharad D Silwal*, **Sapto Indratno** and **Diego Maldonado**, Kansas State University (1067-35-2242)

9:00AM (1864) *A Sensitivity Analysis for Partial Differential Equations with Applications.*
Faranak Pahlevani, Penn State Abington (1067-35-1458)

9:15AM (1865) *Semilinear wave equations with non-monotone nonlinearity.*
Alfonso Castro, Harvey Mudd College (1067-35-388)

9:30AM (1866) *Regularity of n/2-harmonic maps into spheres.*
Armin Schikorra, RWTH Aachen, Germany (1067-35-57)

9:45AM
► (1867) *Edge-Enhancing Speckle Denoising for Ultrasound Images.*
John R Corring*, University of Southern Mississippi, **Helene Duke**, Providence College, **Arundhati Bagchi Misra** and **Hyeona Lim**, Mississippi State University (1067-00-1687)

10:00AM (1868) *Wave-breaking for a generalized two-component Camassa-Holm system.*
Robin Ming Chen, University of Minnesota (1067-35-1783)

10:15AM
► (1869) *Blow-up Solution for Complex-valued Burgers Equation.*
Netra Prakash Khanal, The University of Tampa (1067-35-1417)

10:30AM
► (1870) *A nonlinear free boundary problem in gas dynamics.*
Michael T. Heitzman* and **Carmen Chicone**, University of Missouri (1067-35-2009)

10:45AM *Universality of Fibonacci Patterns.*
► (1871) **Patrick D Shipman**, Colorado State University,, **Zhiying Sun***, University of California, Irvine, **Alan C Newell** and **Pennybacker F Mattew**, University of Arizona (1067-35-481)

AMS Committee on Education Panel Discussion

8:30 AM – 10:00 AM

Teaching elementary math is not elementary: How mathematicians can help, and why?

Moderator: **Lawrence F. Gray**, University of Minnesota

Panelists: **Johnette Roberts**, City of Baker School System
Kristin Umland, University of New Mexico
Hyman Bass, University of Michigan, Ann Arbor
Kenneth I. Gross, University of Vermont

AMS Session on Functional Analysis

8:45 AM – 10:55 AM

8:45AM (1872) *Unconditional convergence in the strong operator topology and ℓ_∞.* Preliminary report.
Ioana Ghenciu*, University of Wisconsin-River Falls, and **Paul Lewis**, University of North Texas (1067-46-202)

9:00AM (1873) *Real one-sided M-ideals.* Preliminary report.
Sonia Sharma, University of Houston (1067-46-281)

9:15AM (1874) *On non-associative L_p-spaces associated with Maharam traces on JBW-algebras.*
Alexander A. Katz, St. John's University, NY, USA (1067-46-353)

9:30AM (1875) *Extreme points and isometries on vector-valued Lipschitz spaces.*
Fernanda Botelho, University of Memphis, **Richard J. Fleming***, Central Michigan University, and **James E. Jamison**, University of Memphis (1067-46-1015)

9:45AM (1876) *Operators on the $\mathcal{L}_\infty$ spaces of Bourgain and Delbaen.*
Lon H Mitchell, Virginia Commonwealth University (1067-46-1285)

10:00AM (1877) *Embedding Banach spaces into spaces with very few operators.* Preliminary report.
S. Argyros, National Technical University of Athens, **D. Freeman***, University of Texas, **R. Haydon**, University of Oxford, **E. Odell**, University of Texas, **Th. Raikoftsalis**, National Technical University of Athens, **Th. Schlumprecht**, Texas A&M University, and **D. Zisimopoulou**, National Technical University of Athens (1067-46-2196)

10:15AM (1878) *Strictly singular operators between separable Banach spaces.*
Kevin James Beanland, Virginia Commonwealth University (1067-46-2288)

10:30AM (1879) *Graph Algebras, Aperiodicity, and Condition (F).* Preliminary report.
Sarah E. Wright, College of the Holy Cross (1067-46-2304)

10:45AM (1880) *The Schur-Horn Theorem for Operators with Three Point Spectrum.*
John D Jasper, University of Oregon (1067-46-2424)

AMS Colloquium Lectures: Lecture III

8:50 AM – 9:50 AM

(1881) *Expander graphs in pure and applied mathematics, III.*
Alexander Lubotzky, The Hebrew University of Jerusalem (1067-51-15)

ASL Invited Address

9:00 AM – 9:50 AM

(1882) *O-minimality and Hilbert's 16th problem.*
Patrick Speissegger, McMaster University (1067-03-66)

MAA Invited Paper Session on The Intersection of Graphs and Geometry, I

9:00 AM – 10:55 AM

Organizer: **Edward Scheinerman**, Johns Hopkins University

9:00AM (1883) *The Genus of a Digital Image is Determined by its Foreground, Background, and Reeb Graphs.* **Donniell Fishkind***, Johns Hopkins University, **Lowell Abrams**, George Washington University, and **Carey Priebe**, Johns Hopkins University (1067-AF-1469)

9:30AM (1884) *Tolerance Graphs.* **Ann N. Trenk**, Wellesley College (1067-AF-1534)

10:00AM (1885) *Geometric Drawings of Graphs Using Few Edge Lengths.* Preliminary report. **Dan Archdeacon**, University of Vermont (1067-AF-1483)

10:30AM (1886) *Lombardi drawings: an artist-inspired approach to drawing graphs.* **Christian A. Duncan***, Louisiana Tech University, **David Eppstein**, **Michael T. Goodrich**, University of California Irvine, **Stephen G. Kobourov**, University of Arizona, and **Martin Nöllenburg**, Institute of Theoretical Informatics (1067-AF-1532)

MAA Minicourse #12: Part B

9:00 AM – 11:00 AM

Concepts, data, and models: College algebra for the real world.

Organizers: **Sheldon P. Gordon**, Farmingdale State College
Florence S. Gordon, New York Institute of Technology

MAA Minicourse #3: Part B

9:00 AM – 11:00 AM

Geometry and algebra in mathematical music theory.

Organizers: **Thomas M. Fiore**, University of Michigan-Dearborn
Dmitri Tymoczko, Department of Music, Princeton University
Robert Peck, School of Music, Louisiana State University

MAA Minicourse #6: Part B

9:00 AM – 11:00 AM

Green linear optimization.

Organizer: **Glenn H. Hurlbert**, Arizona State University

MAA Committee on Graduate Students-Young Mathematicians' Network Panel Discussion

9:00 AM – 10:20 AM

Maximize your career potential!

Organizers: **Rachel Esselstein**, California State University Monterey Bay
David Manderscheid, University of Nebraska-Lincoln

Speakers: **Geir Helleloid**, Acuitus Inc.
Aba Mbrika, Bowdoin College

MAA Committee on Technology in Math Education Panel Discussion

9:00 AM – 10:20 AM

Publishing mathematics on the Web.

Organizer: **Thomas E. Leathrum**, Jacksonville State University

Panelists: **Lawrence Moore**, Duke University
Robert Miner, Design Science, Inc.
Thomas E. Leathrum
David Ruddy, Project Euclid/Cornell University

SIGMAA on Math Circles for Students and Teachers Special Presentation

9:00 AM – 11:00 AM

Math Circles demonstration.

Presenter: **James Tanton**, St. Mark's Institute of Mathematics

NAM Panel Discussion

9:00 AM – 9:50 AM

NAM honors the life of Dr. David Harold Blackwell.

Exhibits and Book Sales

9:00 AM – NOON

Employment Center

9:00 AM – NOON

Student Hospitality Center

9:00 AM – 2:00 PM

AMS Session on Calculus of Variations, Optimal Control, and Optimization

9:15 AM – 10:55 AM

9:15AM (1887) *Isoperimetric Problems with Density.* Preliminary report. **Frank Morgan**, Williams College and Fields Institute (1067-49-398)

9:30AM (1888) *Existence of surface energy minimizing partitions of space satisfying volume constraints and having independent surface energy density functions.* **David George Caraballo**, Georgetown University (1067-49-662)

9:45AM ► (1889) *The Minimum Speed for a Blocking Problem on the Half Plane.* **Tao Wang*** and **Alberto Bressan**, Pennsylvania State University (1067-49-1323)

10:00AM ► (1890) *Modeling complex physical phenomena using energy minimization principle.* Preliminary report. **Robert D Hill**, George Mason University (1067-49-1327)

10:15AM (1891) *Synthesis of two-dimensional electromagnetic media that achieve desired transfer functions.* **Harish Subrahmanya Bhat**, University of California, Merced (1067-49-2395)

10:30AM ► (1892) *Identification of nodes in a network: a discrete analogue of optical tomography.* **Bonnie Jacob**, National Technical Institute for the Deaf (1067-49-2124)

10:45AM ► (1893) *Modeling optimal age-specific vaccination strategies against pandemic influenza.* Preliminary report.
Sunmi Lee, Mathematical and Computational Modeling Sciences Center, Arizona State University (1067-49-569)

ASL Invited Address

10:00 AM – 10:50 AM

(1894) *Ordered groups definable in o-minimal theories.*
Alf Onshuus, University of Los Andes (1067-03-65)

NAM Business Meeting

10:00 AM – 10:50 AM

MAA Invited Address

10:05 AM – 10:55 AM

(1895) *Lessons from the Netflix Prize.*
Robert M. Bell, AT&T (1067-A0-35)

AWM Workshop: Poster Session with Presentations from Women Graduate Students

10:30 AM – 11:00 AM

10:30AM (1896) *Zero Cycles of Degree One on Principal Homogeneous Spaces.*
Jodi A. Black, Emory University (1067-11-210)

10:30AM (1897) *Algebraic model structures.*
Emily Riehl, University of Chicago (1067-18-228)

10:30AM ► (1898) *Long Time Behavior of radially symmetric solutions of higher dimensional Kuramoto-Sivashinsky Equation.*
Aslihan Demirkaya, University of Kansas (1067-37-249)

10:30AM (1899) *Title: Conjugacy Classes of σ-stable Maximal k-split Tori.* Preliminary report.
Catherine Andrea Buell, North Carolina State University (1067-20-256)

10:30AM (1900) *A Generalization of Turaev's Virtual String Cobracket and the Homotopy Rank of a Virtual String.* Preliminary report.
Patricia R Cahn, Dartmouth College (1067-57-258)

10:30AM (1901) *A Finite Element Approach to C^β Extension using Prefractals.*
Emily J Evans, Worcester Polytechnic Institute (1067-35-259)

10:30AM (1902) *An example of computing local cohomology.*
Emily E. Witt, University of Michigan (1067-13-266)

10:30AM (1903) *A counterexample related to Muckenhoupt-Wheeden conjecture.*
Maria Carmen Reguera, Georgia Institute of Technology (1067-43-271)

10:30AM (1904) *Calculus of Functors.* Preliminary report.
Rosona M Eldred, University of Illinois at Urbana-Champaign (1067-18-285)

10:30AM ► (1905) *Modeling of Intracranial Aneurysms using Immersed Boundary Methods.* Preliminary report.
Lisa Melanson, Northwestern University (1067-76-289)

10:30AM (1906) *Characterizations of Projective Spaces and Smooth Quadric Hypersurfaces via $\wedge^p T_X$.*
Kiana L. Ross, University of Washington (1067-14-290)

10:30AM (1907) *Cluster Analysis of Data on Finite Groups and Homogeneous Spaces.* Preliminary report.
Paige E. Rinker, Dartmouth College (1067-08-326)

MAA Business Meeting

11:10 AM – 11:40 AM

Chair: **David Bressoud**, Macalester College

AMS Business Meeting

11:45 AM – 12:15 PM

NAM Claytor-Woodard Lecture

1:00 PM – 1:50 PM

► (1908) *Galois Representations and L-Series: A Tour Through Mathematics.*
Edray Herber Goins, Purdue University (1067-11-2267)

AMS-MAA Special Session on Centers for Teaching/Education/Outreach in Departments of Mathematics

1:00 PM – 5:50 PM

Organizer: **Michael E. Mays**, West Virginia University

1:00PM ► (1909) *The Institute for Mathematics and Education.*
Joceline Lega, University of Arizona (1067-00-1972)

1:30PM ► (1910) *The UNL Center for Science, Mathematics and Computer Education.* Preliminary report.
W James Lewis, University of Nebraska-Lincoln (1067-97-1742)

2:00PM ► (1911) *Quantitative Education as Applied Mathematics.*
Andrew G Bennett, Kansas State University (1067-97-1823)

2:30PM ► (1912) *University of Wyoming Science and Mathematics Teaching Center: Report on Mathematics Teaching, Education, and Outreach through a joint unit of College of Arts and Sciences and College of Education.* Preliminary report.
Robert Lee Mayes, University of Wyoming (1067-97-645)

3:00PM (1913) *New Goals and Associated Changes at the Mathematics and Science Teaching (MAST) Institute at the University of Northern Colorado (UNC).*
Steven William Anderson, MAST Institute, The University of Northen Colorado (1067-97-755)

3:30PM ► (1914) *The Center for Leadership and Diversity in STEM (Science, Technology, Engineering, and Mathematics) at West Point.*
Donald A Outing* and **Archie Wilmer**, West Point (1067-97-2157)

4:00PM ► (1915) *GMU COMPLETE: Center for Outreach in Mathematics Professional Learning and Educational Technology.* Preliminary report.
Padmanabhan Seshaiyer* and **Jennifer Suh**, George Mason University (1067-97-152)

4:30PM (1916) *How the Mathematics Department Supports the UTeach Program in the College of Natural Sciences at the University of Texas at Austin.*
Mark L. Daniels* and **Efraim P. Armendariz**, University of Texas at Austin (1067-97-81)

5:00PM ► (1917) *The Texas Leadership Initiative and Texas LIMIT Projects: Training the Trainers.* Preliminary report.
Thomas W Judson*, **Lesa L Beverly** and **Kimberly M Childs**, Stephen F. Austin State University (1067-97-1166)

5:30PM ► (1918) *WRAP - The Worthing Rice Apprenticeship in Computational Neuroscience.*
Steven J. Cox*, Rice University, **Jessica C Joyce**, Bioengineering, Rice University, **Kathryn Ward** and **Jay Raol**, Rice University (1067-97-58)

AMS-SIAM Special Session on Control and Inverse Problems for Partial Differential Equations, II

1:00 PM – 5:50 PM

Organizers: **Ana-Maria Croicu**, Kennesaw State University
Michele L. Joyner, Kennesaw State University

1:00PM (1919) *A Dynamical Inverse Problem on a Metric Graph.*
John Matthews*, **Boris P. Belinskiy**, University of Tennessee at Chattanooga, and **Sergei A Avdonin**, University of Alaska Fairbanks (1067-35-599)

1:30PM (1920) *Hydraulic Conductivity Inverse Formulation for the Groundwater Flow Problem with Variable Density.*
Yanzhao Cao, Auburn University (1067-65-834)

2:00PM (1921) *An efficient and robust numerical algorithm for estimating parameters in Turing systems.*
Marcus R. Garvie, University of Guelph, **Philip K. Maini**, Centre for Mathematical Biology, Mathematical Institute, and **Catalin Trenchea***, University of Pittsburgh (1067-49-1480)

2:30PM (1922) *Target Tracking Strategies for a Nonlinear Aircraft Model.*
Animesh Chakravarthy, University of Florida, **Katie A Evans**, Louisiana Tech University, **Johnny Evers**, Air Force Research Laboratory, Munitions Directorate, and **Lisa M Kuhn***, Louisiana Tech University (1067-49-2309)

3:00PM ► (1923) *HIV Model Analysis, State Estimation and Optimal Control.*
John A. David, The College of Wooster (1067-49-575)

3:30PM ► (1924) *Optimal control of a spatio-temporal epidemic model.*
Suzanne Lenhart*, University of Tennessee, and **Rachael Miller Neilan**, Louisiana State University (1067-49-945)

4:00PM (1925) *Optimization Strategy for Single and Dual Resistance of Antibiotics in Hospitals.* Preliminary report.
Michele L Joyner, East Tennessee State University (1067-49-1915)

4:30PM (1926) *Adaptive Tracking and Estimation for Nonlinear Control Systems.*
Frederic Mazenc, Projet INRIA DISCO, **Michael Malisoff*** and **Marcio de Queiroz**, Louisiana State University (1067-93-515)

5:00PM (1927) *Effect of random perturbations on adaptive observation techniques.*
Jakir Hossen, Dhakka, Bangaladesh, **Ionel Michael Navon***, Florida State University, and **Dacian N Daescu**, Fariborz Maseeh Department of Mathematics and Statistics, Portland State University (1067-49-1280)

5:30PM (1928) *A dual weighted trust-region adaptive POD 4D-Var applied to a Finite-Volume global shallow-water Equations Model in Sphere.*
Xiao Chen*, Florida State University, **Santha Akella**, Department of Earth and Planetary Sciences, Johns Hopkins University, and **Ionel Michael Navon**, Department of Scientific Computing, Florida State University (1067-49-209)

AMS Special Session on Asymptotic Methods in Analysis with Applications, II

1:00 PM – 5:50 PM

Organizers: **Diego Dominici**, State University of New York at New Paltz
Peter A. McCoy, U.S. Naval Academy

1:00PM (1929) *Application of special functions to disparate fields.* Preliminary report.
Roger W. Barnard, Texas Tech University, Lubbock, TX (1067-33-1032)

1:30PM (1930) *Asymptotic p-adic methods.*
Erin Beyerstedt, **Victor H. Moll**, Tulane University, and **Xinyu Sun***, Xavier University of Louisiana (1067-33-2233)

2:00PM (1931) *Character analogues of Ramanujan type integrals involving the Riemann Ξ-function.*
Atul Abhay Dixit, University of Illinois at Urbana-Champaign (1067-11-597)

2:30PM (1932) *An effective asymptotic formula for the Stieltjes constants.*
Mark W. Coffey, Colorado School of Mines (1067-30-1085)

3:00PM (1933) *Asymptotics and Zeros for Partition Statistics Polynomials.* Preliminary report.
Robert P. Boyer*, Drexel University, **William M. Y. Goh**, Department of Statistics and Finance, University of Science and Technology of China, and **Daniel T. Parry**, Drexel University (1067-11-946)

3:30PM (1934) *Asymptotic analysis of the linearized Navier-Stokes equations in a general domain.*
Gung-Min Gie*, University of California, Riverside, **Makram Hamouda** and **Roger Temam**, Institute for Scientific Computing and Applied Mathematics, Indiana University (1067-35-511)

4:00PM (1935) *The Diffusion Phenomenon and Decay Rates for Hyperbolic Equations with Damping.*
Petronela Radu*, University of Nebraska-Lincoln, **Grozdena Todorova** and **Borislav Yordanov**, University of Tennessee-Knoxville (1067-35-82)

4:30PM (1936) *Asymptotic Models of the Nonlinear Adaptive Orthotropic Elastic Rod and Plate.*
Robert J Ronkese, United States Military Academy at West Point (1067-74-1549)

5:00PM (1937) *Asymptotic Laplace Transforms and Watson's Lemma .*
Claudiu Mihai, Daemen College (1067-44-2252)

5:30PM (1938) *Asymptotic Expansions Of Solutions Of An Inhomogeneous Equation.*
Xinfu Chen and **Susmita Sadhu***, University Of Pittsburgh (1067-34-2156)

AMS Special Session on Applied Optimization and Douglas-Rachford Splitting Methods for Convex Programming

1:00 PM – 5:45 PM

Organizer: **Ram U. Verma**, Seminole State College of Florida

1:00PM (1939) *Douglas-Ratchford iterations in the absence of convexity.*
Jonathan M Borwein* and **Brailey Sims**, CARMA, University of Newcastle NSW Australia (1067-49-224)

2:00PM (1940) *Generalized Invexity and Higher Order Duality for Variational Problems.*
R N Mohapatra, University of Central Florida (1067-90-1013)

3:00PM (1941) *Second Order Necessary Conditions in Scalar Nonsmooth Set Constrained Optimization.*
Elena Constantin, University of Pittsburgh at Johnstown (1067-49-347)

3:30PM (1942) *Optimality Conditions in Semi-Infinite and Infinite Programming.*
Boris Mordukhovich and **Nghia Tran***, Wayne State University (1067-49-568)

4:00PM ► (1943) *On Solutions for Fractional-order Functional Integrodifferential Equations with Infinite Delay.* Preliminary report.
Haewon Lee* and **Peter Frempong-Mireku**, Dillard University (1067-45-2345)

4:30PM (1944) *Applications of Nonsmooth Optimization to a Generalized Fermat-Torricelli Problem.*
Boris Mordukhovich, Wayne State University, and **Nguyen Mau Nam***, University of Texas-Pan American (1067-49-684)

5:00PM ► (1945) *Relatively Relaxed Proximal Point Algorithms for Generalized Maximal Monotone Mappings and Douglas-Rachford Splittings.* Preliminary report.
Ram U Verma, Texas A&M Universitty - Kingsville (1067-49-697)

AMS Special Session on Stochastic, Fractional, and Hybrid Dynamic Systems with Applications

1:00 PM – 5:50 PM

Organizers: **A. S. Vatsala**, University of Louisiana at Lafayette
G. S. Ladde, University of South Florida

1:00PM (1946) *Uniqueness and parameter dependence of positive solutions for systems of fractional boundary value problems.*
John R. Graef*, **Lingju Kong**, The University of Tennessee at Chattanooga, and **Qingkai Kong**, Northern Illinois University (1067-34-940)

1:30PM (1947) *Fractional Differential Equations:Stochastic Modeling, Methods and Analysis.* Preliminary report.
Jean-Claude Pedjeu* and **Gangaram S Ladde**, University of South Florida (1067-60-1006)

2:00PM (1948) *Existence of coupled minimal and maximal solutions of Fractional Periodic Boundary Value Problem via Initial Value Problem.* Preliminary report.
J. Diego Ramirez* and **Aghalaya S. Vatsala**, University of Louisiana at Lafayette (1067-34-751)

2:30PM (1949) *Option Pricing for Hybrid Nonlinear Stochastic Models.* Preliminary report.
Ling Wu* and **Gangaram S Ladde**, University of South Florida (1067-60-1023)

3:00PM (1950) *Monotone Iterative Technique for Finite Systems of Nonlinear Fractional Differential Equations.* Preliminary report.
Zachary Denton* and **Aghalaya Vatsala**, University of Louisiana at Lafayette (1067-34-779)

3:30PM (1951) *Stochastic Stability of Two-scale Network Dynamic Epidemic Model.* Preliminary report.
Divine T Wanduku* and **Gangaram S Ladde**, University of South Florida (1067-60-1026)

4:00PM (1952) *A system of Stochastic Difference Equations Modeling Terrorism.* Preliminary report.
Jairo Santanilla, University of New Orleans (1067-39-2089)

4:30PM (1953) *Stochastic Hybrid Dynamic Model for Risk Process.* Preliminary report.
Daniel Siu* and **Gangaram S Ladde**, University of South Florida (1067-60-1328)

5:00PM (1954) *Some Results for Partial Fractional Differential Inequalities.*
Donna Sue Stutson, Xavier University of Louisiana (1067-34-1902)

5:30PM (1955) *Existence of Coupled Extremal Solutions for Nonlinear Caputo Fractional Reaction Diffusion Equations.* Preliminary report.
Aghalaya S. Vatsala, Louisiana State University, Lafayette (1067-35-1188)

AMS Special Session on Applications of Stochastic Processes in Neuroscience, II

1:00 PM – 5:45 PM

Organizers: **Peter Thomas**, Case Western Reserve University
Kreso Josic, University of Houston
Carson C. Chow, Institutes of Health

1:00PM (1956) *Stochastic Operating Point for the Dynamics of the Primary Visual Cortex.*
David Cai, Courant Institute/Center for Neural Science, New York Univ. & Institute of Natural Sciences, Shanghai Jiao Tong Univ. (1067-92-761)

2:00PM (1957) *Finite-size effects in globally coupled neural networks.*
Carson C Chow* and **Michael A Buice**, NIH (1067-92-771)

2:30PM (1958) *Heterogeneity and Stability in globally coupled neural networks.*
Michael A Buice* and **Carson C Chow**, NIH (1067-92-774)

3:00PM ► (1959) *Gamma-generating networks with inhibitory cells that do not participate in the rhythm.* Preliminary report.
Christoph Borgers, Tufts University (1067-92-500)

3:30PM (1960) *Mechanisms that modulate the transfer of spiking correlations.*
Kresimir Josic*, **Robert Rosenbaum** and **James Trousdale**, University of Houston (1067-92-824)

4:00PM (1961) *Estimation of information measures in coupled diffusion neuronal models.*
Maria Teresa Giraudo*, **Laura Sacerdote**, **Roberta Sirovich** and **Cristina Zucca**, University of Torino, Italy (1067-60-722)

4:30PM (1962) *Modeling the stochastic dynamics of localized calcium elevations and whole cell calcium responses.*
Marco A Huertas, Neuroscience Center for Excellence, Louisiana State University Health Science Center, New Orleans, Louisiana, and **Gregory Douglas Smith***, Department of Applied Science, The College of William and Mary, Williamsburg, Virginia (1067-92-48)

5:00PM (1963) *Random dynamical systems and an application to self-organized criticality in neural data.*
Manfred Denker, Pennsylvania State University (1067-92-276)

AMS Special Session on Analysis of Reaction-Diffusion Models, II

1:00 PM – 5:50 PM

Organizers: **Junping Shi**, College of William and Mary
Xuefeng Wang, Tulane University

1:00PM (1964) *Symmetry of Solutions for Nonlinear Integral and PDE Systems.*
Wenxiong Chen*, Yeshiva University, and **Congming Li**, University of Colorado at Boulder (1067-35-1130)

1:30PM (1965) *Positive solutions to nxn elliptic systems with combined nonlinear effects.*
Jaffar Ali, Florida Gulf Coast University, **Ken Brown**, Heriot-Watt University, UK, and **Ratnasingham Shivaji***, Mississippi State University (1067-35-747)

2:00PM ► (1966) *Cross-diffusion induced Turing instability for a three species food chain model.* Preliminary report.
Zhifu Xie, Virginia State University (1067-35-851)

2:30PM (1967) *Blow-up for A Parabolic System with Nonlinear Memory.*
Keng Deng* and **Zhihua Dong**, University of Louisiana at Lafayette (1067-35-1317)

3:00PM (1968) *Blow-up properties for a semilinear reaction-diffusion system.* Preliminary report.
Tor A. Kwembe and **Zhenbu Zhang***, Jackson State University (1067-35-1264)

3:30PM (1969) *Lifespans for Effective Boundary Conditions.*
Cody Pond, Tulane University (1067-35-1129)

4:00PM (1970) *On finding multiple solutions to a singularly perturbed Neumann problem.*
Jianxin Zhou*, Texas A&M University, **Ziqing Xie** and **Yongjun Yuan**, Hunan Normal University (1067-35-548)

4:30PM ► (1971) *Spiky steady states of chemotaxis systems via global bifurcation and Helly's compactness theorem.* Preliminary report.
Qian Xu, Capital Normal University, **Xuefeng Wang***, Tulane University, and **Yaping Wu**, Capital Normal University (1067-35-1377)

5:00PM ► (1972) *Structure of Principal Eigenvectors and Genetic Diversity.*
Peter W Bates, Michigan State University, **Fengxin Chen***, University of Texas at San Antonio, and **Richard Lenski**, Michigan State University (1067-35-1098)

5:30PM (1973) *Uniqueness of positive solution to semilinear elliptic systems.*
Jann-Long Chern, National Central University, **Chang-Shou Lin**, Taiwan University, **Junping Shi***, College of William and Mary, and **Yong-Li Tang**, National Central University (1067-35-1627)

AMS Special Session on Continued Fractions, II

1:00 PM – 5:45 PM

Organizers: **James G. McLaughlin**, West Cester University
Nancy J. Wyshinski, Trinity College

1:00PM ► (1974) *Generalizing Stern's Diatomic Sequences via Multi-dimensional Continued Fractions.* Preliminary report.
Thomas Garrity, Williams (1067-11-1907)

2:00PM ► (1975) *A Statistical Look at the Gauss-Kuzmin Distribution.* Preliminary report.
Steven E Duff* and **Nathan C Ryan**, Bucknell University (1067-11-158)

2:30PM ► (1976) *Modular identities involving powers of the Rogers-Ramanujan functions.*
Chadwick Gugg, Georgia Southwestern State University (1067-11-2110)

3:00PM ► (1977) *Certain Properties of the Ramanujan-Göllnitz-Gordon Continued Fraction.*
Boonrod Yuttanan, University of Illinois at Urbana-Champaign (1067-11-430)

3:30PM (1978) *Weighted divisor sums and Bessel function series.*
Bruce C. Berndt, University of Illinois at Urbana-Champaign, **Sun Kim***, Pennsylvania State University, and **Alexandru Zaharescu**, University of Illinois at Urbana-Champaign (1067-11-716)

4:00PM (1979) *Classification and Symmetries of a Family of Continued Fractions With Bounded Period Length.*
Renate Scheidler*, Unversity of Calgary, Canada, **Kell H. F. Cheng**, Hong Kong Institute of Education, **Richard K. Guy** and **Hugh C. Williams**, University of Calgary, Canada (1067-11-331)

4:30PM (1980) *Continued Fraction Proofs of m-versions of Some Identities of Rogers-Ramanujan-Slater Type.*
Douglas Bowman, Northern Illinois University, **James G Mc Laughlin***, West Chester University, and **Nancy Wyshinski**, Trinity College, Hartford, CT (1067-33-588)

5:00PM (1981) *Harmonic Continued Fractions.* Preliminary report.
Douglas C Bowman, Northern Illinois University (1067-11-2421)

AMS Special Session on Noncommutative Harmonic Analysis and Dynamic Systems, II

1:00 PM – 5:50 PM

Organizers: **Tao Mei**, Wayne State Unviersity
Alan D. Wiggins, University of Michigan at Dearborn

1:00PM (1982) *Weak and strong weighted norm of any Calderon–Zygmund operator are equivalent.*
Alexander L Volberg, Michigan State University (1067-35-479)

1:30PM (1983) *Non commutative diffusion semigroups.* Preliminary report.
Marius Junge*, UNiversity of Illinois, **Eric Ricard**, Besancon, France, and **Dimar Shlyahktenko**, UCLA (1067-46-1347)

2:00PM (1984) *A Hilbert module approach to certain group properties.*
Zhe Dong, Zhejiang University, and **Zhong-Jin Ruan***, University of Illinois at Urbana-Champaign (1067-46-785)

2:30PM (1985) *Schur multipliers of Calderon-Zygmund type.*
Javier Parcet, Instituto de Ciencias Matematicas, Madrid (1067-42-494)

3:00PM (1986) *Beurling-Fourier algebras of compact groups.*
Nico Spronk, University of Waterloo (1067-43-745)

3:30PM (1987) *Von Neumann algebras with unique Cartan subalgebras.*
Ionut Chifan, Vanderbilt University (1067-47-1262)

4:00PM (1988) *Hardy spaces associated with semigroups of operators.*
Steve Avsec, University of Illinois Urbana-Champaign (1067-46-2042)

4:30PM (1989) *A non-commutative Path Space approach to stationary free Stochastic Differential Equations.*
Yoann N. Dabrowski, University of California, Los Angeles (1067-46-610)

5:00PM (1990) *Rigidity Results for Ergodic Actions of Wreath Product Groups.*
J. Owen Sizemore, UCLA (1067-46-927)

5:30PM (1991) *A family of non-cocycle conjugate E_0-semigroups obtained from boundary weight doubles.*
Christopher Jankowski, Ben-Gurion University of the Negev (1067-46-560)

AMS Special Session on Combinatorial Algebraic Geometry, II

1:00 PM – 5:50 PM

Organizers: **Frank Sottile**, Texas A&M University
Alexander T. Yong, University of Illinois, Urbana-Champaign

1:00PM (1992) *An Implicitization Challenge for Binary Factor Analysis.*
Maria Angelica Cueto, UC Berkeley, **Enrique A. Tobis**, Universidad de Buenos Aires, and **Josephine Yu***, Georgia Tech (1067-05-846)

1:30PM (1993) *Complex and non-Archimedean Coamoebas.*
Mounir Nisse* and **Frank Sottile**, Texas A&M University, College Station (1067-14-1116)

2:00PM ► (1994) *Computing Node Polynomials for Plane Curves.*
Florian Block, University of Michigan (1067-05-566)

2:30PM (1995) *Lifting Tropical Curves and Linear Systems on Graphs.*
Eric Edward Katz, University of Texas (1067-14-685)

3:00PM (1996) *The tropical motivic nearby fiber.*
Alan Stapledon, University of British Columbia (1067-14-1003)

3:30PM (1997) *Newton-Okounkov bodies of Bott-Samelson varieties.*
David E Anderson, University of Washington (1067-14-1501)

4:00PM (1998) *Newton-Okounkov bodies and crystal bases.*
Kiumars Kaveh, Univ. of Pittsburgh (1067-14-1248)

4:30PM (1999) *Milnor numbers of projective hypersurfaces and the chromatic polynomial of graphs.*
June Huh, UIUC (1067-14-696)

5:00PM (2000) *Spaces of rational curves in flag manifolds and the quantum Chevalley formula.* Preliminary report.
Leonardo C. Mihalcea*, Baylor University/Univ. of Louisiana at Lafayette, and **Anders S. Buch**, Rutgers University (1067-14-831)

5:30PM (2001) *Finiteness of cominuscule quantum K-theory.* Preliminary report.
Anders S Buch*, Rutgers University, **Pierre-Emmanuel Chaput**, Laboratoire de Mathematiques, Jean Leray, **Leonardo C Mihalcea**, Baylor University, and **Nicolas Perrin**, Universite Pierre et Marie Curie (1067-14-2339)

AMS Special Session on Structure Theory for Matroids and Graphs, II

1:00 PM – 5:50 PM

Organizers: **Bogdan Oporowski**, Louisiana State University
James G. Oxley, Louisiana State University

1:00PM ► (2002) *Fragile matroids.* Preliminary report.
Dillon Mayhew*, **Carolyn Chun**, **Geoff Whittle**, Victoria University of Wellington, and **Stefan van Zwam**, Centrum Wiskunde & Informatica (1067-05-1432)

1:30PM (2003) *Towards a splitter theorem for internally 4-connected binary matroids.* Preliminary report.
Carolyn Chun*, **Dillon Mayhew**, Victoria University of Wellington, and **James Oxley**, Louisiana State University (1067-05-1190)

2:00PM (2004) *Characterizations of fundamental transversal matroids.*
Joseph E. Bonin*, The George Washington University, **Joseph P.S. Kung**, University of North Texas, and **Anna de Mier**, Universitat Politecnica de Catalunya (1067-05-356)

2:30PM (2005) *Parcels defined by congruence conditions and evaluations of the Tutte polynomial.* Preliminary report.
Joseph Kung, University of North Texas (1067-05-314)

3:00PM (2006) *Quaternionic unimodular matroids.*
David G. Wagner, University of Waterloo (1067-05-643)

3:30PM Discussion

4:00PM (2007) *When the branch width is high...*
Jim Geelen, University of Waterloo, Ontario, Canada, and **Stefan H.M. van Zwam***, Centrum Wiskunde en Informatica, Amsterdam, The Netherlands (1067-05-345)

4:30PM (2008) *Non-degenerate even cycle matroids.*
Bertrand Guenin, **Irene Pivotto***, University of Waterloo, and **Paul Wollan**, University of Rome, La Sapienza (1067-05-1092)

5:00PM (2009) *Growth rates in minor-closed classes of matroids.*
Peter Nelson* and **Jim Geelen**, University of Waterloo (1067-05-926)

5:30PM ► (2010) *Unavoidable Minors of 3-Connected Matroids.* Preliminary report.
Deborah A Chun, Louisiana State University (1067-05-718)

AMS Special Session on The Mathematics of Modeling Multiscale Heterogeneous Media

1:00 PM – 5:50 PM

Organizers: **Robert P. Lipton**, Louisiana State University
Tadele A. Mengesha, Louisiana State University

1:00PM (2011) *Why does nature go multiscale?*
Yury Grabovsky*, Temple University, and **Lev Truskinovsky**, Ecole Polytechnique (1067-74-847)

2:00PM (2012) *Models for growth of heterogeneous sandpiles via Mosco convergence.*
Marian Bocea, North Dakota State University (1067-35-1560)

2:30PM (2013) *L-infinity estimates for gradients of solutions to some nonlinear problems.* Preliminary report.
Yuliya Gorb, University of Houston (1067-35-1989)

3:00PM (2014) *New optimal bounds for two-phase non-well-ordered composites.*
Liping Liu, University of Houston (1067-35-419)

3:30PM (2015) *Gradient estimates for elliptic equation and system from composite media.*
Ellen Shiting Bao*, University of Minnesota, **Haigang Li**, Beijing Normal University, **Yanyan Li**, Rutgers University, and **Biao Yin**, University of Connecticut (1067-35-2125)

4:00PM (2016) *Coordinate transformations of two scale convergent sequences.*
Bacim Alali* and **Daniel Onofrei**, University of Utah (1067-00-2420)

4:30PM (2017) *Local representations of L^∞ norms for weakly convergent sequences of gradient fields.*
Tadele Mengesha* and **Robert Lipton**, Louisiana State University (1067-35-797)

5:00PM (2018) *Modeling damage evolution in high strength titanium alloys.*
Michael Stuebner*, North Carolina State University, and **Robert P Lipton**, Louisiana State University (1067-74-1909)

5:30PM (2019) *Upscaling methods of flow and transport in heterogeneous porous media.*
Yan Li*, Institute for Mathematics and Its Applications, and **Chen Yuguang**, Chevron Energy Technology Company (1067-65-939)

AMS Special Session on Global Dynamics of Discrete Dynamical Systems in the Plane with Applications

1:00 PM – 5:50 PM

Organizers: **M. R. S. Kulenovic**, University of Rhode Island
Orlando Merino, University of Rhode Island

1:00PM (2020) *Period doubling cascades for ordinary differential equations.* Preliminary report.
James A. Yorke, Univ of Maryland (1067-37-2072)

1:30PM ► (2021) *Stability and bifurcation of a discrete logistic competition model.* Preliminary report.
Saber N Elaydi, Trinity University (1067-39-680)

2:00PM (2022) *A Juvenile-Adult Discrete-Time Model Of Exploited Fishery Systems.* Preliminary report.
Nianpeng Li and **Abdul-Aziz Yakubu***, Howard University (1067-92-1659)

2:30PM (2023) *On invariant curves of certain nonhyperbolic equilibria of planar competitive systems.*
Orlando Merino, RI (1067-39-1731)

3:00PM (2024) *Reducing the order of a second-order difference equation with application to a biological model.*
H Sedaghat, Virginia Commonwealth University (1067-39-1780)

3:30PM Discussion.

4:00PM (2025) *Properties of a semiflow related to the integers.*
Alica Miller, University of Louisville (1067-37-1755)

4:30PM ► (2026) *Basins of Attraction of Equilibrium Points of Monotone Difference Equations.*
Ann Brett, University of Rhode Island (1067-39-1238)

5:00PM (2027) *The Topology of Tank Stirring.*
Barry Alan Peratt*, Winona State University, and **Judy A. Kennedy**, Lamar University (1067-37-1596)

5:30PM (2028) *The dynamics of Pielou's equation under the effect of harvesting.* Preliminary report.
Ziyad AlSharawi*, Sultan Qaboos University, **R. Abu-Saris**, Walden University, and **M. Rhouma**, Sultan Qaboos University (1067-39-445)

AMS Special Session on Measures of Entanglement of Macromolecules and Their Applications

1:00 PM – 5:50 PM

Organizers: **Isabel K. Darcy**, University of Iowa
Kenneth C. Millett, University of California, Santa Barbara
Eric J. Rawdon, University of St. Thomas
Mariel Vazquez, San Francisco State University

1:00PM (2029) *The writhe additivity formula and its applications to biomolecules.*
Christian Laing*, Departments of Mathematics and Chemistry, New York University, and **De Witt Sumners**, Florida State University (1067-54-264)

1:30PM (2030) *The variance of the writhe of equilateral random polygons.* Preliminary report.
Yuanan Diao, UNC Charlotte (1067-57-1234)

2:00PM ► (2031) *Entanglement Statistics for lattice models of polymer systems.*
C Soteros, University of Saskatchewan (1067-82-1736)

2:30PM (2032) *Oriented Skein Relation for HFK and Biological Applications.*
Candice Renee Price, University of Iowa (1067-55-1890)

3:00PM (2033) *The Classification of Rational Tangle Adjacencies, with Applications to Complex Nucleoprotein Assemblies.*
Dorothy Buck*, Imperial College London, and **Ken Baker**, University of Miami (1067-57-871)

3:30PM (2034) *DNA Knotting in Bacteriophage Capsids.*
De Witt Sumners, Florida State University (1067-92-925)

4:00PM (2035) *The XerCD-FtsK system unlinks replication catenanes in a stepwise manner.*
Mariel Vazquez, San Francisco State University (1067-92-930)

4:30PM ► (2036) *A lower bound for the trisecants of a knot.* Preliminary report.
Teresita Ramirez-Rosas, Grand Valley State University (1067-54-633)

5:00PM (2037) *Computational results on tight composite knots.*
Jason Cantarella*, University of Georgia, **Eric Rawdon**, St. Thomas University, and **Albert La pointe**, University of Georgia (1067-53-1222)

5:30PM ► (2038) *Flat Ribbon Links in* $\mathbb{R}^2$. Preliminary report.
Elizabeth Denne*, Smith College, **John M Sullivan**, Technische Universität, Berlin, and **Nancy C Wrinkle**, Northeastern Illinois University (1067-57-1256)

AMS Special Session on Time Scales: Theory and Applications, II

1:00 PM – 5:20 PM

Organizers: **Billy Jackson**, St. Xavier University
Joan Hoffacker, Clemson University

1:00PM (2039) *Variational theory on time scales including the delta indefinite integral.*
Natalia da Costa Martins* and **Delfim F. M. Torres**, University of Aveiro, Portugal (1067-49-447)

1:30PM ► (2040) *Alternative Solutions of Inhomogeneous Second-Order Linear Dynamic Equations on Time Scales.*
Douglas R. Anderson, Concordia College-Moorhead (1067-34-24)

2:00PM (2041) *Foundations of Nabla Fractional Calculus on Time Scales and Inequalities.* Preliminary report.
George A. Anastassiou, University of Memphis (1067-39-122)

2:30PM ► (2042) *A time scales model of competition in the southern pine beetle, Dendroctonus frontalis.* Preliminary report.
Heidi Berger*, Simpson College, **Jo Hoffacker**, Clemson University, and **Raegan Siwatu**, Texas Tech University (1067-39-814)

3:00PM (2043) *Dynamic inequalities of Bernoulli type.*
Namjip Koo* and **Sung Kyu Choi**, Chungnam National University, Korea (1067-34-1065)

3:30PM (2044) *A Fourth Order Boundary Value Problem with Multiple Resonance Conditions on a Time Scale.* Preliminary report.
Eric R Kaufmann, University of Arkansas at Little Rock (1067-34-778)

4:00PM (2045) *Shift operators and stability in delayed dynamic equations.*
Youssef Naim Raffoul*, Unversity of Dayton, and **Murat Adivar**, Izmir University of Economics (1067-37-1106)

► 4:30PM (2046) *Recursive Representations for the Unique Solution of the Transport Equation on Isolated Time Scales.*
Chris R Ahrendt, University of Wisconsin-Eau Claire (1067-39-754)

5:00PM (2047) *Existence of positive solutions of a first order dynamic equations on time scales.*
Seshadev Padhi, Birla Institute of Technology, Mesra, Ranchi (1067-34-2389)

MAA Invited Paper Session on The Intersection of Graphs and Geometry, II

1:00 PM – 3:15 PM

Organizer: **Edward Scheinerman**, Johns Hopkins University

1:00PM (2048) *Kleitman's Parity Theorem for crossing numbers.*
R. Bruce Richter, University of Waterloo (1067-AF-1481)

1:30PM (2049) *Interval Shadow Orders.*
William T. Trotter, Georgia Institute of Technology (1067-AF-1536)

2:00PM (2050) *Precedence Orders.*
Jerry Spinrad* and **Garrett Linn**, Vanderbilt University (1067-AF-1541)

2:30PM (2051) *Chromatic Number of the Plane: Yesterday, Today & Tomorrow.*
Alexander Soifer, University of Colorado (1067-AF-1545)

MAA Minicourse #13: Part B

1:00 PM – 3:00 PM

Creating demonstrations and guided explorations for multivariable calculus using CalcPlot3D.

Organizer: **Paul Seelburger**, Monroe Community College

MAA Minicourse #1: Part B

1:00 PM – 3:00 PM

Special relativity through a linear algebraic lens.

Organizer: **John de Pillis**, Unversity of California Riverside

MAA Minicourse: #5: Part B

1:00 PM – 3:00 PM

A Game Theory path to quantitative literacy.

Organizers: **David L. Housman**, Goshen College
Richard A. Gillman, Valparaiso University

AMS Session on Commutative Rings and Fields

1:00 PM – 5:25 PM

1:00PM (2052) *Annihilators of Local Cohomology.* Preliminary report.
Laura R Lynch, University of Nebraska-Lincoln (1067-13-625)

1:15PM (2053) *Minimal Zero-Dimensional Extensions.*
Marcela Chiorescu*, Georgia College & State University, GA, and **Fred Richman**, Florida Atlantic University, FL (1067-13-56)

1:30PM (2054) *Castelnuovo-Mumford regularity and relation type.*
Linh Cao Huy*, Hue University, Vietnam, and **Brodmann Markus**, University of Zurich, Switzerland (1067-13-800)

1:45PM (2055) *Characterizations of various integral domains of the form* $A + B[\Gamma^*]$. Preliminary report.
Gyu Whan Chang, University of Incheon, **Byung Gyun Kang** and **Jung Wook Lim***, Pohang University of Science and Technology (1067-13-879)

2:00PM (2056) *Integer-valued Polynomials over Noncommutative Rings.*
Nicholas J. Werner, The Ohio State University (1067-13-880)

2:15PM (2057) *On modules whose proper homomorphic images are of smaller cardinality.*
Adam Salminen*, University of Evansville, and **Greg Oman**, Ohio University (1067-13-907)

2:30PM (2058) *Some properties of term ideals.*
Hamid Kulosman, University of Louisville (1067-13-1758)

2:45PM (2059) *Tendencies of Trivariate Monomial Resolutions.* Preliminary report.
Jared L Painter, The University of Texas at Arlington (1067-13-2229)

3:00PM (2060) *Asymptotic Regularity of Powers of Ideal Sheaves.*
Wenbo Niu, University of Illinois at Chicago (1067-13-1812)

3:15PM (2061) *Irreducible Divisor Graphs.*
Nicholas R Baeth, University of Central Missouri (1067-13-1223)

3:30PM (2062) *Cut Sets of Zero-Divisor Graphs of Commutative Rings.*
Michael Axtell, University of St. Thomas, **Nicholas Baeth**, University of Central Missouri, **Shane Redmond**, Eastern Kentucky University, and **Joe Stickles, Jr.***, Millikin University (1067-13-1888)

► 3:45PM (2063) *Unique Maximal-Length Factorization in Numerical Semigroups.* Preliminary report.
Lance Bryant*, **James Hamblin** and **Lenny Jones**, Shippensburg University (1067-13-2118)

► 4:00PM (2064) *An Infinite System of Hypercomplex Numbers.*
Paul A Sundheim, University of Wisconsin (1067-13-222)

► 4:15PM (2065) *Factorization Techniques for Numerical Semigroup Rings.*
Paul Baginski*, Universite Lyon 1, and **K. Grace Kennedy**, University of California, Santa Barbara (1067-12-1494)

4:30PM (2066) *DEMOCRACY: a new technique for solving polynomial systems of equations over finite fields via stochastic local search.* Preliminary report.
Gregory V. Bard, Fordham University (1067-12-1908)

► 4:45PM (2067) *Random Trinomials and Lower Binomials.https://amsweb.ams.org/misapps/mtgs/mtgsmenu?mtg Mtgs Menu* Preliminary report.
Kenneth B Ascher, SUNY Stony Brook (Texas A&M REU) (1067-12-196)

5:00PM *Twin Irreducible Polynomials over* $\mathbf{F}_2$ *- Background.*
► (2068) Preliminary report.
Cooper Boniece* and **Gove Effinger**, Skidmore College (1067-12-1319)

5:15PM *Twin Irreducible Polynomials over* $\mathbf{F}_2$ *- Conjectures.*
► (2069) Preliminary report.
Cooper Boniece and **Gove Effinger***, Skidmore College (1067-12-1324)

AMS Session on Systems Theory, Information, and Computer Science

1:00 PM – 4:10 PM

1:00PM *Formal Definition of Probability and Probabilistic*
► (2070) *Function on Finite and Discrete Sample Space for Proving Security of Cryptographic Systems Using Mizar.*
Hiroyuki Okazaki*, **Yasunari Shidama** and **Yuichi Futa**, Shinshu University (1067-94-740)

1:15PM *Construction of zero autocorrelation stochastic*
► (2071) *waveforms.* Preliminary report.
Somantika Datta, University of Idaho (1067-94-1311)

1:30PM *Quantization dimension for an infinite iterated*
(2072) *function system.*
Mrinal Kanti Roychowdhury, The University of Texas-Pan American (1067-94-1354)

1:45PM *Resilient Modulus Modeling by Neural Network*
(2073) *Models with Information Theory Approach.*
Preliminary report.
Ali Saleh Shaqlaih*, University of North Texas at Dallas, **Luther White**, University of Oklahoma, and **Musharraf Zaman**, Dept of Civil Engineering, University of Oklahoma (1067-94-1917)

2:00PM *Identification of Regime-Switching Systems with*
(2074) *Structural Uncertainties.*
Shaobai Kan*, CUNY, and **George Yin**, Wayne State University (1067-93-804)

2:15PM *Exact Controllability of a Rayleigh beam with a*
(2075) *single boundary control.*
Ahmet Ozkan Ozer, Iowa State University (1067-93-1686)

2:30PM *Autoregulation Mechanisms in Complex Networks.*
(2076) **Radu C Cascaval**, University of Colorado at Colorado Springs (1067-93-1956)

2:45PM *Discrete-Time Sensitivity Analysis for MinMax*
► (2077) *Parameter Choice for the Heat Equation.*
John Teye Brown, Louisiana Tech University (1067-93-2301)

3:00PM *Changing Base without Losing Space.*
► (2078) **Yevgeniy Dodis**, New York University, **Mihai Patrascu** and **Mikkel Thorup***, AT&T Labs-Research (1067-68-1246)

3:15PM *Random 2-SAT Solution Components and a Fitness*
► (2079) *Landscape.*
Damien Pitman, SUNY Cortland (1067-68-1936)

3:30PM *Maximum-Weight Connected-Subgraph Problems.*
► (2080) **Peh H. Ng***, University of Minnesota, Morris, and **Herve L. Kerivin**, Clemson University (1067-90-1378)

3:45PM *Weighted Graph Model for Document Classification.*
► (2081) **Qin Wu***, **Eddie Fuller** and **Cun-Quan Zhang**, West Virginia University (1067-68-609)

4:00PM *Tracing contaminants using non-linear filter*
► (2082) *approximation.*
Menaka B Navaratna*, Florida Gulf Coast University, and **Channa N Navaratna**, Indiana University of PA (1067-68-1390)

AMS Session on Group Theory, II and Topological and Lie Groups

1:00 PM – 3:55 PM

1:00PM *Galois groups of p-class towers.*
(2083) **Michael R Bush**, Smith College (1067-20-1820)

1:15PM *Genericity of Filling Elements.*
(2084) **Brent B. Solie**, University of Illinois at Urbana-Champaign (1067-20-1051)

1:30PM *Faithful actions of automorphisms on the space of*
(2085) *orderings of a group.*
Thomas Koberda, Harvard University (1067-20-2285)

1:45PM $\mathbb{Z}_p$*-modules with partial decomposition bases.*
(2086) Preliminary report.
Peter Loth, Sacred Heart University (1067-20-350)

2:00PM *Distance in the Ellipticity Graph.*
(2087) **Yakov I Berchenko-Kogan**, California Institute of Technology (1067-20-425)

2:15PM *Groups of Graphs of Groups.*
► (2088) **Thomas Q. Sibley**, St. John's University/College of St. Benedict (1067-20-477)

2:30PM *Groups of finite Morley rank with a split* BN*-pair of*
(2089) *rank* 1.
Josh Wiscons, University of Colorado at Boulder (1067-20-841)

2:45PM *On weighted* ℓ^2*-Betti numbers of Coxeter groups.*
(2090) Preliminary report.
Dan Boros, Ohio State University (1067-20-2222)

3:00PM *On Automorphisms of the Hyperelliptic Torelli*
(2091) *Group.*
Leah R. Childers, Pittsburg State University (1067-20-1912)

3:15PM *The Boltzmann Principle and Degeneracy.*
(2092) **Dennis F. Cudia**, Rockford, Illinois (1067-20-1263)

3:30PM *Changing the rate at which a sequence in* $\mathbb{R}^n$ *is*
(2093) *forced to converge to zero.*
T. Christine Stevens, Saint Louis University (1067-22-2391)

3:45PM *Elements of Polynomials evaluated at points of* βS*.*
(2094) Preliminary report.
Kendall Williams, Howard University (1067-22-1287)

AMS Session on Operator Theory

1:00 PM – 4:25 PM

1:00PM *A direct calculation of the vector Riemann*
(2095) *constants corresponding to the marked doubles.*
Cyrus P. Aryana, Saginaw Valley State University (1067-47-1170)

1:15PM *The Mackey Machine for Groupoid Crossed*
(2096) *Products.*
Geoff R Goehle, Western Carolina University (1067-47-412)

1:30PM *Partially normal composition operators relevant to*
(2097) *weighted directed trees.*
George R. Exner, Bucknell University, **Il Bong Jung**, **Eun Young Lee*** and **Mi Ryeong Lee**, Kyungpook National University (1067-47-721)

1:45PM *Backwards weighted shifts and* n*-contractivity.*
(2098) Preliminary report.
George R Exner, Bucknell University (1067-47-650)

2:00PM *The Inverse of a Two-level Positive Definite Toeplitz*
(2099) *Operator.*
Selcuk Koyuncu* and **Hugo Woerdeman**, Drexel University (1067-47-316)

2:15PM (2100) *Schatten p-class Weighted Composition Operators on Bergman Spaces of the Unit Ball.*
Waleed Khaled Al-Rawashdeh, Montana Tech of the University of Montana (1067-47-1852)

2:30PM (2101) *The Szegö Kernel for Certain Non-Pseudoconvex domains in $\mathbb{C}^2$.*
M Anthony Gilliam*, University of Montana, Missoula, and **Jennifer Halfpap**, University of Montana (1067-47-176)

2:45PM (2102) *On characterization of range spaces of composition operator on spaces of entire functions.*
S. Mukherjee*, **F. Jafari**, University of Wyoming, and **J. E. McInroy**, Dept. Electrical & Computer Engineering, University of Wyoming (1067-47-324)

3:00PM (2103) *The Muckenhoupt-type estimations for the best constants in multidimensional modular inequalities over spherical cones.* Preliminary report.
Chang-Pao Chen*, Hsuan Chuang University, **Jin-Wen Lan**, National Tsing Hua University, and **Dah-Chin Luor**, I-Shou University (1067-47-351)

3:15PM (2104) *Irregular orbits of operators.*
Gabriel T Prajitura, SUNY Brockport (1067-47-427)

3:30PM (2105) *Multiplication Operators between Lipschitz-Type Spaces of an Infinite Tree.*
Robert F. Allen*, University of Wisconsin - La Crosse, **Flavia Colonna**, George Mason University, and **Glenn R. Easley**, System Planning Corporation (1067-47-441)

3:45PM (2106) *Estimating Arbitrary Symmetric Norms.* Preliminary report.
Duane K Farnsworth, Marshall University (1067-47-689)

4:00PM (2107) *Multipliers and hereditary subalgebras of operator algebras.* Preliminary report.
Damon M. Hay, Sam Houston Sate University / University of North Florida (1067-47-1952)

4:15PM (2108) *On the Uniqueness of Topological Degrees for Densely Defined Mappings Involving Variants of (S_+) Operators.* Preliminary report.
Dhruba R Adhikari, Mississippi University for Women (1067-47-2149)

MAA Session on Alternative Approaches to Traditional Introductory Statistics Courses, II

1:00 PM – 5:55 PM

Organizers: **Brian T. Gill**, Seattle Pacific University
Nancy J. Boynton, SUNY Fredonia
Michael A. Posner, Villanova University

1:00PM ► (2109) *Two-way tables: A path less traveled.*
Melinda Miller Holt* and **Stephen M. Scariano**, Sam Houston State University (1067-B1-961)

1:20PM ► (2110) *Teaching Two Tailed Tests.* Preliminary report.
Philip S. Marcus, Bradley University (1067-B1-197)

1:40PM (2111) *Consequences of Resequencing Topics in an Introductory Statistics Course.*
Chris J Malone*, **Tisha L Hooks** and **April T Kerby**, Winona State University (1067-B1-2220)

2:00PM (2112) *A different flavor of introductory statistics: Teaching students to really cook.*
Robert delMas*, **Joan Garfield**, **Andrew Zieffler**, **Laura Le**, **Rebekah Isaak**, **Jiyoon Park** and **Laura Ziegler**, University of Minnesota, Twin Cities (1067-B1-1565)

2:20PM ► (2113) *An Active Approach to Statistical Inference using Randomization Methods.* Preliminary report.
Todd M Swanson* and **Jill L VanderStoep**, Hope College (1067-B1-1940)

2:40PM ► (2114) *Early Inference: Using Bootstraps to Introduce Confidence Intervals.*
Robin H Lock* and **Patti Frazer Lock**, St. Lawrence University (1067-B1-2075)

3:00PM (2115) *Early Inference: Using Randomization to Introduce Hypothesis Tests.*
Kari F. Lock*, Harvard University, **Eric F. Lock**, University of North Carolina at Chapel Hill, and **Dennis F. Lock**, Iowa State University (1067-B1-2270)

3:20PM ► (2116) *Success!Teaching Introductory Statistics Online.*
Pamela B. Omer, Western New England College (1067-B1-922)

3:40PM ► (2117) *Introductory Statistics and Science: A Collaborative Teaching Approach.*
M. Leigh Lunsford* and **Alix D. Dowling Fink**, Longwood University (1067-B1-1906)

4:00PM ► (2118) *Deep Assignments: Getting Students to Think.* Preliminary report.
K. Scott Alberts, Truman State University (1067-B1-1747)

4:20PM ► (2119) *Looking for a semester long project to enhance student learning? We have one for you!*
Pamela Omer* and **Marilyn Pelosi**, Western New England College (1067-B1-2053)

4:40PM ► (2120) *FREE CLICKERS!: Using PollEverywhere for Formative Assessment in the Classroom.* Preliminary report.
Michael A Posner, Villanova University (1067-B1-1047)

5:00PM (2121) *Some Active Learning Ideas in Introductory Statistics Courses.*
John C. Wagaman, Western Carolina University (1067-B1-527)

5:20PM (2122) *Revising a course to meet the GAISE guidelines.*
Kimberly A Roth, Juniata College (1067-B1-730)

5:40PM ► (2123) *Seeing Statistics.* Preliminary report.
John P Travis, Mississippi College (1067-B1-1639)

MAA Session on Using Program Assessment to Improve Student Learning

1:00 PM – 2:55 PM

Organizers: **Bonnie Gold**, Monmouth University
William A. Marion, Valparaiso University
Jay A. Malmstrom, Oklahoma City Community College

1:00PM ► (2124) *Assessment: What are we learning?* Preliminary report.
Sarah V Cook* and **Donna LaLonde**, Washburn University (1067-Y1-1567)

1:20PM ► (2125) *Course-based Program Assessment.*
Joe A. Guthrie and **Helmut Knaust***, University of Texas at El Paso (1067-Y1-1670)

1:40PM ► (2126) *Assessing and Improving Students' Fundamental Mathematical Skills throughout their STEM Education.* Preliminary report.
Lee A Evans*, **Jeremy M Riehl** and **Kristin M Arney**, United States Military Academy (1067-Y1-2174)

2:00PM (2127) *Constructing Tests for Program Assessment.* Preliminary report.
Jacalyn M Huband, University of West Florida (1067-Y1-1653)

2:20PM ► (2128) *Improving Student Proficiency in Statistics through Core Curriculum Assessment at Virginia Military Institute.* Preliminary report.
Vonda K Walsh, Virginia Military Institute (1067-Y1-1913)

2:40PM *Using Rubrics for Calculus 2 Maple Labs.*
► (2129) **Jenn D. Berg**, Fitchburg State University (1067-Y1-1911)

MAA Session on Trends in Undergraduate Mathematical Biology Education, II

1:00 PM – 5:35 PM

Organizers: **Timothy D. Comar**, Benedictine University
Raina Robeva, Sweet Briar College
Mike Martin, Johnson County Community College

1:00PM *The constructive role of noise in cellular processes.*
► (2130) Preliminary report.
Patricia Theodosopoulos* and **Ted Theodosopoulos**, Saint Ann's School (1067-X1-2181)

1:20PM *Student Projects for the Mathematical Modeling of*
► (2131) *Wound Healing.* Preliminary report.
Richard Schugart, Western Kentucky University (1067-X1-1660)

1:40PM *Introduction to Mathematical Models in Biology.*
(2132) Preliminary report.
Mazen Shahin, Delaware State University (1067-X1-2146)

2:00PM *Mathematical Biology Modules Based on Modern*
(2133) *Molecular Biology and Modern Discrete Mathematics.*
Terrell L. Hodge*, Western Michigan University, and **Raina Robeva**, Sweet Briar College (1067-X1-2095)

2:20PM *Integrating mathematics and the life sciences to*
► (2134) *better prepare graduates for medical school.*
Kelly E Matthews*, **Peter Adams** and **Merrilyn Goos**, University of Queensland (1067-X1-1424)

2:40PM *Addressing the Revision of the MCAT Within the*
► (2135) *Symbiosis Project.*
Jeff R Knisley, East Tennessee State University (1067-X1-1588)

3:00PM *BioMath Program at Florida Tech: How to Sustain*
► (2136) *it?* Preliminary report.
Semen Koksal*, **D. Carroll** and **R. Sinden**, Florida Institute of Technology (1067-X1-1894)

3:20PM *Short Courses in Biomathematics Topics for NSF*
► (2137) *Undergraduate Biology Mathematics Program (UBM Grant).* Preliminary report.
Ron Barnes* and **Edwin Tecarro**, University of Houston-Downtown (1067-X1-2148)

3:40PM *UBM Group Seminar Discussions: Grappling with*
(2138) *Issues beyond the Curriculum.*
D. Brian Walton, James Madison University (1067-X1-1645)

4:00PM *Integrated undergraduate research experiences in*
► (2139) *biological and mathematical sciences for minority students.* Preliminary report.
Kaibin Fu, Prairie View A&M University (1067-X1-1361)

4:20PM *Mathematics, Biology, and Imaging: Engaging*
► (2140) *Undergraduates in Research on the Fringe of Mathematical Biology.*
Aaron Luttman, Clarkson University (1067-X1-812)

4:40PM *Interdisciplinary Training in Mathematical Biology*
(2141) *Through Team-based Undergraduate Research and Courses.*
Jason E Miller, Truman State University (1067-X1-1746)

5:00PM *Teaching Mathematical Modeling: Challenging*
(2142) *Torricelli's Law.*
Brynja R. Kohler*, **Janice Bodily**, **Jessica Munns Davis**, **James Haefner** and **James Powell**, Utah State University (1067-X1-2221)

5:20PM *Transformative Research and Training in biological*
► (2143) *and bio-inspired systems in undergraduate mathematics.* Preliminary report.
Padmanabhan Seshaiyer* and **Maria Emelianko**, George Mason University (1067-X1-1461)

MAA Session on Humanistic Mathematics, II

1:00 PM – 6:00 PM

Organizers: **Gizem Karaali**, Pomona College
Mark Huber, Claremont McKenna College
Dagan Karp, Harvey Mudd College

1:00PM *Grading Without Numbers.*
► (2144) **Russell W Howell**, Westmont College (1067-I1-2419)

1:20PM *Three Humanistic Approaches.* Preliminary report.
► (2145) **Satish C. Bhatnagar**, University of Nevada Las Vegas (1067-I1-2397)

1:40PM *What do we mean by mathematical proof?*
► (2146) **Todd CadwalladerOlsker**, California State University, Fullerton (1067-I1-90)

2:00PM *Student Inquiry into the Limits of Knowledge -*
(2147) *Removing Barriers in Mathematics for Liberal Arts.* Preliminary report.
Philip K Hotchkiss*, Westfield State University, **Julian F Fleron**, **Volker Ecke** and **Christine von Renessee**, Westfield State College (1067-I1-2215)

2:20PM *Teaching Reading and Writing Mathematics for*
► (2148) *Social Justice.*
Teodora B. Cox, SUNY Fredonia (1067-I1-1988)

2:40PM *Transmitting Philosophies of Mathematics Through*
► (2149) *Pedagogy.*
Erin R. Moss, Millersville University of Pennsylvania (1067-I1-1848)

3:00PM *Development of the appreciation of mathematics*
► (2150) *via teaching mathematics education for the public interest.* Preliminary report.
José María Menéndez* and **Laura Jacobsen**, Radford University (1067-I1-977)

3:20PM *Mathematical Learning: A Humanistic Re-formation*
► (2151) *of Core-curricular Instruction.* Preliminary report.
Clyde I. Greeno, The MALEI Mathematics Institute (1067-I1-2093)

3:40PM *Success in the university mathematics classroom:*
► (2152) *Learning from the voices of students.*
Angie Hodge* and **Christina D Weber**, North Dakota State University (1067-I1-1699)

4:00PM *Psychologism as an Issue in the Mathematical*
► (2153) *Philosophy of Bertrand Russell.*
Carl Behrens, Alexandria, VA (1067-I1-1506)

4:20PM *A Humanistic Approach to Teaching Mathematics to*
► (2154) *the Liberal Arts Student.*
James P Fulton, SUNY Suffolk County Community College (1067-I1-1896)

4:40PM *A 2-week summer camp.*
(2155) **Kazem Mahdavi**, The University of Texas at Tyler (1067-I1-431)

5:00PM *Cooperative Systems Course: The Mathematics of*
► (2156) *Harmony.*
Chris Arney, United States Military Academy (1067-I1-242)

5:20PM Wrap up and group discussion.

MAA Session on Influences of the Calculus Reform Movement on the Teaching of Mathematics, II

1:00 PM – 4:35 PM

Organizers: **Steven R. Benson**, Lesley University
Marilyn Carlson, Arizona State University
Ellen E. Kirkman, Wake Forest University
Joe Yanik, Emporia State University

1:00PM (2157) *Finding the Sum of an Infinite Series.* **Robert P Webber**, Longwood University (1067-J1-544)

1:20PM (2158) *A Survey Transition Course.* **William Johnston***, Randolph-Macon College, and **Alex M McAllister**, Centre College (1067-J1-557)

1:40PM (2159) *Not Just Grading the Answer: Assessing Process and Communication Effectively and Efficiently with Rubrics.* **Michael A Brilleslyper***, **Trae D Holcomb** and **Dustin D Keck**, U. S. Air Force Academy (1067-J1-1333)

2:00PM (2160) *An Emphasis on Application and Communication through Podcasts.* **Erick B Hofacker**, University of Wisconsin - River Falls (1067-J1-2060)

2:20PM (2161) *The Impact of Web-Based Homework on University Calculus Students.* **Teodora B. Cox***, SUNY Fredonia, and **Stacey Singer**, Salamanca High School (1067-J1-1995)

2:40PM (2162) *Getting in on the Ground Floor: How Growing Up with Calculus Reform Helps with Web 2.0.* **Steven W. Morics**, University of Redlands (1067-J1-2289)

3:00PM (2163) *Preparation for a technical core: Algebra & trigonometry at the Air Force Academy.* Preliminary report. **Beth Schaubroeck*** and **Michael Courtney**, U.S. Air Force Academy (1067-J1-2083)

3:20PM (2164) *Using Mathematical Modeling in Undergraduate Mathematics Courses to Promote Creativity and Critical Thinking.* **Kristin Arney***, **Hilary Fletcher** and **Gerald Kobylski**, United States Military Academy (1067-J1-2092)

3:40PM (2165) *Making Calculus Come Alive with Dynamic Visualization.* Preliminary report. **Paul E Seeburger**, Monroe Community College (1067-J1-2379)

4:00PM (2166) *Differential Equations as a basis for Calculus II.* **Duff Campbell**, Hendrix College (1067-J1-1053)

4:20PM (2167) *Bayesian Analysis of a Real Galton Board.* Preliminary report. **Marcus Pendergrass**, Hampden-Sydney College (1067-J1-1993)

MAA Session on the Mathematical Foundations for the Quantitative Disciplines

1:00 PM – 3:35 PM

Organizers: **Yajun Yang**, Farmingdale State College of SUNY
Laurette Foster, Prairie View A&M University
Ray E. Collings, Georgia Perimeter College
K. L. D. Gunawardena, University of Wisconsin-Oshkosh

1:00PM (2168) *Not your mother's college algebra course – rethinking how we prepare students for quantitative reasoning across the disciplines.* Preliminary report. **Suzanne I Doree**, Augsburg College, Minneapolis (1067-N1-1619)

1:20PM (2169) *Integrating Statistics into College Algebra: Providing the Mathematics that Students Need.* **Sheldon P. Gordon**, Farmingdale State College (1067-N1-1899)

1:40PM (2170) *Ways to teach meaningful modeling in algebra-based courses.* Preliminary report. **Marko Kranjc**, Western Illinois University (1067-N1-1093)

2:00PM (2171) *A year's experience with implementing a data modeling based course at the College Algebra level.* **D Scott Dillery**, Lindsey Wilson College (1067-N1-1391)

2:20PM (2172) *The Right Stuff: Are We Teaching It In College Algebra?* **Lisa S Yocco**, Georgia Southern University (1067-N1-586)

2:40PM (2173) *Using Global Warming to Teach College Algebra: Preliminary Report.* **Jill F McGowan**, Howard University (1067-N1-2044)

3:00PM (2174) *Discrete Dynamical Modeling for Freshmen.* **Richard D. West**, Francis Marion University (1067-N1-1625)

3:20PM (2175) *Faculty and Student Support for Quantitative Reasoning and How to Make it Count.* **David G Taylor**, Roanoke College (1067-N1-393)

MAA General Contributed Paper Session, XIII

1:00 PM – 4:40 PM

Organizers: **Kristen Meyer**, Wisconsin Lutheran College
Thomas R. Hagedorn, The College of New Jersey

1:00PM (2176) *A New View of Presentation Theory for C*-algebras.* **William Benjamin Grilliette**, University of Nebraska - Lincoln (1067-Z1-1601)

1:15PM (2177) *Crossed Products of Certain Non-Simple Non-Commutative C*-Algebras.* **Julian M Buck**, Francis Marion University (1067-Z1-2077)

1:30PM (2178) *Positive operators on Banach lattices and domination properties.* **Pedro Tradacete**, University of Barcelona (1067-Z1-1702)

1:45PM Break

2:00PM (2179) *Positive Solutions for Infinite Semipositone Problems with Falling Zeros.* **Jinglong Ye***, Center for Computational Sciences, Mississippi State University, **EunKyoung Lee**, Pusan National University, and **Ratnasingham Shivaji**, Mississippi State University (1067-Z1-443)

2:15PM (2180) *Demystifying the Dirac Delta "Function".* Preliminary report. **Trent C Kull**, Winthrop University (1067-Z1-1484)

2:30PM (2181) *What is a Functional Equation?* Preliminary report. **Maria Neophytou**, Purdue University (1067-Z1-2208)

2:45PM (2182) *Measuring discontinuities of functions.* **Djalalidin Djayanbaev**, Rogers State University (1067-Z1-603)

3:00PM *Archimedean Hypersurfaces.*
► (2183) **Vincent Coll**, Lehigh University, **Jeff Dodd**, Jacksonville State University, and **Michael Harrison***, King's College London (1067-Z1-1728)

3:15PM *K-energy on hypersurfaces.*
(2184) **TseChing Lien**, University of Wisconsin, Madison (1067-Z1-2245)

3:30PM *Fractals and their Dimensions.* Preliminary report.
► (2185) **A Melissa Glass**, Wake Forest University (1067-Z1-2254)

3:45PM *Parabolic Monoids of Matrices.*
(2186) **Eric D. Bancroft**, North Carolina State University (1067-Z1-1070)

4:00PM *"Rigidity" and Language of Fundamental Groups of*
► (2187) *Manifolds.* Preliminary report.
Luc Patry, University of Arkansas at Pine Bluff (1067-Z1-1844)

4:15PM *Cleavability over Fréchet-Urysohn LOTS.*
(2188) **Shari S Levine**, University of Oxford, Mathematical Institute (1067-Z1-61)

4:30PM *Semigroup Operators in Cauchy Problems.*
► (2189) **Yang Xinyao**, University of Missouri-Columbia (1067-Z1-1562)

MAA General Contributed Paper Session, XIV

1:00 PM – 5:10 PM

Organizers: **Kristen Meyer**, Wisconsin Lutheran College
Thomas R. Hagedorn, The College of New Jersey

1:00PM *Vector coloring of graphs.*
► (2190) **Louis Deaett**, University of Victoria (1067-Z1-2207)

1:15PM *Uniquely D-colorable Digraphs With Large Girth.*
(2191) Preliminary report.
Liam Rafferty, University of Montana (1067-Z1-2265)

1:30PM *Graph Factors Including or Excluding Certain Edge*
► (2192) *Sets in Bipartite Graphs.*
Hollie L Buchanan, West Liberty University (1067-Z1-2108)

1:45PM *Mean First Passage Times and the Kemeny Constant*
(2193) *on Tree Networks.*
Mary E Allison, University of Wyoming (1067-Z1-2032)

2:00PM *Investigations in Linear Algebra and Combinatorics*
► (2194) *related to Biclique Decompositions of Graphs.*
Shadiyah Amani Mangru, George Mason University (1067-Z1-1623)

2:15PM *Conditions for Embedding a Partial Latin Square*
► (2195) *Inside a Latin Square of a Given Order.* Preliminary report.
Serge C Ballif, The Pennsylvania State University (1067-Z1-1999)

2:30PM *Probabilistic Pentominos and other Polyforms.*
► (2196) **Dale K Hathaway*** and **Mark J Lockwood**, Olivet Nazarene University (1067-Z1-530)

2:45PM *A Combinatorial Formula for Certain*
► (2197) *Two-Dimensional Sequences Related to Generalized Bernoulli Polynomials.* Preliminary report.
Hieu D Nguyen, Rowan University (1067-Z1-738)

3:00PM Break

3:15PM *Tetranomial Thue Equations of Small Degree.*
(2198) Preliminary report.
Daniel P. Wisniewski*, DeSales University, and **Helen G. Grundman**, Bryn Mawr College (1067-Z1-1290)

3:30PM *The Shard Intersection Order on the Symmetric*
(2199) *Group.*
Erin Elizabeth Bancroft, North Carolina State University (1067-Z1-900)

3:45PM *Generalizations of Thompson's Group V.*
(2200) Preliminary report.
Matthew F Short, Binghamton University (1067-Z1-2024)

4:00PM *On the solution of the conjugacy problem of*
► (2201) *Thompson's group F.*
Candace M. Schenk, Binghamton University (1067-Z1-2001)

4:15PM *A new proof of the Pieri rule for the dual*
(2202) *Grothendieck polynomials.*
Derek H Heilman* and **Jennifer Morse**, Drexel University (1067-Z1-2296)

4:30PM *The Schur Property on Positive Tensor Products.*
(2203) Preliminary report.
Wei-Kai Lai, University of South Carolina, Salkehatchie (1067-Z1-2368)

4:45PM *The behavior of Conway's RATS sequences.*
► (2204) **Johann A. Thiel**, University of Illinois Urbana-Champaign (1067-Z1-1986)

5:00PM *New Ramanujan congruences for partition related*
(2205) *eta-quotients.*
T Hudson Harper, University of South Carolina (1067-Z1-1882)

MAA General Contributed Paper Session, XV

1:00 PM – 4:40 PM

Organizers: **Kristen Meyer**, Wisconsin Lutheran College
Thomas R. Hagedorn, The College of New Jersey

1:00PM *Cool Calculus; From Weight Loss to Climate Change*
(2206) *in an Intermediate Calculus Course.*
Mihaela Dobrescu, Christopher Newport University (1067-Z1-2331)

1:15PM *Grand finale: The Basel Problem as a culminating*
► (2207) *objective in Calculus II.* Preliminary report.
Jonathan A Cox, SUNY Fredonia (1067-Z1-2052)

1:30PM *Dogs don't need calculus.*
► (2208) **Michael D. Bolt***, Calvin College, and **Daniel C. Isaksen**, Wayne State University (1067-Z1-2364)

1:45PM *RGB to HSI.* Preliminary report.
► (2209) **Yesem Kurt Peker***, Randolph College, **Catherine Beneteau**, University of South Florida, and **David A. Eubanks**, Johnson C. Smith University (1067-Z1-2163)

2:00PM *Squigonometry: Using Calculus to Develop New*
► (2210) *Transcendental Functions.* Preliminary report.
William E Wood, Hendrix College (1067-Z1-884)

2:15PM *Using a Wireless Tablet to Lecture in Mathematics*
► (2211) *Classes.* Preliminary report.
Peter L Staab, Fitchburg State University (1067-Z1-1250)

2:30PM *Writing Projects For Mathematics Courses.*
(2212) **Dawn Archey**, Marymount Manhattan College (1067-Z1-2167)

2:45PM *CalcTool 3: An applet to visualize 3D objects.*
► (2213) Preliminary report.
James S Rolf, United States Air Force Academy (1067-Z1-2256)

3:00PM *Utilizing Web-Based Mathematical Resources in*
► (2214) *Teaching Nontraditional Undergraduate Students in Online Learning Environments.*
Michael D Miner, American Public University System (1067-Z1-1869)

3:15PM (2215) *Integrating Technology to Match Learning Styles in an Online Mathematics Course.* Preliminary report.
Denise J LeGrand, University of Arkansas at Little Rock (1067-Z1-561)

3:30PM (2216) *Using Online Mathematics Modules for Physical Chemistry Students.* Preliminary report.
Jim Gleason*, **Daniel Burton** and **Martin Bakker**, The University of Alabama (1067-Z1-45)

3:45PM (2217) *From Zero to LaTeX in Three Weeks: Teaching Scientific Typesetting to Undergraduates.*
Ryan S. Higginbottom, Washington & Jefferson College (1067-Z1-2197)

4:00PM (2218) *Teaching Introductory Computer Programming to Mathematics Majors with SAGE.*
Don K Krug, Northern Kentucky University (1067-Z1-1926)

4:15PM (2219) *The School of Empathy.*
Rosanna Iembo*, University of Calabria, Italy, and **Irene Iaccarino**, School of Music in Crotone (1067-Z1-630)

4:30PM (2220) *An Inhibitor to Learning College Level Mathematics Math Anxiety: Problems and Proposed Solutions.*
Agnes M Rash, Saint Joseph's University (1067-Z1-1254)

SIAM Minisymposium on Graph Theory

1:00 PM – 5:55 PM

Organizers: **Michael Ferrara**, University of Colorado, Denver
Stephen Hartke, University of Nebraska-Lincoln

1:00PM (2221) *Spectra of Hypergraphs.*
Joshua N Cooper* and **Aaron M Dutle**, University of South Carolina (1067-15-1312)

1:30PM (2222) *On pre-coloring extension to list-colorings.*
Maria Axenovich*, Iowa State University, **Joan Hutchinson**, Macalester College, and **Michelle Lastrina**, Iowa State University (1067-05-1821)

2:00PM (2223) *A Variation of the Classical Turán Type Problem.*
Zi-Xia Song, University of Central Florida (1067-05-1205)

2:30PM (2224) *Ramsey-type Numbers for Degree Sequences.*
Arthur Busch*, University of Dayton, **Michael Ferrara**, **Michael Jacobson**, University of Colorado Denver, and **Stephen Hartke**, University of Nebraska-Lincoln (1067-05-2004)

3:00PM (2225) *Saturation Numbers for Families of Subdivisions.*
Michael Ferrara, **Michael Jacobson**, University of Colorado Denver, **Kevin Milans**, University of South Carolina, **Craig Tennenhouse**, University of New England, and **Paul S Wenger***, University of Colorado Denver (1067-05-2068)

3:30PM (2226) *2-factors with long cycles in cubic graphs.*
André Kündgen*, California State University San Marcos, and **R. Bruce Richter**, University of Waterloo, CANADA (1067-05-1429)

4:00PM (2227) *Distributing vertices on a hamiltonian cycle.*
Colton Magnant, Atlanta, GA (1067-05-315)

4:30PM (2228) *New Ore-Type Conditions for H-Linked Graphs.*
Michael Ferrara*, University of Colorado Denver, **Ronald Gould**, Emory University, **Michael Jacobson**, University of Colorado Denver, **Pfender Florian**, Universität Rostock, Rostock, Germany, **Jeffrey Powell**, Samford University, and **Thor Whalen**, Methodic Solutions, Inc., Atlanta GA (1067-05-1273)

5:00PM (2229) *Immersion in digraphs and related problems.* Preliminary report.
Alexandra Ovetsky Fradkin* and **Paul D. Seymour**, Princeton University (1067-05-1008)

5:30PM (2230) *On Maximum Cuts of Connected Digraphs.* Preliminary report.
Guantao Chen*, Georgia State University, **Manzhan Gu**, Shanghai Universiyt of Finance and Economics, and **Nana Li**, Georgia State University (1067-05-2413)

AWM Workshop Panel Discussion

1:00 PM – 2:15 PM

Starting a career in mathematics.

Moderator: **Susan Williams**, University of South Alabama

Panelists: **Sarah Frick**, Furman University
Pierre Gremaud, SAMSI and North Carolina State University
T.Christine Stevens, Saint Louis University
Tad White, National Security Agency

AMS Session on Probability, II

1:15 PM – 5:25 PM

1:15PM (2231) *On a Processor Sharing Queue That Models Balking.*
Qiang Zhen*, University of North Florida, **J.S.H. van Leeuwaarden**, Eindhoven University of Technology, and **Charles Knessl**, University of Illinois at Chicago (1067-60-803)

1:30PM (2232) *Large Deviations and Importance Sampling for a Feedforward Network.*
Leila Setayeshgar* and **Hui Wang**, Brown University (1067-60-295)

1:45PM (2233) *A Stochastic Stefan Problem.*
Kunwoo Kim*, **Richard B. Sowers** and **Zhi Zheng**, University of Illinois at Urbana-Champaign (1067-60-410)

2:00PM (2234) *Stochastic control for linear systems with fractional Brownian motion.* Preliminary report.
Yalcin Sarol, University of Southern Indiana (1067-60-1161)

2:15PM (2235) *Counting and Partition Function Asymptotics for Subordinate Killed Brownian Motion.*
Sarah N Bryant, Dickinson College (1067-60-2283)

2:30PM (2236) *Continuous-time random walks, their scaling limits, and connections with stochastic integration.* Preliminary report.
Meredith Burr, Rhode Island College (1067-60-849)

2:45PM (2237) *Ruin probability in the Cramér-Lundberg model with risky investments.* Preliminary report.
Sheng Xiong* and **Wei-Shih Yang**, Temple University (1067-60-585)

3:00PM (2238) *A Nash Equilibrium with several large traders.* Preliminary report.
Tankut Dogrul, University of Tennessee at Chattanooga (1067-60-582)

3:15PM (2239) *Quantile Hedging for Guaranteed Minimum Death Benefits with Regime-Switching.* Preliminary report.
Yumin Lolita Wang*, Binghamton University (SUNY), and **Gang George Yin**, Wayne State University (1067-60-1126)

3:30PM (2240) *Cluster K and probabilistic-Nearest-Neighbor Predictions in Foreign Exchange Markets.* **Vindya Kumari Pathirana***, University of South Florida, Tampa, Florida, and **Kandethody M. Ramachandran**, University of South Florida, Tampa, FL (1067-60-2015)

3:45PM Discussion

► 4:00PM (2241) *Average time until fixation of mutant allele in a given population.* Preliminary report. **Komi Segno Messan***, North Carolina A&T State University, **Michael Lynch** and **Matthew Ackerman**, Indiana University (1067-60-2319)

4:15PM (2242) *A Point Process Model for Simulating Gang Violence.* **Mark Allenby***, Pepperdine University, **Kym Louie**, Harvey Mudd College, and **Marina Masaki**, University of California Irvine (1067-60-2193)

► 4:30PM (2243) *Budding yeast, branching processes, and generalized Fibonacci numbers.* **Peter Olofsson*** and **Ryan C Daileda**, Trinity University (1067-60-468)

► 4:45PM (2244) *Estimating bacterial lag phase: a branching process approach.* **Peter Olofsson** and **Xin Ma***, Trinity University (1067-60-469)

5:00PM (2245) *On equality of critical exponents in inhomogeneous percolation models.* Preliminary report. **John C. Wierman** and **Matthew R.A. Sedlock***, Johns Hopkins University (1067-60-1489)

5:15PM (2246) *On equality of critical exponents in homogeneous percolation models.* Preliminary report. **John C. Wierman*** and **Matthew R. A. Sedlock**, Johns Hopkins University (1067-60-1491)

AMS Session on Dynamical Systems, and Topics in Analysis, II

1:15 PM – 4:55 PM

1:15PM (2247) *Mapping Schemes Realizable by Obstructed Topological Polynomials.* **Gregory A Kelsey**, University of Illinois at Urbana-Champaign (1067-37-31)

► 1:30PM (2248) *Quadratic-like mappings and iterated Weierstrass elliptic functions.* **Joshua J Clemons**, Virginia Tech (1067-37-164)

1:45PM (2249) *Orbit distributions in iterated function systems with finitely many forms.* **R E Lampe**, South University (1067-37-1584)

► 2:00PM (2250) *Families of periodic orbits of fractal billiard tables.* **Michel L. Lapidus** and **Robert G. Niemeyer***, University of California, Riverside (1067-37-1874)

► 2:15PM (2251) *Dynamics of degree* 3 *rational maps with parabolic fixed points.* Preliminary report. **Rika Hagihara***, St. Mary's College of Maryland, and **Jane Hawkins**, University of North Carolina at Chapel Hill (1067-37-2116)

2:30PM (2252) *Strong Orbit Equivalence and Residuality.* **Brett M. Werner**, University of Northern Iowa (1067-37-2282)

2:45PM (2253) *Product structure of the spectral zeta function of the Sturm-Liouville operator on fractals.* Preliminary report. **Nishu Lal*** and **Michel Lapidus**, University of California, Riverside (1067-37-2287)

3:00PM (2254) *Random Subshifts of Finite Type.* **Kevin McGoff**, University of Maryland (1067-37-1934)

3:15PM (2255) *Partition zeta functions of self-similar measures.* **Kate E. Ellis**, California State University, Stanislaus, **Michel L. Lapidus**, University of California, Riverside, **Michael C. Mackenzie**, University of Connecticut, and **John A. Rock***, California State University, Stanislaus (1067-28-55)

► 3:30PM (2256) *q-Orthogonal Polynomial Solutions to a Class of Differential-Difference Equations.* Preliminary report. **Daniel Joseph Galiffa**, Penn State Erie (1067-33-631)

3:45PM (2257) *Parametric solution of certain nonlinear differential equations with applications in cosmology.* **Jennie D'Ambroise***, University of Minnesota at Morris, and **Floyd L WIlliams**, University of Massachusetts at Amherst (1067-33-1566)

4:00PM (2258) *High-Dimensional Counterexamples of the Kaplan-Yorke Conjecture: Fractal Dimension of the Drosophila Circadian Clock.* **Fathallah-Shaykh M Hassan**, The University of Alabama at Birmingham (1067-37-1241)

► 4:15PM (2259) *Orthogonal and Maximal Sets for Bernoulli Measures.* Preliminary report. **Bryan Archer**, **Rees Dooley**, **Reid Kelley**, **Alyssa Leone** and **Patrick Orchard***, University of Oklahoma (1067-28-140)

4:30PM (2260) *The truncated matrix-valued K-moment problem on $\mathbb{R}^d$, $\mathbb{C}^d$, and $\mathbb{T}^d$.* Preliminary report. **David P. Kimsey*** and **Hugo J. Woerdeman**, Drexel University (1067-28-1291)

► 4:45PM (2261) *A simple, general proof of Descartes' rule of signs.* **Robert J. Blodgett**, Food and Drug Administration (1067-26-399)

AMS Session on Partial Differential Equations, IV

1:15 PM – 4:10 PM

1:15PM (2262) *Ideal Magnetohydrodynamics, Non-Newtonian fluids with infinite Weissenberg number and related issues.* **X.J. Wang*** and **Michael Renardy**, Virginia Tech (1067-35-999)

1:30PM (2263) *Global existence and long time behavior of the general Ericksen-Leslie system.* **Xiang Xu***, The Pennsylvania State University, **Hao Wu**, Fudan University, and **Chun Liu**, The Pennsylvania State University (1067-35-1355)

1:45PM (2264) *Open Loop Stabilization of Nonlinear Schrodinger Equation.* **Turker Ozsari**, Dogus University (1067-35-896)

2:00PM (2265) *Bifurcation problem of the discrete nonlinear Schrödinger equations with sign changing nonlinearity.* Preliminary report. **Guoping Zhang**, Morgan State University (1067-35-1072)

► 2:15PM (2266) *Instability of Nonmonotone Magnetic Equilibria of the Relativistic Vlasov-Maxwell System.* **Jonathan Ben-Artzi**, Brown University (1067-35-415)

► 2:30PM (2267) *Exact solutions for a class of 3D-ratholes in highly frictional granular solids.* **Daniel Arrigo**, **Long H Le*** and **Jason Torrence**, University of Central Arkansas (1067-35-416)

► 2:45PM (2268) *Bifurcation and Continuation Analysis of Equilibria of the Diblock Copolymer Equation in One Dimension.* Preliminary report. **Ian Johnson**, George Mason University (1067-35-2405)

3:00PM (2269) *An existence and uniqueness theorem for periodic solutions to Boussinesq equations.* Preliminary report.
Timur Milgrom* and **David M. Ambrose**, Drexel University (1067-35-1609)

3:15PM (2270) *Existence of a unique solution to a quasilinear elliptic equation with data at an interior point of the domain.* Preliminary report.
Diane Denny, Texas A&M University-Corpus Christi (1067-35-1703)

3:30PM (2271) *A multiplicity result for a class of infinite positone problems.*
Eunkyung Ko*, Mississippi State University, **Eunkyoung Lee**, Pusan National University, and **R. Shivaji**, Mississippi State University (1067-35-171)

3:45PM (2272) *Positive Solutions for Infinite Semipositone Problems on Exterior Domains.*
Eunkyoung Lee, Pusan National University, Busan, **Lakshmi Sankar*** and **Ratnasingham Shivaji**, Mississippi State University (1067-35-162)

4:00PM (2273) *S-Shaped Bifurcation Curves in Ecosystems.*
Sarath Sasi*, Mississippi State University, **Eunkyoung Lee**, Pusan National University, Busan, and **Ratnasingham Shivaji**, Mississippi State University (1067-35-160)

AMS Session on Topics in Analysis

1:15 PM – 5:25 PM

1:15PM (2274) *Results on asymptotically regular matrix methods.* Preliminary report.
Jeff Connor*, Ohio University, and **Hafize Gok**, Afyonkarahisar Kocatepe Univ. (1067-40-1448)

1:30PM (2275) *Scattered Data Interpolation on Embedded Submanifolds with Restricted Positive Definite Kernels: Sobolev Error Estimates.*
Edward J. Fuselier*, High Point University, and **Grady B. Wright**, Boise State University (1067-41-283)

1:45PM (2276) *On a free boundary problem for an American put option under the CEV process.*
Charles Knessl and **Miao Xu***, University of Illinois at Chicago (1067-41-949)

2:00PM (2277) *Approximation of the Generalized Poisson-Binomial Distribution.*
Salam Md. Mahbubush Khan, Alabama A&M University (1067-41-1427)

2:15PM (2278) *Greedy Algorithms in Compressed Sensing.*
Vladimir Temlyakov and **Mingrui Yang***, University of South Carolina (1067-41-1569)

2:30PM (2279) *Exact asymptotics of the error of adaptive approximation by harmonic splines.*
Yuliya Babenko*, Kennesaw State University, and **Tatyana Leskevich**, Dnepropetrovsk National University (1067-41-1937)

2:45PM (2280) *Two weight problem for the Fourier transform.* Preliminary report.
Ryan M Berndt, Otterbein University (1067-42-341)

3:00PM (2281) *Fibonacci Sets are good for discrepancy and numerical integration.*
Rui Yu*, **Vladimir Temlyakov** and **Dmitriy Bilyk**, University of South Carolina (1067-42-1598)

3:15PM (2282) *L^p estimates for a singular integral operator motivated by Calderón's second commutator.*
Eyvindur Ari Palsson, Cornell University (1067-42-2276)

3:30PM (2283) *Dichotomy Conjecture on Compact Symmetric Spaces.*
Sanjiv Kumar Gupta, Sultan Qaboos University (1067-42-2307)

3:45PM (2284) *Buffon's needle landing near Besicovitch irregular self-similar sets.*
Matthew R Bond* and **A Volberg**, Michigan State University (1067-42-2324)

4:00PM (2285) *Multiplier theorem on anisotropic Hardy spaces.*
Li-An Daniel Wang, University of Oregon (1067-42-2426)

4:15PM ► (2286) *Completely Simple Topological Semihypergroups.*
Norbert N Youmbi, Saint Francis University (1067-43-1134)

4:30PM (2287) *Sharp L^p-bounds for a perturbation of Burkholder's Martingale Transform.*
Nicholas Boros, Michigan State University (1067-43-2240)

4:45PM ► (2288) *Inversion of the circular Radon transform from partial data.*
Rim Gouia, University of Texas at Arlington (1067-00-72)

5:00PM (2289) *Consistency Conditions for Cone-Beam CT Data Acquired with a Linear Source Trajectory.*
Margo S. Levine*, Department of Radiology, Harvard Medical School and Massachusetts General Hospital, **Emil Y. Sidky** and **Xiaochuan Pan**, Department of Radiology, The University of Chicago (1067-45-274)

5:15PM ► (2290) *Dynamical Systems Method for Solving Ill-conditioned Linear Algebraic Systems.* Preliminary report.
Sapto Indratno* and **Alexander G Ramm**, Kansas State University (1067-45-2369)

ASL Invited Address

2:00 PM – 2:50 PM

(2291) *Special ultrafilters, generic ultrafilters, and partitions.*
Andreas Blass, University of Michigan (1067-03-63)

AWM Workshop: Research Presentations by Recent Ph.D.s, II

2:30 PM – 3:50 PM

Chair: **Alissa Crans**, Loyola Marymount University

2:30PM ► (2292) *Predicting Tumor Response to Vascular-Targeting Therapies using a Mathematical Model.*
Jana Gevertz, The College of New Jersey (1067-92-188)

3:00PM (2293) *Steklov-Neumann Eigenproblems and Nonlinear Elliptic Equations with Nonlinear Boundary Conditions.*
Nsoki Mavinga*, University of Rochester, NY, and **M. N. Nkashama**, University of Alabama at Birmingham (1067-35-261)

3:30PM (2294) *Compatibility of Slender Body Theory and Surface Traction.*
Eva M Strawbridge, University of Chicago (1067-92-201)

AMS-MAA-SIAM Gerald and Judith Porter Public Lecture

3:00 PM – 4:30 PM

(2295) *From flapping birds to space telescopes: The mathematics of origami.*
Robert J. Lang, Robert J. Lang Origami
(1067-00-37)

4:00PM Light refreshments will be served after the lecture.

ASL Session for Contributed Papers, II

3:10 PM – 4:20 PM

3:10PM (2296) *A pretabular classical relevance logic.*
John G. Mersch, Xavier University of Louisiana

3:35PM (2297) *More reverse mathematics of the Heine-Borel theorem.*
Jeffry Hirst*, Appalachian State University, and
Jessica Miller, Catawba Valley Community College

4:00PM (2298) *Reverse mathematics and equivalents of the axiom of choice.*
Damir D. Dzhafarov, University of Chicago, and
Carl Mummert*, Marshall University

MAA Minicourse #10: Part B

3:30 PM – 5:30 PM

Teaching introductory statistics.
Organizers: **Michael A. Posner**, Villanova University
Carolyn K. Cuff, Westminster College

AMS-MAA Special Film Presentation

4:30 PM – 5:30 PM

Between the Folds: Watch ten artists and theoretical scientists fuse mathematics and sculpture in the medium of origami.

AMS Banquet Reception

6:30 PM – 7:30 PM

AMS Banquet

7:30 PM – 10:00 PM

Steven H. Weintraub
AMS Associate Secretary
Bethlehem, Pennsylvania

Gerard A. Venema
MAA Associate Secretary
Grand Rapids, Michigan

AMERICAN MATHEMATICAL SOCIETY

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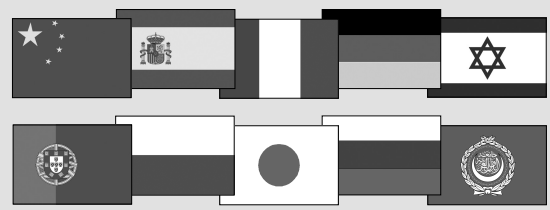

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AMERICAN MATHEMATICAL SOCIETY

Meetings and Conferences of the AMS

Associate Secretaries of the AMS

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The Meetings and Conferences section of the *Notices* gives information on all AMS meetings and conferences approved by press time for this issue. Please refer to the page numbers cited in the table of contents on this page for more detailed information on each event. Invited Speakers and Special Sessions are listed as soon as they are approved by the cognizant program committee; the codes listed are needed for electronic abstract submission. For some meetings the list may be incomplete. **Information in this issue may be dated. Up-to-date meeting and conference information can be found at** www.ams.org/meetings/.

Meetings:

Important Information Regarding AMS Meetings

Potential organizers, speakers, and hosts should refer to page 100 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.)

February 17–21, 2011: AAAS Meeting in Washington, DC (Please see www.aaas.org/meetings for more information.)

June 12–July 2, 2011: MRC Research Communities, Snowbird, Utah. (Please see http://www.ams.org/amsmtgs/mrc.html for more information.)

July 4–7, 2011: von Neumann Symposium on Multimodel and Multialgorithm Coupling for Multiscale Problems, Snowbird, Utah. (Please see http://www.ams.org/meetings/amsconf/symposia/symposia-2011 for more information.)

AMERICAN MATHEMATICAL SOCIETY

CURRENT EVENTS BULLETIN

Saturday, January 8, 2011, 1:00 PM to 5:00 PM

Joint Mathematics Meetings, New Orleans, LA

Organized by David Eisenbud, University of California, Berkeley

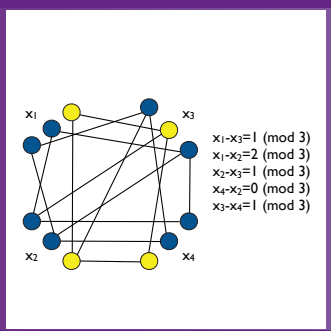

Image courtesy of Luca Trevisan.

1:00 PM

Luca Trevisan, Khot's unique games conjecture: its consequences and the evidence for and against

A conjecture that makes fundamental new connections between some classical mathematics and the difficulty of computing

Figure by C. Goodman-Strauss from John H. Conway, Heidi Burgiel, and C. Goodman Strauss. *The Symmetries of Things*. AK Peters, Ltd., 2008.

2:00 PM

Thomas Scanlon, Counting special points: logic, Diophantine geometry and transcendence theory

Another beautiful use of logic to prove a deep theorem about rational numbers

Image courtesy of Ulrike Tillmann.

3:00 PM

Ulrike Tillmann, Spaces of graphs and surfaces

Topological tools lead to new ways of distinguishing families of graphs and surfaces

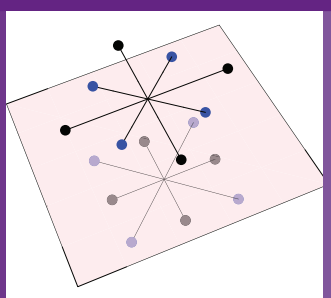

Image courtesy of David Jordan.

4:00 PM

David Nadler, The geometric nature of the fundamental lemma

The geometry behind the number theory behind one of this year's Fields Medals.

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Notices of the American Mathematical Society

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