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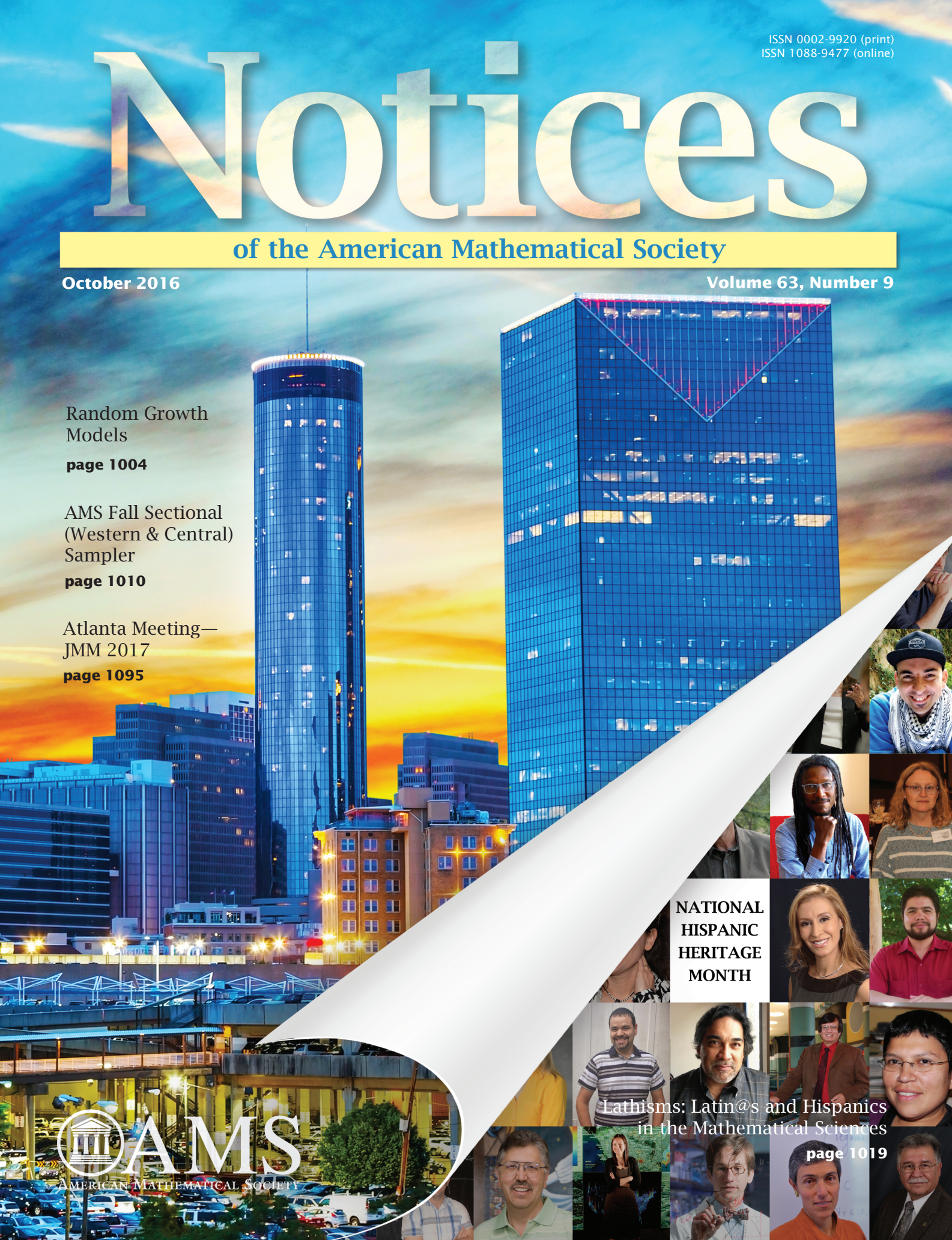

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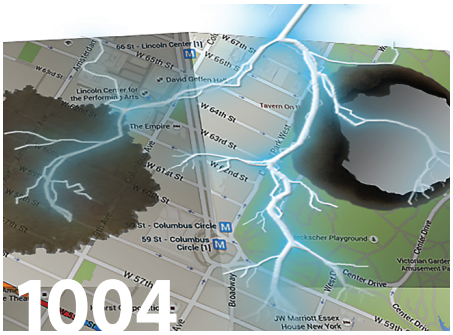
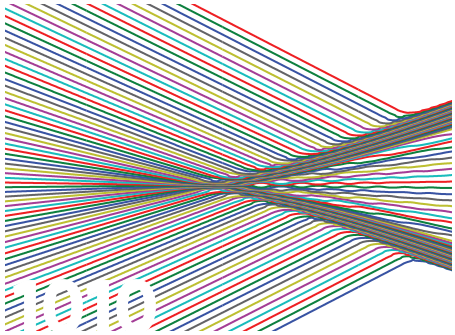


Random Growth Models

Michael Damron, Firas Rassoul-Agha, and Timo Seppäläinen



AMS Fall Western & Central Sectional Sampler

Quantum Symmetries
by Chelsea Walton

Quantizations, Representations, and Morse Theory
by Thomas Nevins

Semiclassical Quantum Dynamics and Bohmian Trajectories
by Christof Sparber

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Lathisms: Latin@s and Hispanics in the Mathematical Sciences

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THE GRADUATE STUDENT SECTION

FROM THE SECRETARY'S OFFICE

JMM 2017:

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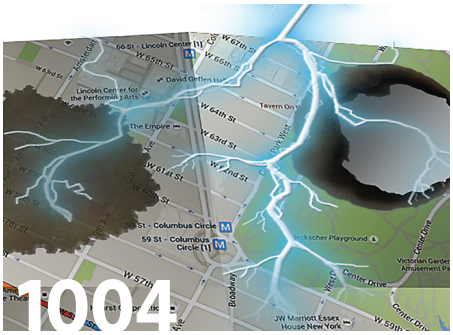

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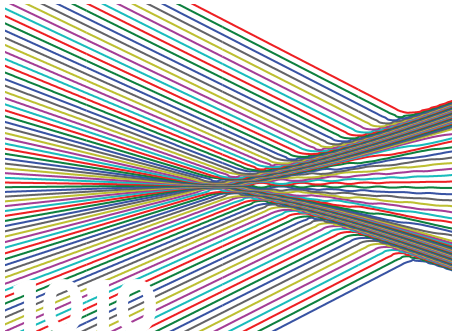

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ALSO IN THIS ISSUE, CONT'D.

IN EVERY ISSUE

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Random Growth Models

Note from Editor: *The organizers of the 2017 Joint Mathematics Meetings Short Course on Random Growth Models have kindly agreed to provide this introduction to the subject.* *See p. 1087 for more information on the JMM 2017 Short Course.*

Michael Damron, Firas Rassoul-Agha, and Timo Seppäläinen

Irregular and stochastic growth is all around us: tumors, bacterial colonies, infections, fluid spreading in a porous medium, propagating flame fronts. The study of simplified mathematical models of stochastic growth began in probability theory half a century ago. Quite serendipitously these models have turned out to be extremely hard to analyze. They have inspired innovative probability theory and have led to new connections between probability and other parts of mathematics.

This brief overview discusses two classes of such mathematical models, namely undirected *first-passage percolation* (FPP) and directed *last-passage percolation* (LPP) on the d-dimensional integer lattice $\mathbb{Z}^d$. The basic idea is the following. An infection starts at the origin and progresses along nearest-neighbor lattice paths. Depending on the model, admissible paths are either *directed*, so that each step is forced to be one of the standard basis vectors e_i, or *undirected*. The time it takes for the infection to reach a given lattice point is determined by random passage times assigned either to edges or to vertices of the lattice. FPP seeks the path of minimal passage time, while LPP maximizes passage time.

In (undirected) first-passage percolation, we give each nearest-neighbor edge e of the lattice $\mathbb{Z}^d$ a nonnegative random passage time t_e. Collectively the random variables $\{t_e\}$ are typically independent and identically distributed. The model is parametrized by the common probability distribution μ of the t_es. The passage time of a lattice path γ (a sequence of consecutive edges) is $T(\gamma) = \sum_{e\in\gamma} t_e$. The passage time between points x and y is $T(x,y) = \inf_{\gamma:x\to y} T(\gamma)$, the minimal passage time of a path between x and y. If none of the t_es are zero, then T is a random metric on $\mathbb{Z}^d$. The infection starts at the origin, and the set of infected sites at time $t \geq 0$ is

$$B(t) = \{x \in \mathbb{Z}^d : T(0,x) \leq t\}.$$

The leftmost picture in Figure 2 illustrates the optimal paths from the origin to the lattice points in $B(t)$. The middle picture in Figure 3 shows a larger FPP cluster, with an experimental cluster on the right for comparison. A thorough recent survey of the mathematics of FPP is provided by Auffinger et al. [1].

Figure 1. A traffic map[1] showing an optimal (geodesic) path between two locations and color-coding the edge weights along the path. Lightning[2] explores every path available to it in space and strikes along the path of least electrical resistance, much like the optimal paths discussed in the section "Geodesics". Shapes such as the ones in the section "Limit Shapes" and Figure 3 are ubiquitous in nature, e.g. stains, burning regions, and growing crystals.[3]

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[1] *Generated using Google Maps.*

[2] *Courtesy of James McGhee.*

[3] *Courtesy of* dans-le-townhouse.blogspot.com.

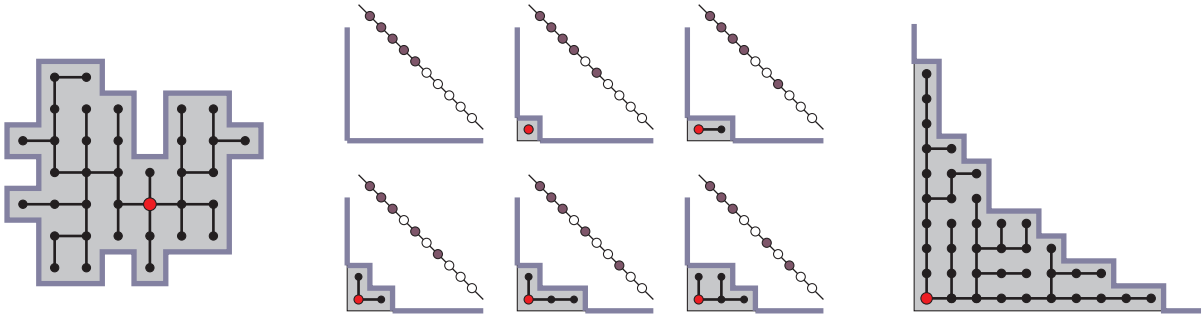

Figure 2. The leftmost picture is a snapshot of the growing FPP cluster on the plane at some fixed time $t > 0$. Bullets mark lattice points x with $T(0,x) \le t$. The origin is distinguished with the red bullet. The gray region is the fattened set $B(t) + [-1/2, 1/2]^2$. The bold black edges are the paths of minimal passage time from the origin. They are not forced to be directed. The middle and rightmost pictures depict a possible early evolution of the corner growth model on the first quadrant of the plane. The origin is again the red bullet. Optimal paths are all directed. The antidiagonals illustrate the mapping of the corner growth model to an interacting particle system of central importance, namely the *totally asymmetric simple exclusion process* (TASEP) [2]. Whenever a point is added to the growing cluster, a particle (solid purple circle) switches places with the hole (open circle) to its right.

Another much-studied model is the *corner growth model*, which is directed last-passage percolation on the planar square lattice. Passage times are conventionally assigned to vertices. Admissible paths take only e_1 and e_2 steps, and $T(0,x)$ is the maximal passage time of a path from 0 to x. This model stands at the nexus of several disciplines: queueing theory, interacting particle systems, integrable systems, and representation theory. Its evolution is illustrated in the middle and right pictures of Figure 2 and in the leftmost picture of Figure 3.

We address below three fundamental questions about the growth of $B(t)$:

(1) Does $B(t)$ acquire a definite shape?
(2) How does $B(t)$ fluctuate randomly around its long-term shape?
(3) How can we describe the geometry of optimal paths (geodesics) for T?

Limit Shapes

The basic law of large numbers of the subject is the *shape theorem*. For first-passage percolation (FPP), it was initially proved by Richardson (1973) and then refined considerably by Cox-Durrett (1981) and Kesten (1986). To give the random infected set $B(t)$ positive volume in $\mathbb{R}^d$, replace it with the fattened sum set $B(t) + [-1/2, 1/2]^d$. Then there is a nonrandom, convex, compact set B_μ in $\mathbb{R}^d$ such that $t^{-1}B(t)$ converges almost surely to B_μ in Hausdorff distance, as $t \to \infty$. B_μ depends on the common probability distribution μ of the weights t_e. It is symmetric about the axes and has nonempty interior. In Figure 4 we can discern that the growing clusters approach a limiting shape.

What does B_μ look like in FPP? For a trivial point of comparison, note that with constant edge weights the limit shape is the ℓ^1 unit ball, which is a diamond with sharp corners and flat faces and edges. The randomness of the weights is expected to smooth out and curve the limit shape. If μ is continuous, it is predicted that B_μ is strictly convex with a uniformly positively curved, differentiable boundary. There is little progress toward verifying these properties. It is not even known that B_μ is not a polygon (that is, has infinitely many extreme points), except in the case of some atomic μ in two dimensions. Contrary to good taste, it is believed that B_μ is not a Euclidean ball for typical μ. This has been proved in high dimensions. There are no results that say that generally the shape is not a ball in low dimensions, but this has been verified for certain distributions.

For the first fifty years of the subject, no general descriptions of limit shapes existed beyond their limit definitions. Recently Krishnan and independently Georgiou, Rassoul-Agha, and Seppäläinen discovered variational formulas for the limiting time constant $g(x) = \lim_{n\to\infty} n^{-1}T(0, \lfloor nx \rfloor)$. These variational formulas live on complicated infinite-dimensional spaces of functions or measures, and consequently extracting information from them is a difficult problem in itself.

Among directed models in two dimensions there are special *exactly solvable* ones where fortuitous coincidences of combinatorics and probability permit a closed-form evaluation of the limit shape. The oldest such is the corner growth model with exponentially distributed weights (the leftmost picture of Figure 3).

Shape Fluctuations

A law of large numbers raises the question of fluctuations, that is, the difference between $t^{-1}B(t)$ and B_μ. In Figures 3 and 4 we see the roughness of the growing boundary that results from the stochastic fluctuations in the growth.

One can split this error into a random part and a nonrandom part. The random part is represented by the discrepancy between $T(0,x)$ and its mean $\mathbb{E}T(0,x)$ when x is large. The nonrandom part is the discrepancy between $\mathbb{E}T(0,x)$ and the limiting value $g(x)$. It is predicted that

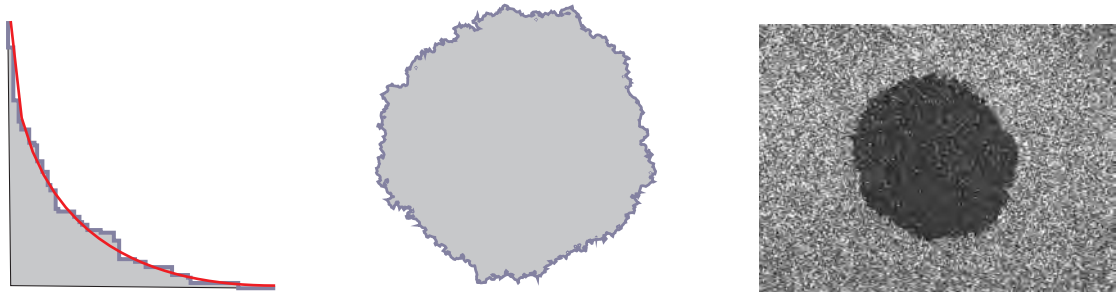

Figure 3. Left: The corner growth model with exponentially distributed vertex weights with mean 1. The gray region is a simulation of the scaled growing set $t^{-1}(B(t) + [-1/2, 1/2]^2)$ at time $t = 160$. Its boundary (the thick blue line) approximates the red limit curve $\sqrt{x} + \sqrt{y} = 1$, as first proved by Rost in 1981. Middle: A simulation of the scaled set $t^{-1}(B(t) + [-1/2, 1/2]^2)$ at time $t = 40$ for undirected first-passage percolation with edge weights that are exponential with mean 1. Such shapes are ubiquitous in nature, e.g. stains, fire fronts, and surfaces of growing crystals. Right: A growing interface in liquid-crystal turbulence. Takeuchi and Sano demonstrated that these experimental interfaces possess the same KPZ statistics as the corner growth model with exponential weights. It is believed that this behavior is universal among two-dimensional FPP and LPP models.

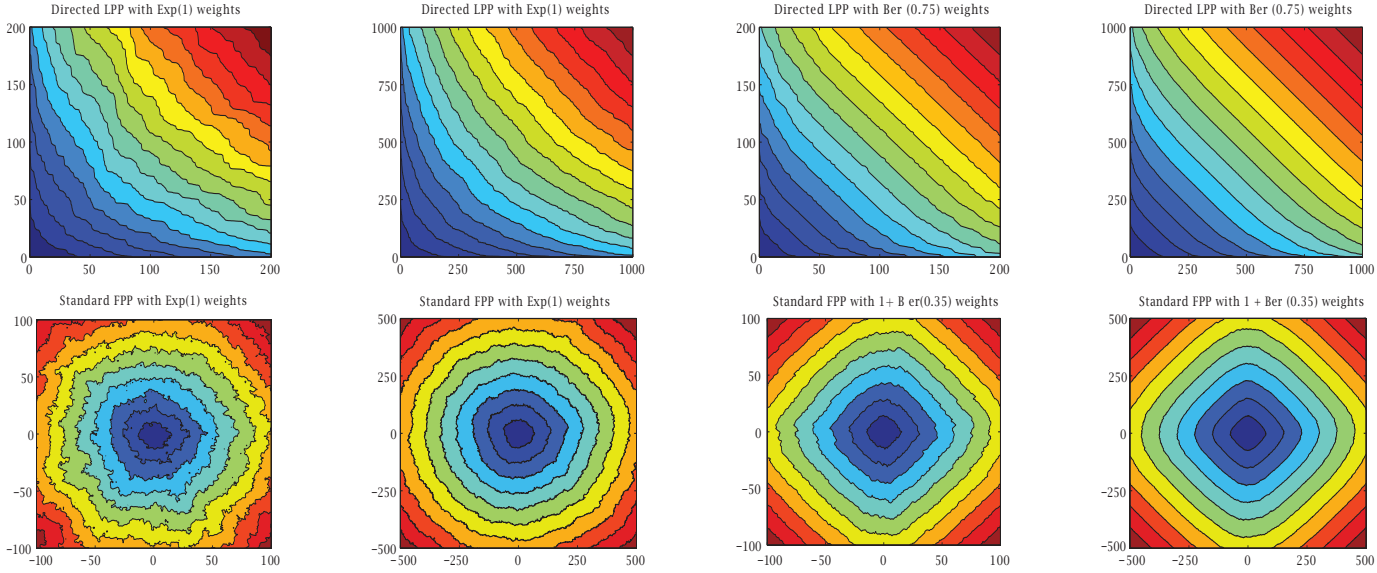

Figure 4. Growth of the infected region with exponential and Bernoulli distributed weights. Top row directed LPP, bottom row undirected FPP, colors mark successive level sets of $T(0, x)$, and lattice distances are marked on the axes. The right-hand pictures illustrate the *Durrett-Liggett flat edge*. A flat edge appears in the limit shape when the optimal weight values are frequent enough to form an infinite directed connected component on $\mathbb{Z}^d$. This phenomenon is called *oriented percolation*.

there is a dimension-dependent exponent ζ such that the typical deviation of $T(0, x)$ from $\mathbb{E}T(0, x)$ is of order $|x|^{\zeta}$. One way to phrase this is to assert that $\mathrm{Var}[T(0, x)]$ is of order $|x|^{2\zeta}$.

What is predicted or proved about this exponent ζ? Physicists believe that at least for low dimensions, ζ is positive and strictly less than $1/2$. This latter behavior is called "subdiffusivity" and is associated with other predicted aspects of the model, like abundance of near-optimizing paths. The best rigorous bounds to date were established by Kesten (1993), stating that $0 \le \zeta \le 1/2$ for all dimensions. In two dimensions there are logarithmic lower bound corrections $\mathrm{Var}[T(0, x)] \ge c \log |x|$ by Pemantle-Peres (1993) and Newman-Piza (1995), and for $d \ge 2$ there are similar corrections to the upper bound: $\mathrm{Var}[T(0, x)] \le c|x|/\log |x|$ by Benjamini-Kalai-Schramm (2003), Benaïm-Rossignol (2008), and Damron-Hanson-Sosoe (2014).

For a handful of exactly solvable two-dimensional directed models, there are precise results that give $\zeta = 1/3$ and even the limiting distribution for the scaled discrepancy $n^{-1/3}(T(0, \lfloor nx \rfloor) - ng(x))$ as $n \to \infty$. These phenomena are studied by mathematicians and physicists under the rubric *Kardar-Parisi-Zhang universality* [2]. It is

Figure 5. Top row, left to right: A burnt-out hole in a paper, a coffee stain that percolated on a piece of paper, and a Borax crystal.[4] A traffic map[5] showing an optimal (geodesic) path between two locations and color-coding the edge weights along the path. Lightning[6,7] explores every path available to it in space and strikes along the path of least electrical resistance, much like the optimal paths discussed in the section "Geodesics".

expected that, subject to a mild moment assumption on the random passage times, all two-dimensional FPP and LPP models obey KPZ universality.

Geodesics

When μ is continuous, optimal paths or *geodesics* between points are almost surely unique. In 1995 Newman introduced an approach to infinite geodesics (infinite paths whose segments are geodesics) that starts with the *infection tree* $\mathcal{T}$ defined as the union of the geodesics from the origin to all the lattice points. Somewhat trivially, the analogous tree in $\mathbb{R}^d$ under the Euclidean metric would have an infinite ray from 0 in each direction and hence uncountably many disjoint infinite paths from 0. A similar property is predicted for these growth models, at least in low dimension. One expects an infinite path in $\mathcal{T}$ from 0 in each fixed direction, and so uncountably many such distinct paths. (Two paths are distinct if they separate eventually.)

In undirected FPP, these statements are far from being proved. Hoffman showed in 2008 that in general $\mathcal{T}$ has at least four infinite eventually disjoint paths starting from 0. But not even the existence of a single continuous distribution μ such that a path in $\mathcal{T}$ has an asymptotic direction is known. As one might expect, in directed planar models geodesics are better understood. In exactly solvable cases, such as the exponential corner growth model of Figure 3, the aforementioned geodesic conjecture can be proved in full.

Suppose now we start infections from two points on the lattice and let these infections compete for space. The growth model has become a model of competition. Figure 6 shows the *competition interface* between two infections emanating from $(1,0)$ and $(0,1)$, both in the directed corner growth model, and for undirected first-passage percolation.

Figure 6. Left: The full tree of infection in the corner growth model. The origin is the open circle at the bottom left. The solid black line marks the *competition interface* that separates the two competing infections that grow from points $(1,0)$ and $(0,1)$ marked with larger circles. Globally, the competition interface points in a precise but randomly chosen direction whose probability distribution can be derived in exactly solvable cases. Right: Competition in undirected FPP. The competition interface separates the infection trees originating from $(1,0)$ and $(0,1)$ marked with larger circles.

For competition in undirected first-passage percolation, there are two possible scenarios: either both infections have a chance of growing indefinitely (*coexistence*) or ultimately one encircles the other for sure. Conditions for these two occurrences are a subject of ongoing research. In coexistence, the competition interface is a doubly infinite path with two random asymptotic directions.

[4] *Courtesy of* dans-le-townhouse.blogspot.com.
[5] *Generated using Google Maps.*
[6] *By Axel Rouvin via Wikimedia Commons.*
[7] *By Jp Marquis via Wikimedia Commons.*

The behavior of the competition interface can be quantified with *Busemann functions*. This notion from metric geometry was introduced into percolation by Newman and Hoffman. In our context, Busemann functions are equal to the limits $b(x,y) = \lim_{v\to\infty}(T(x,v) - T(y,v))$ as a point v recedes to infinity in a particular direction. In exactly solvable models, this limit can be proved to exist, and its behavior is understood completely. Busemann functions can be used to construct *stationary* growth models whose global probability laws are invariant under spatial translations and whose growth is linear on average. Such versions of stochastic processes are very useful for proofs and explicit calculations. A recent development in the field, in the work of Damron-Hanson and Georgiou-Rassoul-Agha-Seppäläinen, is that Busemann functions have provided a route toward verifying versions of the geodesic conjectures stated above.

References

[1] Antonio Auffinger, Michael Damron, and Jack Hanson, 50 years of first passage percolation, 2015. arXiv:1511.03262

[2] Ivan Corwin, *Kardar-Parisi-Zhang universality*, Notices Amer. Math. Soc. **63** (2016), no. 3, 230–239. MR 3445162

THE AUTHORS

Michael Damron

Firas Rassoul-Agha

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CHELSEA WALTON, Bloch Brown Assistant Professor of Mathematics at Temple University;
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CHRISTOF SPARBER, professor of mathematics in the Department of Mathematics, Statistics, and Computer Science at the University of Illinois at Chicago; and
SAMUEL N. STECHMANN, associate professor of mathematics at the University of Wisconsin—Madison
kindly provide the following introductions to their Invited Addresses for the upcoming AMS Fall Western Sectional (Colorado, October 8–9, 2016) and the AMS Fall Central Sectional (Minnesota, October 28–30, 2016).

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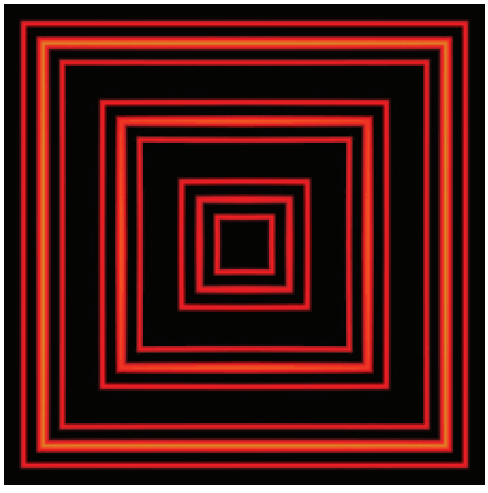
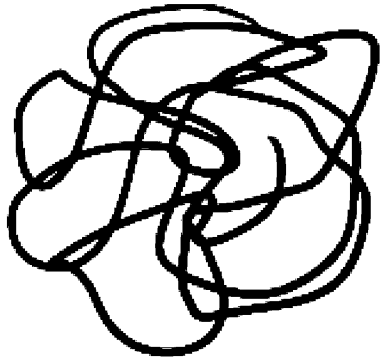
Quantum Symmetries

Chelsea Walton



The motivation of this talk is the classical notion of symmetry. Mathematically, a *symmetry* of an object is an invertible, property-preserving transformation of the given object. Further, a collection of such symmetries forms a group. For instance, consider symmetries of a square—these include reflections, rotations, translations, and also scaling; indeed, the proportions of side-lengths, angles, and orientation of the square are preserved under these invertible transformations.

On the other hand, take the object below:



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DOI: http://dx.doi.org/10.1090/noti1428

Now we would say that this object does not admit many symmetries, that is, this object is more *rigid* than the square.

But let us turn our attention to objects that algebraists know and love: algebras! For a fixed algebra A, we will study invertible transformations of A (i.e., bijective vector space maps) that preserve the multiplication and unit of A. The algebras of interest here are finitely presented, are associative, and are not necessarily commutative.

For example, take A to be $\mathbb{C}[x,y]$, a polynomial ring in two variables over $\mathbb{C}$. This algebra is commutative and admits a myriad of symmetries, including those induced by the following linear transformations:

$$\begin{cases} x \overset{g\cdot}{\mapsto} ax + cy, \\ y \overset{g\cdot}{\mapsto} bx + dy, \end{cases} \quad \text{for } g = \begin{pmatrix} a & b \\ c & d \end{pmatrix} \in GL_2(\mathbb{C}).$$

In particular, if we realize $\mathbb{C}[x,y]$ as the quotient of the free algebra $\mathbb{C}\langle x,y\rangle$ by the ideal $(xy-yx)$, it is easy to check that any action of the group element g as above preserves both $\mathbb{C}\langle x,y\rangle$ and the relation space $\mathbb{C}(xy-yx)$ of $\mathbb{C}[x,y]$.

Next, let us take a noncommutative algebra that has many of the same (ring-theoretic and homological) properties of $\mathbb{C}[x,y]$: the q-polynomial ring

$$\mathbb{C}_q[x,y] := \mathbb{C}\langle x,y\rangle/(xy-qyx)$$

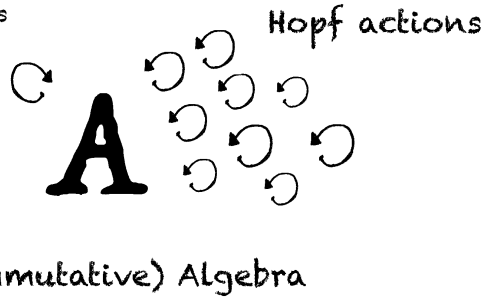
for $q \in \mathbb{C}^\times$. Using the linear transformation above, we obtain:

$$\begin{aligned} g \cdot (xy - qyx) &= (g\cdot x)(g\cdot y) - q(g\cdot y)(g\cdot x) \\ &= (1-q)(ab)x^2 + (ad-qbc)xy \\ &\quad - (ad - q^{-1}bc)qyx + (1-q)(cd)y^2. \end{aligned}$$

Thus, as soon as we move away from $q=1$, the number of g-actions that preserve the relation space of $\mathbb{C}_q[x,y]$ decreases. In fact, for $q \neq \pm 1$, the collection of these actions are limited to merely the diagonal ones. So, the algebra $\mathbb{C}_q[x,y]$ for $q \neq 1$ is more rigid than $\mathbb{C}[x,y]$ in the context of linear group actions.

This phenomenon occurs in general: noncommutative algebras admit fewer group actions than their commutative counterparts. Therefore in order to have a rich theory of symmetries of noncommutative algebras, we must think beyond group actions!

We must think beyond group actions!



In the talk, we will discuss **quantum symmetries**, or (co)actions of *Hopf algebras/quantum groups* on (non-commutative) algebras.

Everything, from the notion of a Hopf algebra to its (co)actions on algebras, will be defined and illustrated by plenty of examples. We will also discuss various recent results (of mine, with coauthors, and of many others) in this fruitful direction of research.

THE AUTHOR

Chelsea Walton

Quantizations, Representations, and Morse Theory

Thomas Nevins

Suppose X is a nonsingular complex algebraic variety, and let $\mathbb{C}[X]$ denote its coordinate ring (ring of regular functions). If $X \subset \mathbb{C}^n$, then $\mathbb{C}[X]$ is the algebra of functions that are restrictions of polynomial functions on $\mathbb{C}^n$. For example, if $X = \{(x, y) \in \mathbb{C}^2 \mid y = x^2\}$, two polynomials $f_1(x, y)$ and $f_2(x, y)$ have the same restriction to X if and only if $y - x^2$ divides $f_1 - f_2$ in the polynomial ring $\mathbb{C}[x, y]$; thus, $\mathbb{C}[X]$ is identified with the quotient ring $\mathbb{C}[x, y]/(y - x^2)$.

Similarly, let $\mathcal{D} = \mathcal{D}(X)$ denote the algebra of linear differential operators (with regular function coefficients) on X. For example, if $X = \mathbb{C}^n$, then

$$\mathcal{D}(X) = \mathbb{C}[x_1, \dots, x_n, \partial/\partial x_1, \dots, \partial/\partial x_n], \tag{1}$$

the *nth Weyl algebra*. In general, $\mathcal{D}(X)$ is defined via operators acting on $\mathbb{C}[X]$.

Enhancing a $\mathbb{C}[X]$-module M to a left $\mathcal{D}$-module amounts to choosing a flat (algebraic) connection on M. Via the latter description and the Riemann-Hilbert correspondence, $\mathcal{D}$-modules have close connections to topology and specifically to the Hodge theory of complex varieties.

$\mathcal{D}$-modules on algebraic varieties provide paradigmatic tools for realizing representations of interesting algebras

On the other hand, the algebra $\mathcal{D}(X)$ is a deformation of the algebra $\mathbb{C}[T^*X]$ of functions on the cotangent bundle, as one can imagine when $X = \mathbb{C}^n$ from formula (1). That deformation is closely connected to the canonical symplectic structure on the cotangent bundle T^*X, and thus $\mathcal{D}$-modules connect closely to the symplectic geometry of T^*X, the relationship at the heart of microlocal analysis.

$\mathcal{D}$-modules on algebraic varieties provide paradigmatic tools for realizing representations of interesting algebras. For example, if a complex Lie group G acts on X, then differentiating the action yields a homomorphism $U(\mathfrak{g}) \to \mathcal{D}(X)$ from the enveloping algebra of the Lie algebra $\mathfrak{g}$ of G, and thus every $\mathcal{D}$-module on X yields a representation of $U(\mathfrak{g})$. In the case when $X = G/B$ is the flag variety of a complex semisimple group G, this construction mediates between topology (and Hodge theory) of the projective variety G/B and representations of $\mathfrak{g}$ in the proof (by Beilinson-Bernstein and Brylinski-Kashiwara) of the "Kazhdan-Lusztig conjecture" of Lie theory.

Replacing T^*X by a more general symplectic algebraic variety (or algebraic stack/equivariant space) Y and $\mathcal{D}$ by a quantization of the algebra of functions on Y leads to many more algebras of importance: for example, Cherednik algebras, W-algebras, and more. The space Y yields a rich interplay of symplectic algebraic geometry, quantum algebra, and representation theory that is the subject of intense current research.

One recent new research direction concerns Morse theory. Morse theory provides structural principles governing how the space Y is built from simpler pieces. Furthermore, just as Morse theory controls the cohomology of Y, it also appears "one categorical level higher," controlling how categories of representations, realized via quantum geometry of Y, are assembled from basic constituents. The *categorical Morse theory* for quantum symplectic varieties that thus emerges has new consequences not only for representation theory but also "at lower categorical level" for the topology of Y.

Credit

Photo of Thomas Nevins, courtesy of Kevin McGerty, University of Oxford.

THE AUTHOR

Thomas Nevins

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Semiclassical Quantum Dynamics and Bohmian Trajectories

Christof Sparber

The early days of the twentieth century saw the establishment of quantum mechanics as a novel description of our physical world. Ever since its invention, a basic problem concerns the connection between quantum mechanics and the older, well-understood theory of classical mechanics. It was accepted early on that classical mechanics should be understood as an emergent phenomenon of quantum mechanics, i.e., it should be recovered from the underlying quantum mechanical description when considered over special values of its physical parameters. When trying to follow this basic idea, one immediately faces an obstacle: quantum mechanics and classical mechanics are usually treated within two entirely different mathematical formalisms. While the former is based on the time-evolution of vectors in (infinite-dimensional) Hilbert spaces, the latter is concerned with the dynamics of point particles on a (finite-dimensional) phase space.

Focussing on one of the simplest quantum mechanical systems, we consider the dynamics of a single quantum particle, say, an electron, under the influence of a static external force field mediated by a given real-valued potential $V(x)$, where $x \in \mathbb{R}^3$ denotes the spatial coordinate. The state of the electron at time $t \in \mathbb{R}$ is described by a wave function $\psi(t,\cdot) \in L^2(\mathbb{R}^3;\mathbb{C})$ whose time evolution is governed by Erwin Schrödinger's fundamental equation from 1926:

$$i\varepsilon\frac{\partial}{\partial t}\psi^\varepsilon = -\frac{\varepsilon^2}{2}\Delta_x\psi^\varepsilon + V(x)\psi^\varepsilon, \quad \psi^\varepsilon|_{t=0} = \psi_0^\varepsilon(x).$$

Here we have rescaled the original equation including all physical parameters (mass, charge, the Planck's constant $\hbar$, etc.) into dimensionless units such that only one (small) parameter $\varepsilon > 0$ remains. The latter plays the role of a dimensionless Planck's constant, having the physical unit of an action, i.e. energy $\times$ time. Classical behavior is expected to emerge from quantum dynamics in the limit $\varepsilon \to 0$, incorporating the basic premise that classical mechanics describes systems that vary on energy-time scales much larger than $\hbar$.

However, a moment's reflection reveals that naively passing to the limit $\varepsilon \to 0$ in Schrödinger's equation does not yield anything. Indeed, the classical limit of Schrödinger's equation falls into what is known as "singular limits" for differential equations, a topic with a long history in asymptotic approximation theory. Given the dispersive nature of Schrödinger's equation, we expect solutions ψ^ε to be rapidly oscillating functions in both space and time with frequencies of order $\mathcal{O}(1/\varepsilon)$. In the case where $V \equiv 0$, this is directly seen using the Fourier transform, reaffirming the fact that there is no naive limiting behavior of quantum dynamics as $\varepsilon \to 0$.

In an effort to bypass this problem and give a more direct connection to classical mechanics, Erwin Madelung in 1926 reformulated Schrödinger's equation in terms of a system of equations for the position density $\rho^\varepsilon = |\psi^\varepsilon|^2$ and the current density $J^\varepsilon = \varepsilon\mathrm{Im}(\overline{\psi^\varepsilon}\nabla_x\psi^\varepsilon)$. The hereby obtained system takes the form of a (singular) perturbation of the classical Euler equations of compressible fluid dynamics, and it formally (though not rigorously, in general) converges to the latter in the limit $\varepsilon \to 0$.

Inspired by this reformulation, David Bohm offered in 1952 yet another approach to quantum dynamics: Given any ψ^ε and its associated densities, he postulated that quantum particles will travel along trajectories $t \mapsto X^\varepsilon(t,x) \in \mathbb{R}^3$ obtained from the following dynamical system:

$$\dot{X}^\varepsilon = \frac{J^\varepsilon}{\rho^\varepsilon}, \quad X^\varepsilon(0,x) = x,$$

where the initial data $x \in \mathbb{R}^3$ is in general not known exactly but rather distributed according to the initial probability density $|\psi_0^\varepsilon|^2$. Bohm's interpretation has been controversial within physics, but from a mathematical point of view, one can give a precise and rigorous meaning

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to the dynamical system above and, thus, associate to any given solution ψ^ε of Schrödinger's equation a family of "Bohmian trajectories" X^ε. This point of view offers the advantage that it treats both classical and quantum dynamics on an equal, trajectory-based footing (as Schrödinger's equation remains in the background, used only to define the position and current densities at each space-time point). Ideally, one would like to study the Bohmian trajectories X^ε and recover from them the well-known trajectories of classical point particles in the limit $\varepsilon \to 0$. In the situation at hand, these would simply correspond to Newton's second law written in the form $\dot{X} = P$, $\dot{P} = -\nabla V(X)$, where $(X, P) \in \mathbb{R}^6$ denotes the position and momentum of the particle at time t.

The study of the classical limit of Bohmian trajectories has, in recent years, been a topic of intense research for me and several of my colleagues. Unfortunately, the rather complicated and nonlinear relation between X^ε and ψ^ε makes this a challenging endeavor. Instead of trying to tackle the Bohmian trajectories directly, we first focussed our efforts on a family of phase-space measures β^ε, which we called "Bohmian measures" and which are known to be equivariant with respect to the Bohmian flow. Their classical limit as $\varepsilon \to 0$ (defined in a certain weak sense) can be rigorously studied, and one can show that the resulting limiting measure β^0 not only concentrates on the classical limit of the Bohmian trajectories but also incorporates the classical limits of the densities ρ^ε and J^ε. It remains an open question, however, under which circumstances other physically relevant quantities are correctly described by the Bohmian measure as $\varepsilon \to 0$.

Returning to the study of the classical limit of the Bohmian trajectories themselves, the results available to date require additional assumptions on the potential V and, more importantly, on the considered class of initial wave functions ψ_0^ε. On the positive side, one can show that for initial data given by semiclassical wave packets (these are wave functions known to optimize Heisenberg's uncertainty principle), the Bohmian trajectories stay within a neighborhood of size $\mathcal{O}(\sqrt{\varepsilon})$ of the corresponding classical trajectories for all times $t \in [0, T]$. Surprisingly, though, one can also show that for more general initial data of WKB type, the Bohmian trajectories generically do *not* converge to the corresponding classical ones. More precisely, the limit coincides only with the expected classical one, up to a (small) time $t_* > 0$, depending on the initial data. For $t \geq t_*$ one can prove that the limiting Bohmian dynamics differs from the corresponding classical one by means of a continuity argument (see Figure 1 for an illustration). A more precise description of the limit for $t \geq t_*$ remains a big open question.

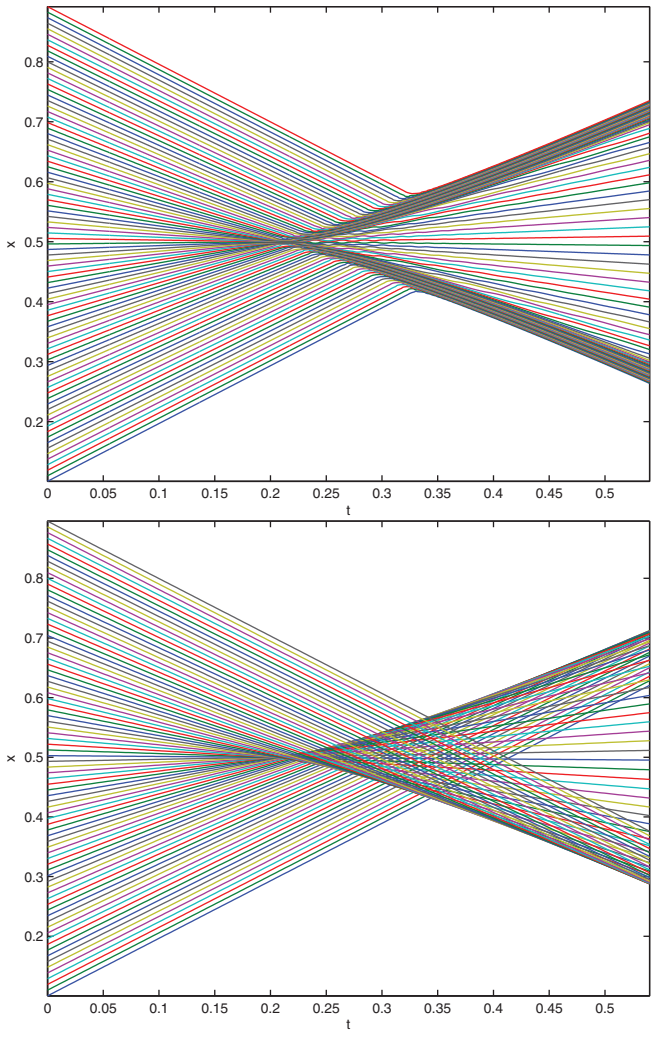

Figure 1. Left: Bohmian trajectories $X^\varepsilon(t, x)$ for WKB initial data and small $\varepsilon = 10^{-2}$. Right: The corresponding classical trajectories, exhibiting interference for $t \geq t_* \approx 0.2$. For more details, see [1].

ABOUT THE AUTHOR

Christof Sparber's research focuses on partial differential equations in mathematical physics and related fields.

Christof Sparber

Reference

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Stochastic PDEs for Tropical Weather and Climate

Samuel N. Stechmann

Tropical weather and climate is different than in the midlatitudes, where most of the United States is located. Yes, it's warmer in the tropics. But the cloud patterns and rainfall are also organized in different ways, as shown in Figure 1. Over the United States and Eurasia, elongated clouds form along fronts, familiar from weather maps. In contrast, near the equator, fronts are absent, and the clouds instead appear to be clustered more randomly.

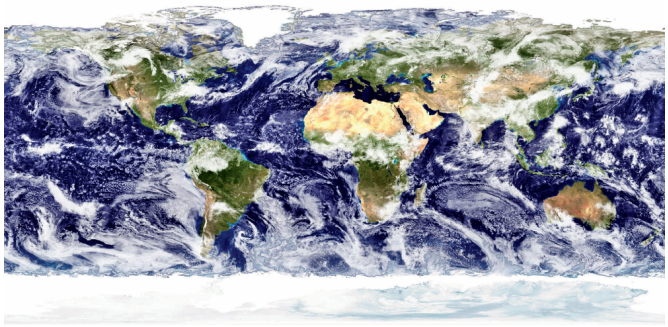

Figure 1. Near the equator, clouds appear to be clustered more randomly.

What causes the differences in cloud patterns between the midlatitudes and the tropics? It is related to the earth's rotation axis $\vec{f}$ and the associated Coriolis force. In the midlatitudes the axis $\vec{f}$ and the earth's inward gravitational acceleration vector $\vec{g}$ are somewhat aligned ($\vec{f} \cdot \vec{g} \neq 0$), and the rotation rate $|\vec{f}|$ is relatively large. The rotation here plays a strong role in governing fronts, atmospheric motions, and the organization of clouds and rainfall. In contrast, at the equator the vectors $\vec{f}$ and $\vec{g}$ are orthogonal ($\vec{f} \cdot \vec{g} = 0$), and consequently tropical clouds are not as strongly influenced by the earth's rotation. Cloud clusters that appear to be somewhat random are the dominant pattern.

Simplified partial differential equations (PDEs) for weather patterns in the midlatitudes have been known for over half a century. In contrast, simplified PDEs for the tropics are still actively proposed and investigated. Given the seemingly random appearance of cloud clusters in the tropics, one can imagine that tropical weather and climate could be modeled using stochastic PDEs. Other important aspects include the effects of dispersive equatorial waves and of nonlinearity from phase changes of water. Together, all of these aspects help form a complex dynamical system whose mathematical (and physical) understanding is still under development.

The societal impact is potentially enormous. Many of the most extreme weather phenomena are tropical, such as hurricanes and monsoons, and a large portion of the world's population lives under the influence of tropical weather. Moreover, weather in the United States is influenced by tropical phenomena, including El Niño and the increasingly discussed Madden-Julian oscillation. These examples have important impacts on the frontier of forecasting: the ability to make predictions not only a few days in advance but weeks or even months in advance. Such long-range forecasting stands as a great contemporary challenge, as foreseen by John von Neumann in his 1955 paper "Some remarks on the problem of forecasting climate fluctuations." It is an exciting area for mathematicians.

Credit

Photo of Figure 1 courtesy of NASA.

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THE AUTHOR

Samuel N. Stechmann

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In honor of
Hispanic Heritage Month
(September 15–October 15)
a personal vignette will be posted by the authors of this piece at the website *Lathisms.org*. "Lathisms" is a word that stands for Latin@s (that is, Latinos and Latinas) and Hispanics in the mathematical sciences.

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Lathisms: Latin@s and Hispanics in Mathematical Sciences

Alexander Diaz-Lopez, Pamela E. Harris, Alicia Prieto Langarica, Gabriel Sosa

National Medal of Science recipient Richard Tapia often uses the phrase "Excellence comes in all flavors" to assert that neither race nor any other characterization determines talent or success. This statement is particularly true in our field of mathematics. Despite this, there is still a major underrepresentation of Latin@s (Latinas and Latinos) and Hispanics in the mathematical sciences. Although 17 percent of the US population is Hispanic,[1] only 3.5 percent of 2014 PhDs in mathematics were Hispanic.[2]

One important step that the mathematical community can take to address this underrepresentation issue is to provide visibility to the research and mentoring contributions of Latin@s and Hispanics, as it is well known that women and minorities greatly benefit from having role models from their own demographics and backgrounds. To this end, we will showcase one Latin@/Hispanic mathematician per day through the AMS Twitter account (@amermathsoc) and the website Lathisms.org during the period of September 15 to October 15. This coincides with the United States observance of Hispanic Heritage Month, a time to acknowledge the contributions that Latin@s and Hispanics have made in the US and to celebrate our culture and heritage.

neither race nor any other characterization determines talent or success

Six samples are presented in this article.

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Gabriel Sosa is visiting assistant professor at Amherst College. His email address is gsosa@amherst.edu.

[1] www.census.gov/newsroom/facts-for-features/2015/cb15-ff18.html

[2] *Supplemental Table D.5: Gender, Race/Ethnicity & Citizenship of 2013–2014 New Doctoral Recipients, July 1, 2013–June 30, 2014,* www.ams.org/profession/data/annual-survey/2013Survey-NewDoctorates-Supp-TableD2.pdf.

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MARIEL VAZQUEZ

Mariel Vazquez, professor of mathematics and of microbiology and molecular genetics at UC Davis.

The Census Bureau announced last year that Hispanics are the largest ethnic group in California, but only 2 percent of Latinos aged eighteen to twenty-four were enrolled at the University of California. I feel a strong sense of responsibility to serve as a role model and mentor to Hispanics, Latin@s, and other underrepresented minorities in STEM to help close this gap. Hispanic Heritage Month offers a wonderful opportunity to highlight the work of people whose faces are not often seen in our community, thus encouraging students of color to pursue a degree in mathematics and other STEM-related fields.

—Mariel Vazquez

Bio and Research

Mariel Vazquez is professor of mathematics and of microbiology and molecular genetics at UC Davis. She works at the interface of mathematics and biology. Her research uses tools from pure mathematics (knot theory, low-dimensional topology, graph theory) to study important biological questions, especially the packing and function of DNA. For example, she has studied the topological changes (changes in shape), of DNA affected by enzymes, how chromosomes are changed by radiation and cancer, and how DNA is packed up within a cell. Her work, often collaborative, has provided keen insights into the packing of DNA and into the mechanism of enzymes involved in important biological processes such as DNA replication and DNA repair.

Awards and Service

Mariel is the recipient of numerous awards, including the 2016 Blackwell-Tapia Prize, the 2015 Dorothy Wrinch Endowed Lectureship at Smith College, a 2014 CAMPOS scholarship at UC Davis, the 2014 Mohammed Dahleh Distinguished Lectureship at UC Santa Barbara, a 2012 US Presidential Early Career Award for Scientists and Engineers (PECASE), and a 2011 NSF CAREER Award. The PECASE honored her for excellent interdisciplinary and international research at the interface of mathematics and biology and for creativity and dedication to recruiting, training, mentoring, and helping students from underrepresented groups achieve their goals.

Mariel serves on the Human Resources Advisory Committee of the Mathematical Sciences Research Institute (MSRI). She has served on the Advisory Board at the National Institute of Mathematical and Biological Synthesis (NIMBioS). She has been actively involved with SACNAS as co-organizer of Scientific Symposia as speaker and mentor, and she has also helped secure federal funding to support mathematics participation. She has been involved as organizer and keynote speaker at the Modern Math Workshop, sponsored by the NSF mathematics institutes.

ROSA ORELLANA

Rosa Orellana, professor of mathematics at Dartmouth College.

Bio and Research

Rosa Orellana is professor of mathematics at Dartmouth College. She works in the area of algebraic combinatorics, an area of mathematics that studies objects that have combinatorial and algebraic properties with the goal of using algebraic methods to answer combinatorial questions and, conversely, applying combinatorial techniques to problems in algebra. Recently her work has focused on the Kronecker product of two irreducible representations of the symmetric group. She and Mike Zabrocki, in joint work, introduced two new bases for the ring of the symmetric group that they hope will lead to progress on the Kronecker product.

Awards and Service

Early in her career Rosa received a University of California President's Postdoctoral Fellowship at UC San Diego. Since then she has mentored many students on research projects, and during the summer in 2013 she led a group of eighteen minority students for MSRI-UP. She received the John M. Manley Huntington Memorial Award at Dartmouth for outstanding research, teaching, and mentoring. She has also served as the advisor for the Dartmouth math club, co-funded a chapter of the Association for Women in Mathematics in an effort to increase the number of women taking and majoring in mathematics at Dartmouth, and has organized Sonia Kovalevsky Math Days to encourage middle and high school girls in the community to study mathematics.

TATIANA TORO

Tatiana Toro, Robert R. & Elaine F. Phelps Professor in Mathematics at the University of Washington.

Bio and Research

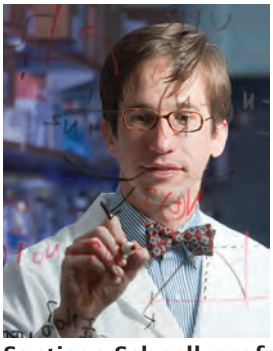
Tatiana Toro is Robert R. & Elaine F. Phelps Professor in Mathematics at the University of Washington. She is working at the interface of geometric measure theory, harmonic analysis, and partial differential equations. The interaction between these three areas has been one of the pillars of her research. Her work focuses on understanding mathematical questions that arise in an environment where the known data is very rough. In particular, she studies the properties of interfaces arising in "noisy" minimization problems. The main premise of her work is that under the right lens, objects which at first glance might appear to be very irregular do exhibit quantifiable regular characteristics. With C. Kenig she introduced the notion of chord arc domains, setting a new framework to study boundary regularity questions for second-order partial differential operators. They laid the foundation of what has become a new, rapidly developing area within PDEs. Her work with C. Kenig and D. Preiss brought tools from geometric measure theory to study basic questions about the structure of harmonic measure. Their ideas have provided a new and original approach to understanding the relationship between the geometry of a domain and the regularity at the boundary of the solutions to second-order partial differential equations. Currently she is very excited about a program she has been developing with G. David and M. Engelstein concerning the properties of almost minimizers. The goal is to show that even in the presence of "noise" variational characteristics preserve regularity up to first order.

Awards and Service

Her awards include a Guggenheim Foundation Fellowship, a Simons Foundation Fellowship, an Alfred P. Sloan Research Fellowship, and a National Science Foundation Mathematical Sciences Postdoctoral Research Fellowship. She was an invited speaker at ICM 2010 in Hyderabad, India. She delivered an invited address at the Joint Mathematics Meeting in New Orleans, Louisiana, in January 2011 and the NAM Clayton-Woodard Lecture at the Joint Mathematics Meetings in Seattle, Washington, in January 2016.

Tatiana has served in numerous leadership positions (including director) at the Pacific Institute for the Mathematical Sciences and is a current member of the Board of Trustees of the Institute for Pure and Applied Mathematics (IPAM). Recently she has been involved in efforts to promote diversity in the mathematical sciences. In the spring of 2015 she co-organized the first Latinos in the Mathematical Sciences (Lat@math) conference at IPAM. The second edition of this conference is being planned for 2018.

SANTIAGO SCHNELL



Santiago Schnell, professor in the Department of Molecular & Integrative Physiology and Department of Computational Medicine & Bioinformatics at the University of Michigan Medical School. He is also a William K. Brehm Investigator at the Brehm Center for Diabetes Research.

Every year the Hispanic Heritage Month provides the opportunity to highlight the achievements of Hispanic Americans who continue to make a positive influence and enrich our nation. With each achievement showcased today comes the great responsibility to exceed expectations in the future for the next generation of Hispanic Americans.

—Santiago Schnell

Bio and Research

Santiago Schnell is a mathematical scientist investigating complex biomedical systems in which modeling and theory aid in the identification of the key mechanisms underlying the behavior of a system as a whole. His primary research contributions have been developing new approaches for measuring the kinetic parameters of biochemical reactions and reworking generally accepted theories of enzyme action and protein aggregation. Santiago's long-term research goal is to continue using mathematical, computational, and statistical methods to develop quantitative approaches to investigate the behavior of biochemical reactions and biomedical complex systems.

Awards and Service

Santiago currently serves on the editorial board of *Mathematical Biosciences*, *Current Opinion in Systems Biology*, and *Cancer Research*. He is a member of the Educational League of Excellence at the University of Michigan Medical School and received the University of Michigan Endowment for Basic Science Teaching Award. He is a recipient of the 21st Century Scientist Award from the James S. McDonnell Foundation and is an elected Fellow of the Royal Society of Chemistry. Presently, he serves as the president for the Society of Mathematical Biology.

RICARDO CORTEZ

Ricardo Cortez, Pendergraft William Larkin Duren Professor in Mathematics at Tulane University and director of the Center for Computational Science.

The celebration of Hispanic Heritage Month provides an occasion not only to look back at accomplishments of Latinos in mathematics but also to conceive concrete opportunities to inspire new generations of Latinos and to promote Latino students and junior investigators in mathematics.

—Ricardo Cortez

Bio and Research

Ricardo Cortez is Pendergraft William Larkin Duren Professor in Mathematics at Tulane University and director of the Center for Computational Science. He is internationally regarded as a leading researcher in fluid dynamics and mathematical modeling. His research interests are in developing and analyzing computational methods for the simulation of biological fluid flows. His elegant and easily implemented method of regularized stokeslets has become a standard computational framework for engineers and physicists studying fluid flow around microorganisms. Throughout his career, Ricardo has promoted interdisciplinary collaborations and continues to integrate computational investigations in joint research activities with experimentalists and applied scientists. Additional research interests include mathematical modeling and secondary mathematics education.

Awards and Service

Early in his career Ricardo received a Career Enhancement Fellowship for Junior Faculty from Underrepresented Groups from the Woodrow Wilson National Fellowship Foundation. For his mentoring work, he has been honored with the SACNAS Distinguished Undergraduate Institution Mentor Award and the SACNAS Presidential Service Award. He was the 2012 recipient of the Blackwell-Tapia Prize for significant contributions to research and for serving as a role model for mathematical scientists and students from underrepresented minority groups.

Ricardo has been a member of numerous committees for such organizations as the National Science Foundation (NSF), Mathematical Sciences Research Institute (MSRI), Mathematical Biosciences Institute, Mathematical Association of America (MAA), Society for Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS), and Society for Industrial and Applied Mathematics (SIAM), among many others. In addition he served as a founding director of the summer research program MSRI-UP from 2007 to 2014.

JUAN MEZA

Juan Meza, dean of the School of Natural Sciences and Professor of applied mathematics at the University of California, Merced.

Bio and Research

Juan Meza is dean of the School of Natural Sciences at the University of California, Merced. His current research interests include nonlinear optimization with an emphasis on methods for parallel computing. He has also worked on various scientific and engineering applications, including scalable methods for nanoscience, power grid reliability, molecular conformation problems, optimal design of chemical vapor deposition furnaces, and semiconductor device modeling. Prior to joining UC Merced, Dr. Meza served as department head and senior scientist for High Performance Computing Research at E. O. Lawrence Berkeley National Laboratory, where he led research programs in computational science and mathematics, computer science and future technologies, scientific data management, visualization, and numerical algorithms and application development.

Awards and Service

Juan received the 2013 Rice University Outstanding Engineering Alumni Award and was named to *Hispanic Business Magazine's Top 100 Influentials* in the area of science. In addition, he has been elected a Fellow of the AAAS and was the 2008 recipient of the Blackwell-Tapia Prize and the SACNAS Distinguished Scientist Award. He was also a member of the team that won the 2008 ACM Gordon Bell Award for Algorithm Innovation.

Juan has served on numerous external committees including the National Research Council Board on Mathematical Sciences and Their Applications, DOE's Advanced Scientific Computing Advisory Committee, the Human Resources Advisory Committee for the Mathematical Sciences Research Institute, the boards of trustees for IPAM and SIAM, the Board of Governors for the Institute for Mathematics and its Applications, and the External Advisory Committee for the National Partnership for Advanced Computational Infrastructure.

Thank you so much, this program made my summer!
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-Elisa
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-Tec

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Interview with Sir Timothy Gowers

Sir Timothy Gowers is professor of mathematics at the University of Cambridge, Fellow of The Royal Society, and Fields Medal recipient. His e-mail address is W.T.Gowers@dpmms.cam.ac.uk.

Editor's Note: *Since this interview, Gowers has been awarded the 2016 Sylvester Medal of the Royal Society of London and the De Morgan Medal of the University of Cambridge (see Mathematical People, page 1063).*

Diaz-Lopez: *When did you know you wanted to be a mathematician?*

Gowers: It was a gradual process encouraged by the education system in Britain, where you specialize quite early. At the age of sixteen I was already doing just math and physics. Then, going to university, I had to choose one subject and that subject was clearly going to be mathematics. Later, when I had the chance to specialize in either pure or applied, it was clear to me that pure is what I wanted to do, and at each stage I wanted to get to the next stage, so if you continue that process then, by induction, you end up as a mathematician.

Diaz-Lopez: *Who encouraged or inspired you?*

Gowers: I had a particularly good primary school teacher who told us about π when we were five years old. Then, when I went to my next primary school, the wife of the headmaster was a Cambridge math graduate and she also told us about things that went well beyond the things we were supposed to be learning. After primary school, again I had somebody who was maybe overqualified for the job, somebody who had been a fellow of King's College in Cambridge in mathematics and then decided to switch to school teaching and was very inspiring. Finally, when I went to Cambridge, my director of studies was Béla Bollobás, who went on to become my research supervisor and was also a very inspiring mathematician.

Diaz-Lopez: *How would you describe your research to a graduate student?*

Gowers: The area that I mainly work in is additive combinatorics. I am drawn to combinatorics because I like problems with elementary statements, problems you can attack with elementary-ish methods, by which I mean ones where in order to start you don't have to spend two years reading literature. But I also don't like it when they are too elementary, so I like having some tools. In fact I like to have the illusion to have discovered the tools by myself, even if I am rediscovering well-known tools. I also like (what I call) impure combinatorics, combinatorics that intersects with areas like analysis, number theory, and group theory.

Diaz-Lopez: *What theorem are you most proud of?*

Gowers: The quantitative bound of Szemerédi's theorem. You might think that's a strange choice because it's just giving a new proof of an existing theorem but because the bounds were new there is a new aspect to it, and the methods that were introduced were new and turned out to be quite fruitful for a number other things. It led on to interesting developments.

Diaz-Lopez: *What advice do you have for graduate students?*

DOI: http://dx.doi.org/10.1090/noti1432

keep asking more and more questions

Gowers: Keep active the whole time. For example, if you are trying to think about a hard problem and you are feeling stuck, ask lots of questions and try to analyze why you are stuck. Think even whether you should switch to a different problem, but not too fast because if you keep doing that you will never do anything. One of the most important things is to keep asking more and more questions and eventually you will find some that you can answer and are interesting, or will help you answer other questions. Some of my best results have been a result of trying to solve unsuccessfully one problem but developing ideas that enabled me to solve others.

Another piece of advice is to keep mathematically curious to the extent that you would be interested in proving things even if you know they are known results. Don't be too hasty to look at the literature to find out whether something is known because if you manage to prove it by yourself you will really understand it. So keep on thinking and if you keep on thinking and having ideas and generating and learning for yourself, eventually the results will start coming.

Diaz-Lopez: *During one of your talks at the 2016 Joint Mathematics Meetings you mentioned that we should think about teaching people how to do research. Is there a way you can teach someone how to do research? If so, how would you do it?*

Gowers: I strongly believe there is, but I can't just at the moment properly justify that belief. It's a project I have in the back of my mind. I have thought quite a lot about the research process while I have been doing it, partly because that's a good thing to do because if you are constantly analyzing what you are doing you can think about how you can do it better or more quickly. At some stage I want to try to set some of the ideas down on paper but right now I haven't gotten them in a sufficiently organized form. So, I am guilty of the crime that I am accusing others of not having diverted enough efforts to explaining how to do it but I do have it as a resolution to do something about that at some stage.

Diaz-Lopez: *You also mentioned the idea of automated proofs. What are your views on the subject and what do you aim to achieve?*

Gowers: It's very related to the previous question because one of the best ways of thinking in depth about how humans find proofs is thinking about how would you automate the process of finding proofs. If you can explain to a computer how to find a proof, you can probably explain it to a human. It's maybe more difficult with computers because there are lots of little things you can take for granted with humans but computers need a lot more help.

The main thing I would like to do is to concentrate on what Mohan Ganesalingam and I called extreme human-oriented automatic theorem-proving. It consists of having computers prove theorems in the sort of ways that humans would do it, not just doing a massive search until you happen to stumble on something that's correct but doing a search process that involves this top-down approach that humans will often have. In such an approach, you have some vague plan for how it works and you try to put in the details and some things work well and other things don't work and you have to modify them and so on. Getting all that to work on a computer is an extremely ambitious goal, obviously. What we have been doing at the moment is trying to do quite easy things in specific subdomains of mathematics, not because that's what really interests us but because you have to start with something.

What I would hope is that there will be two activities: thinking very hard about the research process from the perspective of explaining to humans how to do it, and the bottom-up process of getting a computer to be able to do most sophisticated things. At some point I would like those two to meet in the middle, so the computer can do the easy stuff and then they can get this sort of advice about how to do harder stuff which they will then be able to act on. That's certainly a long-term project.

Diaz-Lopez: *When do you think this will be achieved?*

Gowers: It depends on what you count as the end goal. At this time, I don't see any fundamental obstacle to have computers solving problems that bright undergraduates can solve in an hour, but it's a lot of work and it's not clear when that work is going to get done and by how many people. I would hope that within 10-20 years we can get computers that can do reasonably routine things but sufficiently unroutine to be useful. For example, if you work in one area then something that seems routine to you may seem extremely unroutine to someone in a different area. It would be very helpful to have a computer that can do routine things in all areas of mathematics. Particularly, it will be helpful if it works in this human-oriented way I just described.

Diaz-Lopez: *Do you think machines will ever replace us (as mathematicians)?*

Gowers: It will be a gradual process. People will start using computers more and more to help with their research (as we already do), and each new step will make our research life easier. For example, think back to when we didn't have the Internet, how hard it was to get a hold of a pre-print. So, if research gradually gets easier, each new change will be embraced until eventually we won't need to put in much thought at all to prove things.

At that point I suppose you can ask: Will we not lose very valuable skills? I don't know the answer, and that could be a problem. On the other hand, if one thinks about the use of calculators: I grew up not having calculators, learning how to do long division and now, in principle, if I had to divide one big number by another I know exactly how to do it but I can save a lot of time by using a calculator. That seems to be a good system. We could have a system where we would continue to teach people mathematics, but we might think more carefully about

what we taught people, so that when we use computers to find proofs we would know what was going on. It's not a completely straightforward question, but in general I am relaxed about the idea that the age of mathematical research may be finite and if it is then we will find other things to do.

Diaz-Lopez: *You have mentioned that there is a need to reform our journal system. You recently created an arXiv overlay journal,* Discrete Analysis. *Can you say more about this project?*

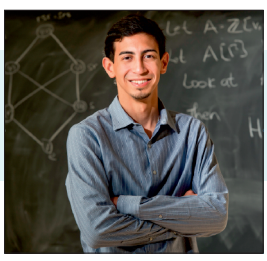
Gowers: *Discrete Analysis* is meant to be a reasonably broad journal, but broad in the sense of the interests of the editors, which are additive combinatorics, analytic number theory, and other related areas. We are managing the journal at an extremely low cost. I estimated that our annual cost will be comparable to the cost of the article processing charge for one article in one of the traditional publishers' journal. As you mentioned, it is an arXiv overlay journal, meaning that our published articles live on the arXiv; there are no charges for readers and no charges for authors. I hope this will be a catalyst for other people to do the same thing. Part of the reason that the current publishing system hasn't collapsed is that there isn't an alternative out there waiting, and this is one of many different attempts to make a start.

Diaz-Lopez: *Any final comments?*

Gowers: Don't necessarily accept that the way we transmit mathematics at the moment is the best way.

Credits

Photo of Sir Timothy Gowers by Gert-Martin Greuel. ©Mathematisches Forschungsinstitut Oberwolfach.



Alexander Diaz-Lopez, having earned his PhD at the University of Notre Dame, is now visiting assistant professor at Swarthmore College. Diaz-Lopez was the first graduate student member of the *Notices* Editorial Board.

WHAT IS...

A Multiple Orthogonal Polynomial?

Andrei Martínez-Finkelshtein and Walter Van Assche

Communicated by Cesar E. Silva

Multiple orthogonal polynomials are polynomials of one variable that satisfy orthogonality conditions with respect to *several* measures. They are a very useful extension of orthogonal polynomials and recently received renewed interest because tools have become available to investigate their asymptotic behavior. They appear in rational approximation, number theory, random matrices, integrable systems, and geometric function theory. Various families of special multiple orthogonal polynomials have been found, extending the classical orthogonal polynomials but also giving completely new special functions [1, Ch. 23].

Definition

The classical Legendre polynomials $P_n(x)$,

$$1,\ x,\ (1/2)(3x^2-1),\ (1/2)(5x^3-3x),\dots,$$

are orthogonal on $[-1,1]$ with respect to the Lebesgue measure:

$$\int_{-1}^{1} P_m(x)P_n(x)dx = 0, \text{ for } m \neq n.$$

Equivalently,

$$\int_{-1}^{1} x^m P_n(x)dx = 0, \text{ for } m < n.$$

Their direct generalization comprises the Jacobi polynomials, orthogonal on the same interval with respect to the beta density $(1-x)^\alpha(1+x)^\beta$, $\alpha,\beta > -1$. Similarly, the classical Hermite polynomials are orthogonal with respect to normal density e^{-x^2} on the whole real line, and the classical Laguerre polynomials are orthogonal with respect to the gamma density $x^\alpha e^{-x}$, $\alpha > -1$, on $[0,\infty)$.

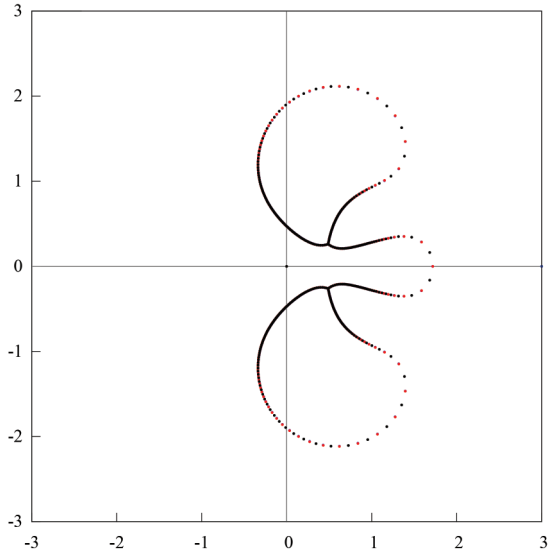


Figure 1. Zeros of $A_{\vec{n},1}$, $A_{\vec{n},2}$ and $B_{\vec{n}}$, $\vec{n} = (350, 350)$, corresponding to Type I Hermite-Padé approximation to the functions $f_1 = w$, $f_2 = w^2$, where $w(z)$ is a solution of the algebraic equation $w^3 + 3(z-3)^2 w + 2i(3z-1)^3 = 0$.

Multiple orthogonal polynomials satisfy orthogonality relations with respect to *several* measures, $\mu_1, \mu_2, \dots, \mu_r$, on the real line. Given a multi-index $\vec{n} = (n_1, n_2, \dots, n_r)$ of positive integers of length $|\vec{n}| = \sum_{i=1}^r n_i$, *type I multiple orthogonal polynomials* are a vector $(A_{\vec{n},1}, \dots, A_{\vec{n},r})$ of polynomials such that $A_{\vec{n},j}$ has degree at most $n_j - 1$ and

$$(1) \qquad \sum_{j=1}^{r} \int x^k A_{\vec{n},j}(x)\, d\mu_j(x) = 0, \qquad 0 \le k \le |\vec{n}| - 2.$$

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The *type II multiple orthogonal polynomial* $P_{\vec{n}}$ is the monic polynomial of degree $|\vec{n}|$ that satisfies the orthogonality conditions

$$\int P_{\vec{n}}(x)x^k\,d\mu_j(x) = 0, \qquad 0 \le k \le n_j - 1, \tag{2}$$

for $1 \le j \le r$. Both relations (1), endowed with an additional normalization condition, and (2) yield a corresponding linear system of $|\vec{n}|$ equations in the $|\vec{n}|$ unknowns: either the coefficients of the polynomials $(A_{\vec{n},1}, \dots, A_{\vec{n},r})$ or the coefficients of the monic polynomial $P_{\vec{n}}$. The matrix of each of these linear systems is the transpose of the other and contains moments of the r measures $(\mu_1, \dots, \mu_r)$. A solution of these linear systems may not exist or may not be unique. In order for a solution to exist and be unique, one needs extra assumptions on the measures $(\mu_1, \dots, \mu_r)$. If a unique solution exists for a multi-index $\vec{n}$, then the multi-index is said to be *normal*. If all multi-indices are normal, then the system $(\mu_1, \dots, \mu_r)$ is said to be a *perfect system*.

Hermite-Padé Approximation

Multiple orthogonal polynomials originate from *Hermite-Padé approximation*, a simultaneous rational approximation to several functions $f_1, f_2, \dots, f_r$ given by their analytic germs at infinity,

$$f_j(z) = \sum_{k=0}^{\infty} \frac{c_{k,j}}{z^{k+1}}, \qquad 1 \le j \le r.$$

A type I Hermite-Padé approximation consists of finding polynomials $(A_{\vec{n},1}, \dots, A_{\vec{n},r})$ and $B_{\vec{n}}$, with $\deg A_{\vec{n},j} \le n_j - 1$, such that

$$\sum_{j=1}^{r} A_{\vec{n},j}(z)f_j(z) - B_{\vec{n}}(z) = \mathcal{O}\Big(\frac{1}{z^{|\vec{n}|}}\Big), \quad z \to \infty;$$

see Figure 1. A type II Hermite-Padé approximation consists of finding rational approximants $Q_{\vec{n},j}/P_{\vec{n}}$ with the common denominator $P_{\vec{n}}$ in the sense that for $1 \le j \le r$,

$$P_{\vec{n}}(z)f_j(z) - Q_{\vec{n},j}(z) = \mathcal{O}\Big(\frac{1}{z^{n_j+1}}\Big), \quad z \to \infty.$$

If the function f_j is the Cauchy transform of the measure μ_j,

$$f_j(z) = \int \frac{d\mu_j(x)}{z - x},$$

then $(A_{\vec{n},1}, \dots, A_{\vec{n},r})$ are the type I multiple orthogonal polynomials and $P_{\vec{n}}$ is the type II multiple orthogonal polynomial for the measures $(\mu_1, \dots, \mu_r)$.

Number Theory

The construction of the previous section goes back to the end of the nineteenth century, especially to Hermite and his student Padé, as well as to Klein and his scientific descendants Lindemann and Perron. Hermite's proof that e is a transcendental number is based on Hermite-Padé approximation. Using these ideas, Lindemann generalized this result, proving that $e^{\alpha_1 z}, \dots, e^{\alpha_r z}$ are algebraically independent over $\mathbb{Q}$ as long as the algebraic numbers $\alpha_1, \dots, \alpha_r$ are linearly independent over $\mathbb{Q}$ (which, in turn, yields transcendence of e and π).

More recently, Apéry proved in 1979 that $\zeta(3)$ is irrational. His proof can be seen as a problem of Hermite-Padé approximation to three functions with a mixture of type I and type II multiple orthogonal polynomials. Similar Hermite-Padé constructions were used by Ball and Rivoal in 2001 to show that infinitely many $\zeta(2n+1)$ are irrational, and somewhat later Zudilin was able to prove that at least one of the numbers $\zeta(5), \zeta(7), \zeta(9), \zeta(11)$ is irrational.

Random Matrices and Nonintersecting Random Paths

A research field where multiple orthogonal polynomials have appeared more recently and turned out to be very useful is random matrix theory. It was well known that orthogonal polynomials play an important role in the so-called Gaussian Unitary Ensemble of random matrices. Another random matrix model is one with an external source, i.e., a fixed (nonrandom) hermitian matrix A and probability density

$$\frac{1}{Z_n} e^{-n\mathrm{Tr}(M^2 - AM)}\,dM.$$

If A has n_j eigenvalues a_j $(1 \le j \le r)$ and $n = |\vec{n}|$, then the average characteristic polynomial

$$P_{\vec{n}}(z) = \mathbb{E}\det(zI_n - M)$$

is a type II multiple orthogonal polynomial with orthogonality conditions

$$\int_{-\infty}^{\infty} P_{\vec{n}}(x)x^k e^{-n(x^2 - a_j x)}\,dx = 0, \quad 0 \le k \le n_j - 1,$$

for $1 \le j \le r$. This is called a *multiple Hermite polynomial*. Instead of Hermitian matrices, one can also use positive definite matrices from the Wishart ensemble and find multiple Laguerre polynomials. More recently, products of Ginibre random matrices were investigated by Akemann, Ipsen, and Kieburg in 2013. The singular values of such matrices are described in terms of multiple orthogonal polynomials for which the weight functions are Meijer G-functions.

Eigenvalues and singular values of random matrices are special cases of determinantal point processes. These are point processes for which the correlation function can be written as a determinant of a kernel function K:

$$\rho_n(x_1, \dots, x_n) = \det(K(x_i, x_j))_{1 \le i,j \le n}$$

for every $n \ge 1$. For random matrices with an external source the kernel is in terms of type I and type II multiple orthogonal polynomials. This kernel extends the well-known Christoffel-Darboux kernel for orthogonal polynomials.

Other determinantal point processes are related to nonintersecting random paths. As Kuijlaars and collaborators have shown, nonintersecting Brownian motions leaving at r points and arriving at 1 point can be described in terms of multiple Hermite polynomials, and the analysis uses the same tools as random matrices with an external source. If the Brownian motions leave from r points and

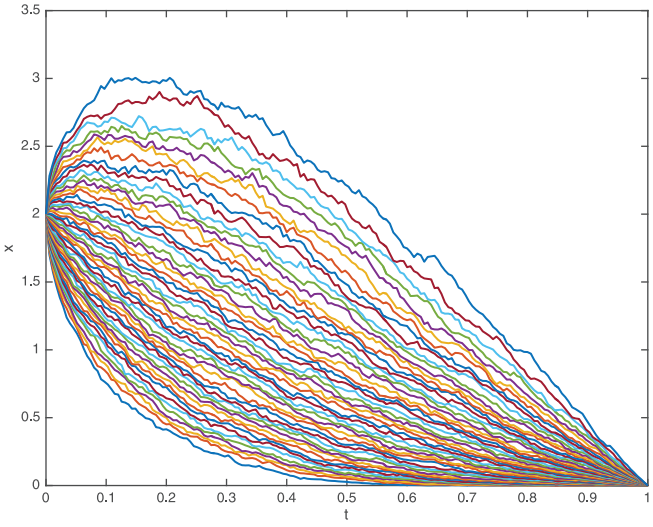


Figure 2. Numerical simulation of 50 rescaled nonintersecting squared Bessel paths, starting at $a = 2$ and ending at the origin. The statistics of the position of the paths at each time t is described in terms of multiple orthogonal polynomials with respect to weights related to modified Bessel functions.

arrive at r points, then one needs a mixture of type I and type II multiple orthogonal polynomials.

Brownian motions in d-dimensional space, in which one tracks the square of the distance of the particle from the origin, give rise to nonintersecting squared Bessel paths, whose determinantal structure is written now in terms of multiple orthogonal polynomials related to modified Bessel functions I_ν and $I_{\nu-1}$, where $\nu = d/2$; see Figure 2.

Analytic Theory of MOPs

As the pioneering work of Nikishin and others showed, various tools from complex analysis and geometric function theory illuminate the study of multiple orthogonal polynomials. For example, one needs to consider extremal problems for the logarithmic energy for a vector of measures. In addition, algebraic functions solving a polynomial equation of order $r + 1$ often come into play. The related Riemann surfaces typically have $r + 1$ sheets, and matrices of order $r + 1$ arise in a matrix Riemann-Hilbert characterization.

One sees here not mere technical complications but rather the richness of the asymptotic behavior of multiple orthogonal polynomials. At least for the near future, it is difficult to envision a general theory.

Reference

[1] M. E. H. Ismail, *Classical and Quantum Orthogonal Polynomials in One Variable*, Encyclopedia of Mathematics and its Applications, vol. 98, Cambridge University Press, 2005 (paperback edition 2009). MR2191786 (2007f:33001)

Credits

Figure 1 courtesy of S. P. Suetin.
Photo of Andrei Martínez-Finkelshtein and Walter Van Assche courtesy of Andrei Martínez-Finkelshtein.

Walter Van Assche (l) and Andrei Martínez-Finkelshtein (r).

ABOUT THE AUTHORS

Andrei Martínez-Finkelshtein's research interests include approximation theory, orthogonal polynomials, asymptotic and numerical analysis, and mathematical modelling in ophthalmology and the life sciences. He likes gadgets, literature, and photography.

Walter Van Assche's main interests are orthogonal polynomials, special functions, and their applications in approximation theory, number theory, and probability. He is an active supporter of the ecological movement and likes to hike and bike.

THE GRADUATE STUDENT SECTION

The AMS Graduate Student Blog, by and for math graduate students, includes puzzles and a variety of interesting columns. *June 2016 posts included these two by undergraduates:*
blogs.ams.org/mathgradblog.

Nate Silver and the Stylish Statistics of Predicting Elections

by Michael Dimock, Augustana College

Nate Silver speaking at SXSW in 2009.

Nate Silver is a statistics guru whose claim to fame has come from correctly predicting forty-nine of the fifty states in the 2008 presidential election as well as all thirty-five Senate races. He is the founder and editor-in-chief of the popular website *FiveThirtyEight*. Extending far beyond major political elections, the website also works with the statistics of sports, science, health, economics, and culture.

Being a mathematics major, I have learned to never blindly trust the statistics that show up in news reports, and Nate Silver is often one of the first to warn others to be wary of statistics presented in the media. A good intro piece to Silver's statistical style and ability is his [TED Talk] "Does racism affect how you vote?" (www.ted.com/talks/nate_silver_on_race_and_politics)…

OKCupid: The Math Behind Online Dating

By Michalina Malysz, Augustana College

OKCupid is a top online dating website…. OKCupid collects data by asking users to answer questions: these questions can range from minuscule subjects like taste in movies or songs to major topics like religion or how many kids the other person desires. …In order to calculate compatibility, the computer must find a way to compare the answer to each question, the ideal partner's answer to each question, and the level of importance of the question against that of someone else's answers….

It turns out that the percent match actually does have an effect on the likelihood of a message being sent and the odds of a single message turning into a conversation. For example, if person A was told that they were only a 30 percent match with person B (and they were only a 30 percent match), then there's a 14.2 percent chance that a single message would be sent and about a 10 percent chance of a single message turning into a conversation of four or more messages. However, if person A was told that they are a 90 percent match (even if they are only a 30 percent match), then the odds of sending one message is 16.9 percent, and the odds that the one message turns into exchanging 4 or more is 17 percent.

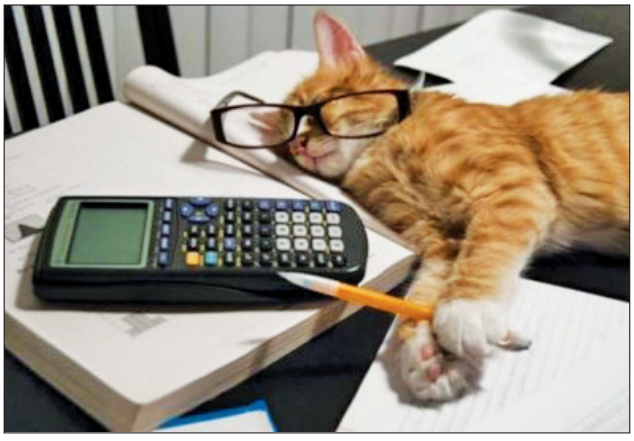
Michael Dimock *recently graduated from Augustana College and is teaching high school mathematics.*

Michalina Malysz *is a senior mathematics major at Augustana College.*

THE BACK PAGE

The June/July Contest Winner Is...

Nancy Paugh, who receives our book award.

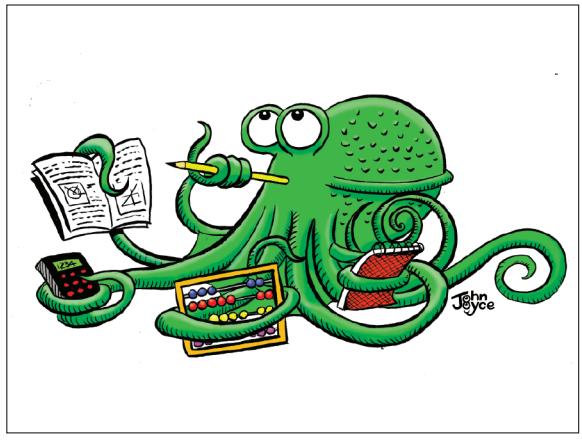


From www.petsfoto.com/couple-smart-animals posted by *bugy20* on November 16, 2010. Reprinted here according to the US Copyright Fair Use Act.

"I'll solve the problem–just need to sleep on it a bit."

The October 2016 Caption Contest:

What's the Caption?



Reprinted artwork by John Joyce; www.spindriftpress.com.

Submit your entry to captions@ams.org by October 25. The winning entry will be posted here in the January 2017 issue.

"One of the best ways of thinking in depth about how humans find proofs is thinking about how would you automate the process of finding proofs."

—Sir Timothy Gowers, Grad Student Section interview (page 1026)

Stats on William Timothy Gowers:

Total publications: 44
Total citations: 1,272
Most cited publication: with B. Maurey, The Unconditional Basic Sequence Problem, *J. Amer. Math. Soc.* **6** (1993). [242 citations]. (**Source:** MathSciNet®)
Erdős Number: 3
Mathematical descendants: 9 students, 15 descendants (**Source:** Mathematics Genealogy Project)
Honors: Fields Medal: 1998; Sylvester Medal and De Morgan Medal: 2016 . See page 1063 of this issue.

QUESTIONABLE MATHEMATICS

"Ivy League economist...interrogated for doing math on American Airlines flight"

—*Washington Post* headline, May 7, 2016

What crazy things happen to you? Readers are invited to submit original short amusing stories, math jokes, cartoons, and other material to: **noti-backpage@ams.org**.

From the AMS Secretary

Report of the Treasurer (2015)

Introduction

The American Mathematical Society enjoyed a financially healthy year in 2015. This was due primarily to two generous bequests from the estates of Isidore Fleischer, and Franklin and Marilyn Peterson, totaling about $1.7 million. In 2015, the net operating income of the Society was approximately $2.4 million, as compared to a net income of $1.8 million in 2014. Without these bequests, net operating income would have been about $700,000. We expand upon these statements in what follows.

The Report of the Treasurer is presented in the *Notices* annually and discusses the financial condition of the Society as of the immediately preceding fiscal year-end and the results of its operations for the year then ended. One of the key responsibilities of the Treasurer is to lead the Board of Trustees in the oversight of financial activities of the Society. This is done through close contact with the executive staff of the Society, review of internally generated financial reports, review of audited financial statements, and twice yearly meetings with the Society's independent auditors. Through these and other means, the Trustees gain an understanding of the finances of the Society and the important issues surrounding its financial reporting.

When reviewing the financial results of the AMS presented here, it is important to note that the financial support for its membership and professional programs is derived from multiple sources. First, a board-designated endowment fund, the Operations Support Fund (OSF), provided $2,048,000 in operating support to the membership and professional programs in 2015. The OSF is a fund that has grown throughout the years from operating net income as well as investment gains; because the fund is dependent upon market conditions, the amount provided varies from year to year. In addition, the membership and professional programs are supported through dues income and contributions. Finally, the margin from the publication programs supports these services as well. Without the margin from publications and the OSF income, dues and contributions alone would not provide enough support to continue professional programs, such as MathJobs, scholarships, fellowships, and *Notices*.

The Society segregates its net assets, and the activities that increase or decrease net assets, into three types: unrestricted, temporarily restricted, and permanently restricted. Total net assets at the end of 2015 were $128 million. Unrestricted net assets are those that have no requirements as to their use placed on them by donors outside the Society. A substantial majority of the Society's net assets are in this category. Temporarily restricted net assets are those with donor-imposed restrictions or conditions that will lapse upon the passage of time or the accomplishment of a specified purpose. Examples of the Society's temporarily restricted net assets and related activities include grant awards and the spendable income from prize and other income-restricted endowment funds. Permanently restricted net assets are those that must be invested in perpetuity and are commonly referred to as endowment funds. The accompanying financial information principally relates to the unrestricted net assets, as this category includes the operating activities of the Society.

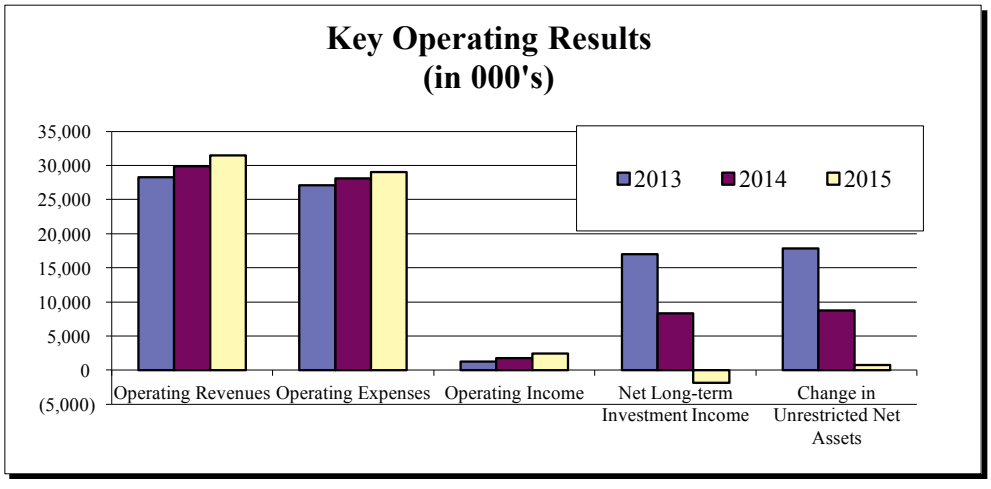


Figure 1

All currency discussed in this report refers to US dollars.

"k" denotes thousand.

"m" denotes million.

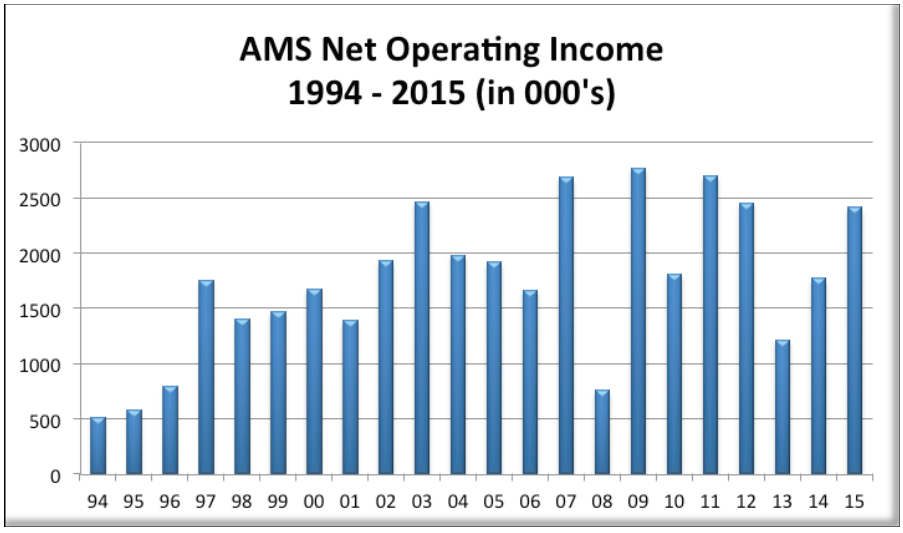


Figure 2

Operating Results

Apart from low investment returns in 2015, Figure 1 shows that the past three years have been good years, financially, for the Society. However, it is important to note that the investment returns are presented on the audited financial statements as investment returns net of the spendable income for the year. Therefore, the 2015 net investment return as shown in Figure 1 is negative; the reason for this is that the OSF spendable income, approximately $2 million, has been subtracted from the returns. The OSF spendable income is determined by multiplying an average of the fund's balance for the prior three years by the spending rate of 4 percent. This is of potential concern for future years if investment returns continue to fare poorly.

As stated in the opening paragraph, the positive net operating income of $2.4 million in 2015 is primarily the result of the receipt of two large bequests, totaling about $1.8 million. Without these bequests, net operating income would have been about $700,000. As shown in Figure 2, the Society has maintained a positive net income for more than two decades. For many years now, it has been important for the Society's management to ensure that expenses grow moderately, because publishing revenues, the Society's major source of revenue, are suffering from subscription attrition and decreased book sales. In order to increase revenues, fundraising efforts have increased in recent years, and there is a corresponding increase in development revenues. Some long-term strategic planning initiatives being developed and implemented now and in the near future by the AMS will address stagnant publishing revenues as well as a continued decline in membership and related dues income.

In 2015, the Society's revenues increased by 5.2 percent over 2014 revenues. The major reason for the overall increase in revenues was development revenues, which increased from $337,917 to $1,813,725 due to receipt of the aforementioned bequests during the year. Publishing revenues decreased by about 1 percent from 2014 to 2015 as a result of a large decrease in book sales. Books sales have been declining for years with a total decrease of about 10 percent over the past six years. Spendable income from endowments and board-restricted funds increased by 11 percent due to the cumulative investment gains the Society has experienced over the past few years. There was a sharp decline of about $380,000 in the income received from short-term operating investments in 2015 due to poor performance in the investment markets during the year.

In 2015, expenses increased by 3.2 percent over the prior year. Wages and benefit costs increased about 3 percent. Many costs, such as building, postage, and equipment costs actually went down or stayed about the same when compared to 2014. Figure 3 shows the amounts spent on major expense categories in 2015.

For more detailed information regarding the Society's operating results, please see the financial statements, including the Statements of Activities, located at the end of this report.

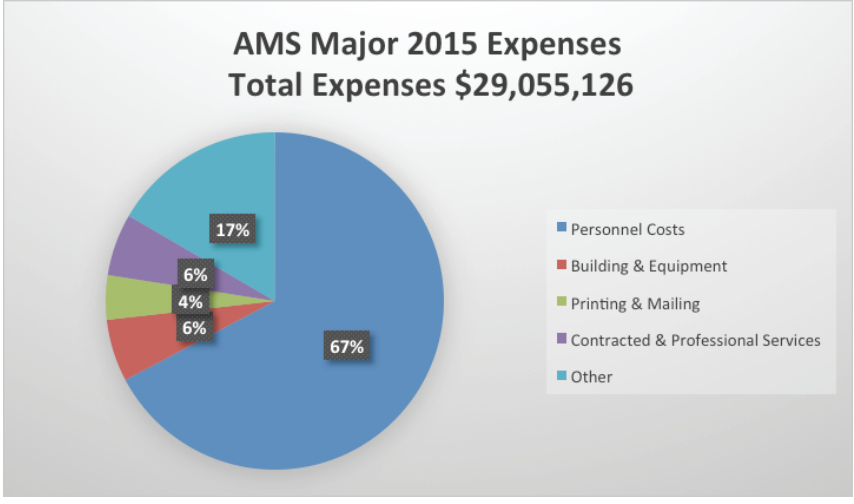


Figure 3

2015 Balance Sheets Highlights

Another report within the financial statements, referred to as the Balance Sheets, is also at the end of this financial review. The Society continues to maintain healthy balance sheets. Total net assets of the organization are $128 million, of which $112 million are unrestricted. Table 1 shows highlights of the Society's 2015 Balance Sheets.

2015 Statements of Invested Funds

The Statements of Invested Funds are divided into the permanently restricted funds that have been acquired from donations in the form of endowment funds,

Highlights of Balance Sheets Changes from 2014 to 2015	Commentary
Certificates of Deposit (CDs) decreased $891k (56%) from the prior year	This decrease is due to the Society not reinvesting cash from CDs after they came due, as the cash was needed to fund operations.
Short-term Investments increased $1,122k or 8 percent	Although the returns from the short-term investments were very weak in 2015, the Society received approximately $925k in donated securities at year-end, creating the increase in this category.
Accounts Receivable increased $494k (75 percent)	This increase is primarily related to two receivables from bequests that were outstanding at year-end totaling $567k
Prepaid Expenses and Deposits increased $373k (25 percent)	The increase is due mainly to higher prepaid costs, such as those for the venue and other pre-payments associated with the Joint Mathematics Meetings in 2016.
Deferred Revenue increased $1.16m (10 percent)	There was an increase in 2016 subscription collection by year-end over the prior year, resulting in an increase in revenues deferred to future years.

Table 1

and the funds that have been designated by the Board of Trustees for specific purposes (which we refer to as quasi-endowment funds).

The Society's Statements of Invested Funds is a listing of the Society's individual endowment and quasi-endowment funds. In addition, the invested funds of the Society contain a temporarily restricted fund, the Beal Prize, which at year-end amounted to $1.236 million. The corpus of this fund, $1 million, is set aside to fund a prize for solving the Beal Conjecture. The spendable income from the fund supports the Erdős Lecture and other programs. Overall, the 2015 Statements of Invested Funds show a small increase of $218k over the prior year. The operations of the AMS generated enough income so that more than $2 million was returned to the investment portfolio at year-end, which offset the outflows from spendable income. The investment return was only 0.17 percent as compared to a 10 percent return in 2014. In 2015, investment performance was poor with the S&P 500 returning only 1.4 percent.

The quasi-endowment funds are set aside for various purposes. The newest fund, the Strategic Initiative Fund, in the amount of $250,000, will support the expenses of implementing the strategic plan mentioned above. Another fund, established in 2014, is the Kathleen Baxter Memorial Fund, which will provide spendable income to support the American Mathematical Society's Centennial Fellow. The Economic Stabilization Fund (ESF) is a fund set aside to cover the postretirement benefit obligation and 75 percent of the current annual operating expenses in case of disaster. The ESF also contains about $1.7 million to self-insure against flood risk. The Society's largest quasi-endowment fund, the Operations Support Fund (OSF), valued at approximately $78 million, provided $2,048,000 in spendable income to the AMS operations in 2015.

Summary Financial Information

The following Statements of Activities and Balance Sheets are from the audited financial statements of the AMS, and the Statements of Invested Funds are from the internal financial records of the AMS. Any member may contact the AMS to request the full audited statements of the Society. The Treasurer will be happy to answer any questions members may have regarding the financial affairs of the Society.

Respectfully submitted,
Jane M. Hawkins
AMS Treasurer

AMERICAN MATHEMATICAL SOCIETY

Balance Sheets

	December 31,	
	2015	***2014***
Assets		
Cash	$ 1,018,324	$ 1,022,196
Certificates of deposit	710,000	1,601,460
Short-term investments	14,454,171	13,331,743
Accounts receivable, net of allowances of $258,480 and $294,801 in 2015 and 2014, respectively	1,150,407	655,752
Deferred prepublication costs	568,295	634,436
Completed books	1,291,914	1,194,235
Prepaid expenses and deposits	1,880,319	1,507,034
Land, buildings and equipment, net	4,379,852	4,449,507
Long-term investments	127,034,621	126,818,565
Total assets	**$ 152,487,903**	**$ 151,214,928**
Liabilities and Net Assets		
Liabilities:		
Accounts payable and accrued expenses	$ 3,589,866	$ 3,873,144
Accrued study leave pay	698,508	722,406
Deferred revenue	12,613,091	11,451,092
Postretirement benefit obligation	7,321,355	7,408,478
Total liabilities	**24,222,820**	**23,455,120**
Net assets:		
Unrestricted:		
Undesignated	120,955	-
Designated	111,782,413	111,171,200
	111,903,368	111,171,200
Temporarily restricted	10,665,546	11,050,480
Permanently restricted	5,696,169	5,538,128
Total net assets	**128,265,083**	**127,759,808**
Total liabilities and net assets	**$ 152,487,903**	**$ 151,214,928**

AMERICAN MATHEMATICAL SOCIETY

Statements of Activities

	Years Ended December 31,	
	2015	***2014***
Changes in unrestricted net assets:		
Operating revenue, including net assets released from restrictions:		
Mathematical Reviews	$ 11,521,492	$ 11,344,158
Journals	5,206,573	5,306,814
Books	3,494,449	3,687,814
Dues, services, and outreach	5,427,103	3,893,767
Investment returns appropriated for spending	2,074,382	1,799,700
Other publications-related revenue	605,080	631,772
Grants, prizes and awards	1,753,884	1,592,929
Meetings	1,321,735	1,189,114
Short-term investment income	64	381,349
Other	68,216	77,375
Total operating revenue	**31,472,978**	**29,904,792**
Operating expenses:		
Mathematical Reviews	7,696,350	7,596,576
Journals	1,515,997	1,501,487
Books	3,442,729	3,236,476
Publications indirect	1,216,181	1,418,636
Customer services, warehousing and distribution	1,625,478	1,751,542
Other publications-related expense	141,647	157,416
Membership, services and outreach	4,533,481	4,054,224
Grants, prizes and awards	2,138,628	1,871,237
Meetings	1,268,016	1,154,390
Governance	569,277	506,583
Member and professional services indirect	891,823	775,200
General and administrative	3,915,508	3,989,842
Other	100,011	118,363
Total operating expenses	**29,055,126**	**28,131,972**
Excess of operating revenue over operating expenses	**2,417,852**	**1,772,820**
Nonoperating revenues and expenses:		
Investment returns less investment returns available for spending	(1,872,939)	8,348,819
Use of board designated funds from Endowment Income Stabilization Fund	(6,680)	(6,335)
Use of board designated funds from Retrodigitization Fund		(159,130)
Depreciation of labor for in house software development	(53,810)	(66,701)
Postretirement benefit-related changes other than net periodic cost	247,745	(1,173,541)
Change in unrestricted net assets	732,168	8,715,932
Changes in temporarily restricted net assets:		
Contributions	$ 332,307	$ 176,795
Investment returns	13,503	1,459,507
Net assets released from restrictions	(730,744)	(554,467)
Change in temporarily restricted net assets	(384,934)	1,081,835
Change in permanently restricted net assets:		
Contributions	158,041	272,137
Change in permanently restricted net assets	158,041	272,137
Change in net assets	**505,275**	**10,069,904**
Net assets, beginning of year	127,759,808	117,689,904
Net assets, end of year	**$ 128,265,083**	**$ 127,759,808**

American Mathematical Society-Statements of Invested Funds
As of December 31, 2015 and 2014

Income Restricted Endowment:	**Original Gift**	**12/31/15**	**12/31/14**
Endowment Funds:	**at 12/31/15**	**Total Value**	**Total Value**
Research Prize Funds			
Steele	145,511	762,236	784,425
Birkhoff	50,132	95,695	98,481
Veblen	58,599	84,688	87,153
Wiener	29,773	50,748	52,225
Bocher	32,557	51,554	53,055
Conant	9,477	50,800	52,278
Cole Number Theory	52,063	71,773	73,593
Cole Algebra	51,713	71,452	73,262
Satter	49,720	83,585	86,018
Chevalley Fund	115,000	116,108	119,488
Doob Prize	80,000	98,274	64,631
Robbins Prize	41,250	58,443	60,145
Eisenbud Prize	40,000	54,734	56,328
Other Prize and Award Funds			
Morgan Prize	25,000	55,282	56,892
Albert Whiteman Prize	95,417	133,902	135,999
Arnold Ross Lectures	103,579	131,363	116,603
Trjitzinsky	196,030	612,435	630,264
C.V. Newsom	100,000	284,994	293,290
Centennial	61,183	152,019	156,444
Menger	97,250	138,464	142,495
Ky Fan (China)	366,757	489,545	503,796
Impact Award	22,110	28,446	29,274
Epsilon	2,076,671	2,803,104	2,780,670
Einstein Lecture	100,000	141,720	145,846
Exemplary Program	100,000	140,853	144,954
Mathematical Art	20,000	28,171	28,991
Subtotal (Income Restricted)	**4,119,793**	**6,790,388**	**6,826,600**
Endowment	111,475	946,521	973,253
Morita	100,000	167,967	173,081
Henderson	548,223	5,008,701	5,161,172
Schoenfeld/Mitchell	573,447	949,627	978,535
Laha	189,309	319,039	328,751
Ritt	51,347	298,411	307,495
Moore	2,575	28,129	28,986
Subtotal (Income Unrestricted)	**1,576,376**	**7,718,395**	**7,951,273**
Total Endowment Funds	**5,696,169**	**14,508,783**	**14,777,873**
Quasi-Endowment Funds (Board-Designated):			
Journal Archive Fund		1,657,495	1,607,169
Young Scholars		843,852	868,952
Economic Stabilization Fund (ESF)		30,131,910	29,407,917
Endowment Income Stabilization Fund (EISF)		482,844	490,634
Backfile Digitization Fund		111,389	111,389
Strategic Initiative Fund		250,000	
Kathleen Baxter Memorial Fund		263,859	263,625
Operations Support Fund (OSF)		78,041,064	78,407,114
Total Quasi-Endowment Funds		**111,782,413**	**111,156,800**
Undesignated			110,985
Beal Prize (Temporarily Restricted)	1,000,000	1,236,302	1,263,562
Total Invested Funds	**$6,696,169**	**$127,527,498**	**$127,309,220**

Statistics on Women Mathematicians

Compiled by the AMS

At its August 1985 meeting the Council of the AMS approved a motion to regularly assemble and report in the *Notices* information on the relative numbers of men versus women in at least the following categories: membership in the AMS, invited hour addresses at AMS meetings, speakers at Special Sessions at AMS meetings, percentage of women speakers in AMS Special Sessions by gender of organizers, and members of editorial boards of AMS journals.

It was subsequently decided that this information would be gathered by determining the gender of the individuals in the above categories based on name identification if no other means was available and that additional information on the number of PhDs granted to women would also be collected using the AMS-ASA-IMS-MAA-SIAM Annual Survey. Since name identification was used, the information for some categories necessitated the use of three classifications:

Male: names that were obviously male

Female: names that were obviously female

Unknown: names that could not be identified as clearly male or female (e.g., only initials given, non-gender-specific names, etc.)

The following is the thirtieth reporting of this information. Updated reports will appear annually in the *Notices*.

Invited Hour Address Speakers at AMS Meetings (2006–2015)

Male:	335	81%
Female:	81	19%
Unknown:	0	0%
Total:	416	

Speakers at Special Sessions at AMS Meetings (2011–2015)

Male:	13,194	77%
Female:	3,673	21%
Unknown:	254	1%
Total:	17,121	

Percentage of Women Speakers in AMS Special Sessions by Gender of Organizers (2015)

Special Sessions with at Least One Woman Organizer

Male:	1,133	68%
Female:	455	27%
Unknown:	84	5%
Total:	1,672	

Special Sessions with No Women Organizers

Male:	1,353	76%
Female:	315	18%
Unknown:	105	6%
Total:	1,773	

2015 Members of the AMS Residing in the US

Male:	10,642	45%
Female:	2,366	10%
Unknown:	10,845	45%
Total:	23,853	

Trustees and Council Members

	2012		2013		2014		2015	
Male:	26	62%	23	62%	23	56%	23	55%
Female:	16	38%	14	38%	18	44%	19	45%
Total:	42		37		41		42	

Members of AMS Editorial Committees

	2006		2007		2008		2009		2010		2011		2012		2013		2014		2015	
Male:	193	84%	194	84%	168	83%	178	84%	176	82%	176	83%	178	83%	182	82%	179	81%	173	80%
Female:	36	16%	36	16%	35	17%	34	16%	39	18%	37	17%	37	17%	40	18%	43	19%	43	20%
Total:	229		230		203		212		215		213		215		222		222		216	

PhDs Granted to US Citizens

	2006		2007		2008		2009		2010		2011		2012		2013		2014		2015	
Male:	399	72%	396	69%	431	69%	515	69%	564	71%	574	72%	621	72%	627	73%	664	72%	636	72%
Female:	153	28%	180	31%	191	31%	227	31%	225	28%	228	28%	242	28%	230	27%	256	28%	244	28%
Total:	552		576		622		742		790		802		863		857		920		880	

Joining Forces in International Mathematics Outreach Efforts

Diana White and Alessandra Pantano, et al.

Participants at a Banff workshop launch Mathematics Outreach International.

Introduction

Valuable and innovative mathematical outreach activities are being held all over the world and have proven to be successful in creating interest in mathematics and spreading awareness of its importance to society. However, despite the international nature of mathematics, the majority of outreach activities never cross the borders of the countries where they are initiated, and in some cases never go beyond their immediate local community. Many of these outreach activities may be beneficial to audiences in other countries, and it is in everyone's interest to find ways to share our resources and expertise and create the means for wider dissemination of successful outreach efforts.

In November 2015 a group of eighteen mathematics outreach specialists converged at the Banff International Research Station (BIRS) in Alberta, Canada, for an international math outreach workshop. The participants included academic faculty from both local and world-renowned institutes and universities, graduate students, program directors, journalists, and filmmakers. Coming from Australia, Canada, Denmark, France, Germany, the United Kingdom, and the United States, they presented examples of their outreach work and engaged in lively discussions about future international collaboration. Participants provided a variety of perspectives and expertise; the spectrum of nationalities further contributed to the richness and diversity of experiences and initiatives on display. They reached agreement on the need to develop an international networking infrastructure for outreach and explored the possibilities of both expanding existing activities and creating new ones. Cédric Villani, Fields Medalist, joined the conversation through Skype; he explained his view of the importance of reaching outside the mathematics community and talked about his own involvement in outreach.

International Math Outreach Workshop participants at the Banff International Research Station (BIRS).

One theme that clearly emerged from the discussions is that outreach initiatives across the world have much in common, most notably goals and inspiration. They also face similar challenges, such as recognition of the involvement of researchers/professors from academic institutions and the realization by policymakers and journalists of the importance of mathematics. Workshop participants compared strategies and solutions for addressing these challenges as they sought to define ways to expand outreach initiatives, with particular attention to gender issues and developing countries; to facilitate cross-country collaborations; and to introduce a certain level of international coordination.

Attendees addressed the many important reasons for conducting mathematical outreach, from a simple desire to inspire people to share a love of mathematics

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Too many people… mistakenly envision mathematics as a dead science

to the need to spread recognition in the wider public and among policymakers of the importance of mathematics in our general understanding of crucial questions for our societies (climate change, limited supply of fossil fuel, etc.). Discussion rapidly led the participants to understand the need to:

• join forces to develop international strategies to eliminate false perceptions about mathematics,

• better exploit the imagination and ingenuity of many ongoing local outreach efforts by sharing resources on the international scene,

• organize mathematics outreach meetings and pool forces around a new international mathematics outreach initiative, and

• develop mathematics outreach activities in the developing world.

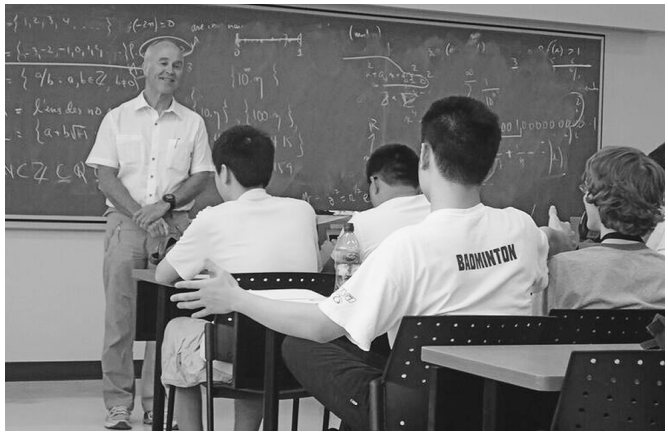
In the remainder of this article we discuss some of the global goals of mathematical outreach, give highlights of interesting specific outreach efforts in various countries presented at the workshop, and end with a discussion of plans for a new Mathematics Outreach International (MOI).

Why Is Mathematical Outreach Important?

Mathematics is an intricate part of everyday life. This is not well understood by large portions of the general public or by policymakers, students, and teachers. Mathematical outreach efforts aim to foster favorable attitudes towards mathematics and to develop a broader awareness of mathematical culture by promoting an understanding of the fundamental role of mathematics in the world. Outreach efforts also seek to enhance the enjoyment of the learning of mathematics.

We know that mathematics is a way for people to access and develop skills such as critical thinking, problem solving, and perseverance and that outreach has the ability to convey solid role models for careers in science, technology, engineering, and mathematics (STEM). It is therefore important that outreach efforts also be aimed at underrepresented groups in education known to disengage with mathematics (and other STEM disciplines) at a higher rate than the rest of the community.

Graduates of the 2013 PIMS Summer Math Camp for Aboriginal students.



Seminar on normal numbers during a 2014 summer camp at Laval University for a group of college students in mathematics.

Institutions of higher education strive to advance learning and to create and disseminate knowledge in society. Thus outreach to the public, to students, and to teachers is an essential component of this mission. Universities then must be among the principal actors in outreach efforts. However, outreach is also a responsibility of the whole mathematical community. There are still too many people who mistakenly envision mathematics as a dead science, in the sense that everything that needed to be discovered in mathematics has already been discovered, or who regard mathematics as a science reserved for the elite or something incredibly difficult and therefore not accessible to everyone. Others simply doubt the relevance of mathematics to the daily lives of most people. By joining forces in outreach initiatives, the mathematical community can develop strategies to eliminate these false perceptions and increase appreciation for mathematics and for its fundamental role in culture and society. Specific outreach efforts may vary significantly in terms of their intended audience as well as their goals. To emphasize the variety, we present some of the outreach initiatives that were outlined and discussed at the BIRS workshop.

Fostering Talent—Competitions and Intensive Programs

Many countries have a culture of mathematical competitions intended to foster talent, with some of the best culminating in participation in the International Math Olympiad. Other kinds of competitions exist, where the focus is on long-term collaborative work rather than on test taking, bringing them closer to a research experience. Some are multidisciplinary, like the US-based Intel Science Talent Search, the German Jugend Forscht, or the European Union Contest for Young Scientists. Others are purely mathematical, like the International Tournament of Young Scientists and its national counterparts: the French Tournoi Français des Jeunes Mathématiciens, the Quebec tournament organized by the Association Québécoise des Jeux Mathématiques, and the recently started Brazilian Torneos de Matemáticas para Jóvenes.

Other programs aim to develop mathematical talent locally, focusing on research more than on competition. For example, the Program in Mathematics for Young Scientists (PROMYS) at Boston University provides a six-week immersive research experience for mathematics majors, high school students, and teachers. In its 27-year history, the PROMYS program has had a remarkable impact on developing mathematical habits of mind in its participants: 277 PROMYS alumni, including 70 women, have, or are currently working on, a PhD in mathematics. In Europe, the Russian Contemporary Mathematics Summer School in Dubna has been organized since 2001; a similar program, Modern Mathematics, has been held in Bremen or Lyon every year since 2011.

Engaging students directly in mathematics is a powerful strategy

Discovering New Mathematical Talent

Engaging students directly in mathematics is a powerful strategy. Research shows that often students who struggle in standard classroom settings may come alive and prosper in informal mathematical activities. Math fairs play an exceptional role in generating enthusiasm towards mathematics. Notable examples include the National Math Festival and the Gathering4Gardner conference in the United States. In France the MATh.en.JEANS program organizes research projects for middle and high school students that are mentored by a research mathematician. Online platforms containing free resources for potential hosts of mathematical events are flourishing in many countries. An example is the Celebration of Mind website, which provides a repository of intriguing mathematical activities (toys, puzzles, magic tricks, and games) for teachers, students, parents, and math enthusiasts of all ages, or the IMAGINARY participatory project and website, hosting exhibitions and other mathematics material.

A number of specialized mathematics museums have been created around the world, like the Mathematikum in Giessen, Germany; the National Museum of Mathematics (MoMath) in New York, USA; and the Giardino di Archimede in Florence, Italy. Organized visits by school children to those museums have demonstrated their impact.

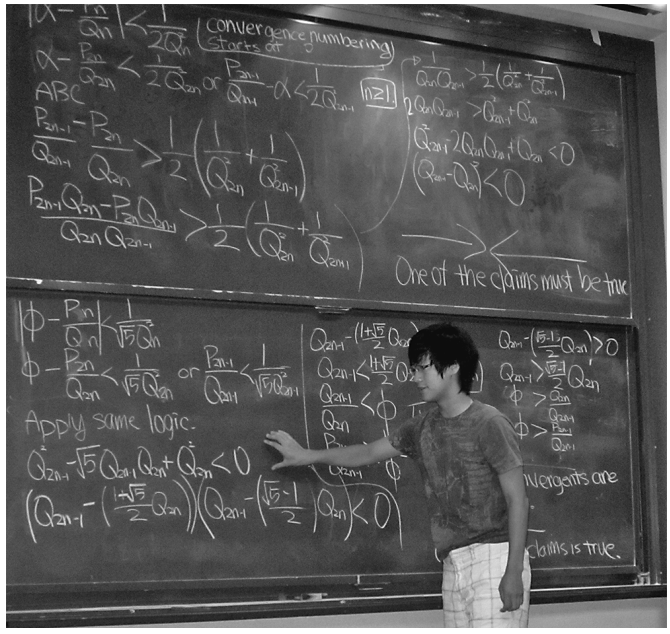
Fostering In-depth or Sustained Engagement

Frequent sessions of mathematical investigations are key to engaging young math enthusiasts in the process of mathematical discovery, which also promotes a deeper understanding of mathematics. Originating in the Eastern European tradition, these activities are currently organized weekly or monthly throughout the world under the name of Math Circles in the United States and Eastern Europe, Maths Masterclasses in the UK, circles or clubs in France, et cetera. The programs promote independence and creativity within a supportive community.

Fostering Social Justice—Democratizing Access to Mathematics

In mathematics-related studies and careers, some groups participate at a much lower rate than others. Examples include indigenous communities, students from language backgrounds other than the predominant language of a country, and young people from low socio-economic backgrounds. Engaging these traditionally underrepresented groups in mathematical outreach initiatives can boost their participation in higher education and STEM careers.

The University of California Irvine, Math Community Educational Outreach is an outreach program aimed at underserved youth, with the dual scope of encouraging children to attend college and providing the mathematical and critical thinking skills necessary to succeed. About one hundred middle school students from local disadvantaged communities visit weekly after school to work on original, thought-provoking mathematics in a small group setting together with a team of Irvine faculty and students. The same kids, along with their parents, participate in a STEM-day at Irvine to learn about the fascinating research taking place "just down the road," explore careers in STEM, and get a taste of college life. Additional meetings are hosted at local schools to provide parents with information concerning college opportunities and financial aid for their kids, and because the schools are 98 percent Hispanic, all the communication is provided in both English and Spanish. The San Francisco Math Circle is another example of a program aimed at urban youth. In France, contrary to the United States, the majority of socially disadvantaged families live



At the end of each summer, students present their independent work to the entire PROMYS program.

in the suburbs. The MathC2+ program organizes math camps geared towards these suburban youths.

Addressing Gender Issues

Mathematics remains a predominantly male profession in most countries, and the same is true for many STEM career paths. The adverse effect of gender stereotypes on mathematics performance has been clearly demonstrated. Specific programs have been developed to address gender issues in mathematics, like the "Girls and mathematics, a shining equation" day of events organized in France.

The participation of girls in national and international olympiads is low. To address this problem, specific competitions for girls, like the European Girls' Mathematical Olympiad, have been created. However, gender imbalance remains a great source of preoccupation; perhaps a diversification of the kinds of competitions offered could provide a remedy.

Mathematics Outreach in Developing Countries

By the end of the twenty-first century, it is expected that nearly half of all babies will be born in Africa. The challenge of providing a good STEM education in developing countries is tremendous. For similar reasons as in affluent countries, getting students interested in mathematics cannot wait until they reach college. Some instruments successfully used in affluent countries, such as math circles and clubs, competitions, and mathematics exhibitions, should be fostered in developing countries as well, with help provided by mathematicians and mathematics educators from around the world.

Increasing Mathematical Literacy among Policymakers and Citizens Alike—Tools to Popularize Mathematics

It is recognized that mathematics plays a fundamental role in our society and culture, here considered in the broad sense to include art, literature, and science. Mathematics provides the necessary tools for scientific thought. For example, the impossibility of sustaining exponential growth in a context of limited resources is certainly pertinent to the understanding of the concrete limits of our continued use of fossil fuels. Other examples include an assessment of risk in health or the impact of social decisions.

Tools for popularizing mathematics include websites, classroom materials, films and books about mathematics and mathematical personalities, theatrical performances, public lectures by prominent mathematicians, radio and television programs, and exhibitions at museums and in other public settings. We discuss two films that were shown during the BIRS workshop in more depth here.

The first, a screening of Olivier Peyon's prize-winning 2013 feature documentary *Comment j'ai détesté les maths* (*How I Came to Hate Math*) sets out to display the public's ambivalence to mathematics and goes on to present the importance of the subject to various human activities, particularly finance. Celebrity mathematicians such as Jean-Pierre Bourguignon, Robert Bryant, Jim Simons, and Cédric Villani are summoned at various points of the movie to convey their thoughts on the relevance of mathematics in everyday life and to shed light on the beauty of this field and its role in seeing deeper structures in the world.

Navajo students make a discovery at math camp in *Navajo Math Circles* (2016), a film by George Csicsery, supported by MSRI, Vision Maker Media, and the Simons Foundation.

The second, *Navajo Math Circles*, a one-hour film produced in 2016 by George Csicsery, MSRI, Vision Maker Media, and the Simons Foundation, documents a three-year project that has brought math circles to a number of schools on the Navajo reservation in the southwestern United States. The project and the film seek to show how the mathematics introduced at a Navajo math camp can be combined with cultural components from the indigenous community to enhance mathematics education and, more broadly, education as a whole for underserved populations.

Mathematics-themed films in the public and private television environment face a variety of challenges. The expansion of social media platforms such as Facebook and Twitter favors production of shorter, high-impact video pieces, while long-form documentary delivered over television is becoming much less prominent. The Web, however, does provide space for longer in-depth productions, such as the *Science Lives* biography series embarked upon by the Simons Foundation in 2010, which now hosts over 90 hours of oral histories with mathematicians telling their own stories.

Samples from the International Landscape

The BIRS workshop showcased a rich and varied sampling of outreach initiatives currently being carried out in many countries. There are many commonalities, such as public lectures, mathematics enrichment sessions for school children, competitions, museum exhibits, movies, and theater performances. Without trying to be exhaustive, here are a few brief examples of national outreach activities presented by BIRS workshop attendees.

Australia Mathematical Sciences Institute: The Australia Mathematical Sciences Institute (AMSI) is engaged with the entire mathematics education pipeline: It develops materials for school-grade mathematics, trains teachers, organizes career workshops for university students, places PhD students in industry internships, plans public events

to popularize mathematics, and works directly with mathematicians. Most recently, AMSI has become involved in gender research and has started a successful gender-based outreach project called Choose Maths. The example of AMSI illustrates the advantage of packaging outreach initiatives under a single brand and demonstrates the value of a good fundraising plan backed by research data.

Canada: Canada has a long and rich tradition in outreach, structured by the three Canadian institutes: the Centre de Recherches Mathématiques, the Fields Institute, and the Pacific Institute for Mathematical Sciences. Other organizations include the Canadian Mathematical Society, the Institut des Sciences Mathématiques, and Mitacs. Activities include math camps in all provinces, competitions, two mathematical magazines for schools (*Pi in the Sky* and *Accromath*), theater shows, public lectures and lectures in schools, and First Nations mathematics education.

France: Mathematics outreach in France is in large part coordinated by the Animath Association. It enjoys a growing level of activities and institutional recognition thanks to the Cap'Maths component of the governmental Investing for the Future stimulus plan. High-level research mathematicians participate in the prestigious public lectures "Un texte, un mathématicien," and many others appear at schools around the country. The French Centre National de la Recherche Scientifique and the French Institut National de Recherche en Informatique et en Automatique sponsor the Images des mathématiques and Interstices websites highlighting current research. Specialized mathematics museums and centers in major cities (Lyon), as well as in remote towns (Beaumont, Jeumont), have an increasing regional impact and will further develop with the future creation of a mathematics museum at the Institut Henri Poincaré. Theatrical plays and mathematics and art exhibitions are a significant aspect of mathematical outreach. Several competitions, team or individual (Rallyes Mathématiques, Kangourou, Olympiads, Coupe Animath…), designed for all or for highly talented and motivated students, are organized. The most motivated children can participate in mathematics camps during their vacations. Some of the aforementioned activities are specially geared towards disadvantaged youth living in the suburbs and rural areas, as well as girls.

Germany: In 2008 the German Federal Ministry of Education launched The Year of Mathematics, a very

AMSI supports teachers to deliver well-planned and sequential mathematics programs across an entire school.

A student seminar from the Deutsche Mathematiker-Vereinigung.

successful nationwide communication initiative promoting mathematics outreach in Germany among the mathematical science institutes, schools, and society at large. The Deutsche Mathematiker-Vereinigung multiplied its outreach activities since the Year of Mathematics was developed with the creation of a media office that provides mathematical topics, texts, and pictures to the media, and a network office that awards prizes to the best high school graduates in mathematics and honors volunteers engaged in mathematics activities monthly on its website. The Year of Mathematics boosted participation in traditional mathematics competitions, such as the mathematics Käenguru Competition, the Bundeswettbewerb Mathematik, and Mathematik Olympiade. In addition, the German Mathematical Society started a new online Math Advent competition that offers daily mathematics problems for students in grades 4–9 during the month of December, inspired by the Matheon-Kalender, a similar competition for college students organized yearly by the Research Center MATHEON. Germany's largest mathematics museum, Mathematikum at Gießen, Hessen, has a growing number of visitors each year, and many smaller museums and other science centers have copied the successful format of hands-on exhibits.

United Kingdom: Due to strong collaboration with the Department of Education, the Higher Education Funding Council, and other policymakers, outreach in the UK is highly recognized. In the recent Research Excellence Framework, a full 20 percent of a university accreditation score was based on the university's impact on industry and society. Although there is not one central institute in charge of every aspect of outreach, many of the activities are centrally coordinated and sharing of resources is common, thus facilitating the flourishing of outreach activities across the country. For example, more than fifty Maths Masterclasses for talented students are organized every Saturday by the Royal Institution. Held all across the country, these mathematics enrichment sessions exhibit an interesting mix of lectures and hands-on workshops. The Maths Inspiration program puts on theater shows all over England to attract teenagers to mathematics. The UK Math Trust organizes national competitions for

Cédric Villani at the Fields Medal Symposium Public Lecture for Students and Undergrads 2014.

young mathematics enthusiasts, while the Mathematics Millennium Project, based in Cambridge, promotes several initiatives to increase mathematical understanding, confidence, and enjoyment, including visits to schools and Internet-based resources such as problem listings and a mathematics magazine.

United States: The United States has a decentralized structure for mathematical outreach, with efforts led locally at schools and higher education institutes by the major mathematical organizations, such as the American Mathematical Society, the Mathematical Association of America, the Society for Industrial and Applied Mathematics, and by major mathematics research institutes, such as the Mathematical Sciences Research Institute and the American Institute of Mathematics. Efforts include competitions, exhibits, festivals, math days, math circles, math camps, films, and books. An increasing number of initiatives are aimed at underserved youth. Practitioners share resources informally; over the past decade it has become common for major national mathematics conferences, such as the Joint Math Meetings and MAA MathFest, to have special sessions related to outreach where participants present program information, resources, best practices, and lessons learned. Across higher education institutes, support for outreach activities varies widely. While many are active supporters, some still actively discourage graduate students and faculty from partaking.

Students working together at the Summer Rocky Mountain Math Student's Circle Workshop.

Cooperation can produce a synergistic effect

Current Examples of International Collaboration

Levels of coordination within and across countries vary greatly from one-off small local projects to large annual national and international projects featuring a range of events. In this section we discuss the successful Mathematics of Planet Earth Year in 2013 and the IMAGINARY platform for open and interactive mathematics.

Mathematics of Planet Earth. The Mathematics of Planet Earth (MPE) initiative illustrates a successful international outreach collaboration that models how cooperation can produce a synergistic effect. Using their own resources, a total of 140 partners around the world organized a plethora of scientific and outreach activities. The MPE outreach activities included formal launches of the year, public lectures (including the international Simons Public Lecture Series), special issues of magazines, museum exhibitions, events for teachers, and a Math Awareness Month related to sustainability. Countries and partners contributed resources and new educational material and found creative ways to give a second life to older material. For example, the American Mathematical Society's "Math Moments" (now published twice a year in *Notices*) and the Society of Industrial and Applied Mathematics' "Nuggets" issued special pages to illustrate highlights related to MPE. Finally, several blogs were introduced around the world, including two daily blogs—one in English, one in French—that were both later published as books.

Key to the success of the MPE program was the selection of an inspiring theme of interest to scientists, schools, journalists, and the public alike. The scope of the initiative allowed getting the patronage of UNESCO and the endorsement of the International Council of Science, the International Mathematical Union, and the International Council of Industrial and Applied Mathematics. Another important ingredient of success was the delocalized structure. The MPE coordinator, Christiane Rousseau, from the Centre de Recherches Mathématiques in Montreal, Quebec, Canada, was assisted by several international committees, and the website migrated to a content management system where partners could post their events themselves.

IMAGINARY. Based at the Mathematics Institute at Oberwolfach, Germany, IMAGINARY is probably the most remarkable example of an international platform for open and interactive mathematics. It features a variety of content that can be used at home, in schools, at exhibitions, or in museums. The platform hosts picture galleries,

hands-on exhibits (such as sculptures, puzzles, games, and papercrafts) and films on many mathematical topics for teachers, students, and the public. It includes a variety of visually attractive and highly interactive software modules to explore mathematics in a variety of contexts, from the melting of alpine glaciers to the vibration of a bridge in response to an earthquake. These open-source exhibitions are cheap and readily accessible online. The free software to create algebraic surfaces is used to prepare many exhibits around the world, triggering competitions for the nicest algebraic surfaces. The IMAGINARY platform hosted the website for the international Math for Planet Earth competition, and it is currently hosting the international Open Source MPE Exhibition.

Shared Challenges and Suggested Solutions

The lack of appreciation for mathematics and outreach in society and in our universities makes it hard to secure adequate funding for outreach activities. The relatively small number of professional mathematicians actively involved in outreach increases the burden. Faculty involved in such activities need to be allotted more support and credit.

A further difficulty lies in evaluating the effectiveness of outreach in its various guises. A simple survey after the activity may reveal whether the initiative was a success, but the rarely measured long-term impacts remain difficult to evaluate or quantify. Hence, such long-term impact studies of outreach activities should be both undertaken and shared, and the results used in funding applications or in dealings with policymakers.

Perhaps the most important theme in the workshop was the growing need to address these challenges further by sharing resources and ideas across international boundaries, including those that separate prosperous economies from developing ones. It was also stressed that there is great value in creating online resources, blogs, and newsletters to support communication among those involved in all of these outreach activities.

The community should also work together to encourage more people to do outreach, providing materials, training, and mentoring. Formal training on how to deal with the media would be valuable, especially for mathematicians leading wide outreach initiatives aimed at the general public, the media, or at policymakers.

Students should be considered as partners in the outreach mission. Partially during their studies and certainly after getting their degrees, it is natural for students to take an active part in the creation and dissemination of knowledge. Students can act as multipliers of the faculty's outreach efforts. In addition, students are a great resource for recruiting new people into outreach, since they are naturally perceived as role models by younger audiences. In fact, students often represent more gender, social, and ethnic diversity than faculty do. Training students in outreach is beneficial for instilling confidence and for sharing knowledge with nonmathematicians. Globally, support from departments and individual professors is needed to help students become more involved with outreach so that they can show and develop their passion for mathematics.

Students can act as multipliers of the faculty's outreach efforts

Deepening Connections and Moving Forward—Mathematics Outreach International (MOI)

Sharing a desire to continue efforts started at the workshop, participants decided to launch a new initiative: Mathematics Outreach International (MOI). MOI will support the expansion and enrichment of outreach activities worldwide, especially those aimed at developing countries and traditionally underrepresented groups. MOI will get advice from an international advisory board made up of prominent outreach leaders; launch a website containing resources and links to organizations, groups, and individuals coordinating national and international outreach activities; and contact the International Mathematical Union to explore the possibility of becoming an IMU committee. In addition, MOI will organize workshops and conferences and will propose them as satellite activities of international meetings of mathematical associations. MOI may also undertake other activities, such as the administration of an International Mathematics Outreach blog, a newsletter, or soliciting guidance from its advisory board on how to encourage policymakers to increase resources for mathematical outreach.

To ensure that things get started with a strong foundation, an initial MOI committee has been formed with members Martin Andler (France), Chris Budd (United Kingdom), Jean-Marie De Koninck (Canada), Janine McIntosh (Australia), and Diana White (United States). Eventually, it is hoped that a committee will be constituted on a more formal footing, actively involving the input and strong involvement of international and national mathematical associations, international mathematical research institutes, and the mathematical community at large.

The BIRS International Math Outreach Workshop provided a unique opportunity for a diverse group of outreach experts to come together to share ideas, network, and make plans for more collective efforts in the future. The participants encourage the broader mathematical community to view mathematical outreach as an essential part of its contribution to society and to consider getting involved and becoming more aware of ongoing efforts. They also solicit those in leadership positions to consider how mathematical outreach fits into their unit, as well as how they can promote mathematical outreach more broadly.

Credits

Photo of the International Math Outreach Workshop participants courtesy of the Banff International Research Station.

Photo of the 2013 PIMS Summer Math Camp courtesy of the Pacific Institute for the Mathematical Sciences (PIMS).

Photo of the 2014 seminar courtesy of Jean-Marie De Koninck.

Photo of the student presenter at PROMYS courtesy of Glenn Stevens.
Photo of the Navajo students courtesy of George Csicsery. All Rights Reserved.
Photo of the grammar school classroom courtesy of Janine McIntosh.
Photo of Cédric Villani courtesy of the Fields Institute.
Photo of the Deutsche Mathematiker-Vereinigung seminar courtesy of Kay Herschelmann.
Photo of the Summer Rocky Mountain Math Students' Circle Workshop courtesy of the Rocky Mountain Math Circle Program.

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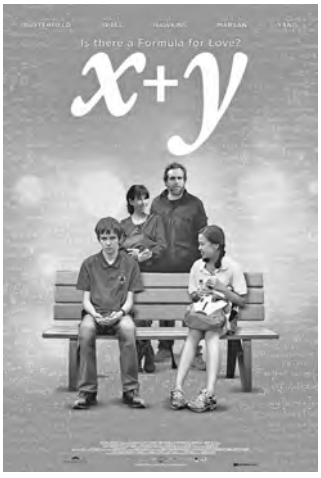
FILM REVIEW



Why Do We Do Mathematics? Thoughts on the Film *A Brilliant Young Mind*

by Mark Saul

A Brilliant Young Mind
(Original title: x + y*)*
2014
Directed by Morgan Matthews

Why do we do mathematics? Usually not because it's useful, although it is useful; and usually not because we can make a living doing it, although many of us can. We do mathematics because we enjoy it and because we are good at it.

The film *A Beautiful Young Mind* explores the meaning of mathematics in our personal lives. It tells the story of Nathan, a young man with Asperger's syndrome, a mild form of autism that causes difficulties in relating to others but is often associated with high mathematical ability. As I see it, the story is about how mathematics saves Nathan's emotional life.

As with many children who have this condition, Nathan quickly finds that he is good in mathematics and enjoys it. Which came first? The film does not answer this question. It is likely that Nathan finds in mathematics an order that he could not find in the world, an order that his mind seeks to impose on the world in ways the rest of us might consider inappropriate. Readers of *The Curious Incident of the Dog in the Night-Time* or the audience of the Tony Award-winning play will remember how the protagonist there, much more deeply afflicted, sought order in ways that the rest of us find preposterous.

Lucky Nathan earns a spot on the British team for the prestigious International Mathematical Olympiad (IMO). Here the story intersects with reality. The IMO is an important part of the international mathematical community. It has helped to kindle interest in mathematics in many countries and has boosted the careers of many significant mathematicians.

The film gives an accurate, but necessarily limited, picture of the IMO. The opening ceremonies are actually much more elaborate than the film would suggest. Problems are significantly more difficult. And the event is much larger in scale. Still, the film gives examples of almost every experience that contestants have at the IMO, from personal contact with other competitors, to personal friction with teammates, to confusion and discovery at being in a new and exotic venue. (The director consulted several mathematicians and former IMO team members, some of whom appear in the film: Geoffrey Smith, Lee Zhou Zhao, Joseph Myers, John Webb, and Andrew Carlotti). The film captures the delightfully ambiguous relationships among team leaders, combining friendly but serious rivalry with a camaraderie born of a common struggle with intractable

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problems. Even for mathematicians without IMO experience, the social aspect of mathematical research will be familiar. It recurs in miniature at the IMO.

Perhaps a more important intersection with reality is how the IMO, both in the film and in life, can contribute towards the personal growth of students like Nathan. I have seen this first-hand: my involvement in the training of Olympiad-level students has brought me in contact with a number who resemble the protagonist. Here are some examples.

Peter (not his real name) was a student I worked with who clearly had trouble relating to others. But in Olympiad training, he came further out of his shell than anyone had ever seen. Holding court among his peers, he related one problem to another, suggested solutions, and even acted as a mentor to students who lacked his exceptional talent. Peter's mathematical ability immediately earned him a status in the group that was undeniable and unassailable and that he didn't have to struggle to earn. Mathematics offered him a bridge to emotional reality, which he crossed with little difficulty. And the joy of Peter's new freedom was written all over his face.

In another case, my colleagues and I couldn't even tell that Jorge had trouble in the Olympiad training program. He was the center of his group, lending it joy and energy, both intellectually and socially. Months later I met him at an international event where he won a medal. His parents had accompanied him—unusual for adolescents—and I wondered why. I recognized him in the midst of a crowd and greeted him enthusiastically. He took my extended hand but wouldn't meet my admiring eye. He barely mumbled a greeting, dropped my hand, and melted into the crowd. I was left wondering…until I met his parents later in the day. They were in fact astonished that I needed an explanation. Jorge suffered severely from Asperger's syndrome. His parents were there because he had great anxiety about traveling, about sleeping away from home, and about living with other students. But I had seen none of this in the preparatory program. Somehow the delight in doing mathematics, and even in doing it with others, overwhelmed the terror that Jorge otherwise found in life.

A Brilliant Young Mind documents a story very much like these. Nathan finds emotion, and even love, at the IMO. In the same way that Peter and Jorge used mathematics as a bridge to reality, Nathan uses it—or life uses it—to connect deeply with people in his life, with people from his past life, and ultimately with himself.

One way of appreciating this story is that it gives a deeper meaning to doing mathematics. Nathan grows in the film. At first he must endure the pain of relating to others in order to be able to work in mathematics. But a twist of events directly related to his participation in the IMO turns his world upside down. Nathan is able to use his experience in working an IMO problem as a tool to relate to others—and most importantly, to himself, to his early years, and to his inner emotional experience. The last scene of the film—viewers will see that it is "touching" in more than one way—shows Nathan experiencing life in a new way.

I suspect that this story can influence us and our field. Anyone reading this review is likely to know at least one colleague with more than average difficulties relating to others. It is likely that their careers could have been given a boost—or maybe have been given a boost—by using mathematics as a therapeutic tool. Perhaps we can create opportunities for young people with this sort of problem to use their mathematical ability to further their emotional growth, a sort of "therapy through mathematics." Then Nathan's story will jump off the screen and into our reality.

Photo Credits

Films and Promotional materials distributed by Samuel Goldwyn Films.

Photo of Mark Saul courtesy of Mark Saul.

ABOUT THE AUTHOR

Mark Saul

Mark Saul is pictured here in front of mathematical models at the mathematics department at the University of Modena. In thirty-five years of teaching, Mark has inspired thousands of mathematically gifted students. He was director of the American Mathematics Competitions at the Mathematical Association of America, of the Courant Institute's Center for Mathematical Talent, and of the Research Science Institute at MIT. He has edited *Quantum*, the Russian/American mathematics and physics journal for high-ability students, and *The Mathematics Teacher*, both for the National Council of Teachers of Mathematics.

AMS Travel Grants for MCA 2017

July 24–28, 2017
in Montreal, Canada

This travel grant program is contingent on receiving funding from the National Science Foundation.

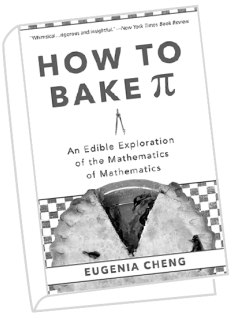
This grant will permit partial travel support for up to 100 U.S. mathematicians attending the Mathematics Congress of the Americas (MCA) that will take place July 24–28, 2017 in Montreal, Canada. The Society is preparing to administer the selection process.

Instructions on how to apply for support will be available in early September on the AMS website at **www.ams.org/programs/travel-grants/mca**. This travel grants program will be administered by the Membership and Programs Department, AMS, 201 Charles Street, Providence, RI 02904–2294.

For questions or more information, contact
Steven Ferrucci at sxf@ams.org,
800-321-4267, ext. 4113 or 401-455-4113.

All information currently available about the MCA 2017 program, organization and registration procedure is located on the MCA 2017 website: **mca2017.org.**

www.MCA2017.org



How to Bake π

A Review by Jeremy L. Martin

How to Bake π: An Edible Exploration of the Mathematics of Mathematics
Eugenia Cheng
Basic Books, 2016 (paperback edition), 304 pages
US$18.33
ISBN: 987-0-465-05171-7

Eugenia Cheng's book *How to Bake π* has an unusual form. Each chapter begins with a short recipe, which the author uses as a springboard to explain something about mathematics. The first part of the book is devoted to broad principles: chapters entitled "Abstraction" and "Generalization" begin with recipes for mayonnaise or hollandaise sauce and olive oil plum cake. In the second part, the author, a working category theorist, sets out to explain her field of research (regarded even by many mathematicians as "abstract nonsense") to a broad audience using analogies to custard and frozen eggs. The approach may sound whimsical, but in fact *How to Bake π* is a success at explaining what mathematics is and how it is done, using simple, appealing language. It should be a rewarding read for mathematicians and nonmathematicians alike.

"If you imagine drawing a circle in the air with a lightsaber, the surface you make is a vector bundle over a circle"

Cheng's language is simple and chatty without being condescending. The book is packed with analogies: in addition to food, we see Lego, train tickets, road signs, the New York Marathon, and welding, among others. Occasionally the chattiness feels slightly forced, but most of the analogies are good and some of them are great, and teachers will find plenty to borrow for their own classrooms (indeed, the book could even serve as a side resource for an undergraduate proof-techniques course). Cheng frequently strips away technical details in order to show the big picture, which is particularly appealing in the book's frequent digressions into specific mathematical content (sometimes marked by gray boxes in the text): topology, Arrow's theorem, fair-division problems, Erdös numbers, the Poincaré Conjecture, the Riemann Hypothesis, and more. These analogies are not just toys: professionals can use the help too. I remember struggling with the formal definition of a vector bundle as a graduate student, and I wish someone had told me that "if you imagine drawing a circle in the air with a lightsaber, the surface you make is a vector bundle over a circle" (p. 175). That makes sense!

The first part of the book is about procedures that we mathematicians have internalized: abstraction, generalization, axiomatization. These are such habitual modes of thought for mathematicians that we take them for granted, yet unfamiliarity with these processes is precisely what makes mathematics look so difficult and inaccessible to many nonmathematicians. So Cheng finds simple, compelling ways to describe abstraction: "blueprints," "tidying away the things you don't need," "simplification," and this great little vignette (p. 20):

> I remember a wonderfully feisty mother at an elementary school I was helping at. She remarked on how frustrating it was when other mothers competitively declared that *their* child could count up to 20 or 30. "My son can count up to three," she said defiantly. "But he knows what three *is*."

Another explanation I particularly like comes from the second part of the book, in the chapter "Structure"—a word that is ubiquitous in mathematical thought and writing but hard to define. Cheng begins with a recipe for baked Alaska (solidly frozen ice cream baked in a meringue shell) and writes: "[Baked Alaska]…is food where the structure is integral to the food…different from a cake in the shape of a dinosaur, where the shape is more or less independent of the taste."

In the last chapter of the first part of the book, "What Mathematics Is," Cheng steps back from mathematics per se and raises the question of how accurately math can model the real world: is life difficult "because we haven't yet made ourselves logically powerful enough to understand it all," or is it the case that "we will never be able to encompass everything by rationality alone, and this is a necessary and beautiful aspect of human existence"? I think this passage is aimed at the lay part of Cheng's audience, but mathematicians will recognize the references to the programs of Hilbert and Russell

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green	red	black	blue
black	green	blue	red

Cheng's book uses a 4-by-4 Battenberg cake as a fanciful way to explain Latin squares, which are arrays of objects in which each object appears exactly once in each row and exactly once in each column.

to formalize and systematize mathematics and then to Gödel's incompleteness theorems.

Cheng's exposition of category theory in the second part of the book is generally excellent. However, I think she frequently overstates its foundational role within mathematics. A lay reader may receive the impression that category theory is responsible for such concepts as equivalence relations (p. 192) and representing a partially ordered set by drawing its covering relations (pp. 202–3). Equivalence relations certainly predate category theory and can be understood without it, and Hasse diagrams are Combinatorics 101. Page 196 features a triangle with vertices labeled "algebra," "geometry," and "logic," and these provocative words: "There's a theory…that all mathematicians are located on some edge of this triangle, [b]ut category theory seems to combine all three of those things." As a geometric combinatorialist, I am pretty sure I am in the interior of that triangle, and experts in algebraic topology or differential equations, among other fields, would surely say the same. Likewise, the excellent chapter "Sameness" explains how the word "same" can have different meanings (characteristically, using vivid analogies: is a toilet brush the same thing as a toothbrush?), but the writing gives the impression that category theory is *necessary* to distinguish between different kinds of sameness. I disagree. Working mathematicians can distinguish between homeomorphism and homotopy equivalence without explicit knowledge of category theory. I don't dispute Cheng's characterization of category theory as "the mathematics of mathematics"; it is just not the only tool that mathematicians use to do what we do.

In the same vein, an early chapter quotes category theory expert John Baez as saying, "But if you don't like abstraction, why in the world are you doing mathematics? Maybe you should be in finance, where the numbers all have dollar signs in front of them." Stripped of context, these lines are combative, if not offensive — how much abstraction must one like in order to qualify as a "real" mathematician, and who gets to decide? I think the author should have included the rest of what Baez wrote: "Indeed, what we often take as 'greater abstraction' is really unfamiliarity. The real answer to the problem of people thinking categories are 'too abstract' is to keep explaining category theory and how it's useful in a wide variety of problems."

These criticisms aside, the book succeeds broadly in its aim of explaining a difficult subject to a wide audience. After all, "mathematics is there to make difficult things easier," writes Cheng (p. 144), and she argues convincingly that category theory can make mathematics easier. I am reminded of a line from Eisenbud and Harris's *The Geometry of Schemes*, another successful exposition of a notoriously difficult and technical subject: "The theory of schemes is widely regarded as a horribly abstract algebraic tool that hides the appeal of geometry to promote an overwhelming and often unnecessary generality. By contrast, experts know that schemes make things simpler."

What about the recipes? I did not try the suggestion (p. 223) of dipping Brussels sprouts in dark chocolate, but the chocolate prune pudding was not bad. Cheng's fruit crisp is very simple: flour, sugar, butter, and fruit. My fruit crisp topping includes pecans and a pinch of salt, and I toss the fruit (peaches or pears) with some cornstarch to add body, and I like to add chopped crystallized ginger. Perhaps it is no surprise that the category theorist's recipe is the more elemental of the two.

Credit

Photo of cake, courtesy of Jeff Cottenden.

ABOUT THE REVIEWER

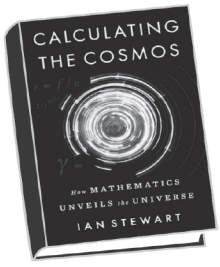
Jeremy Martin is professor at the University of Kansas working in algebraic and geometric combinatorics. He likes both Brussels sprouts and dark chocolate, just not in the same mouthful. And as the photo shows, he bakes a pretty good pi himself.

Jeremy Martin

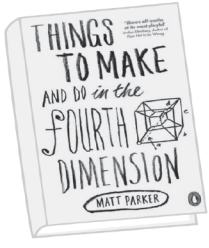
BOOKSHELF

A man is known by the books he reads. —Emerson

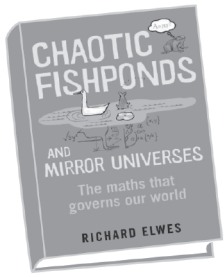
New and Noteworthy Titles on Our BookShelf
October 2016



Calculating the Cosmos: How Mathematics Unveils the Universe, by Ian Stewart (Basic Books, October 2016). Ian Stewart's 217 publications in MathSciNet™ include around eighty books, thirty of which have made him one of the best-known mathematicians on the planet, namely, his popularizations. He has a knack for lucid and elegant prose that exposes the simplicity in mathematical ideas and describes how they arise in science, technology, and everyday life. In his latest book, *Calculating the Cosmos*, Stewart turns his attention to examining the fundamental role mathematics has played in the investigation of astronomical and cosmological phenomena. As he puts it in the book's introduction, "The story of space exploration and the story of mathematics have gone hand in hand from the earliest times." The book begins with the chapter "Attraction at a Distance," which discusses gravity, starting with the ideas of Aristotle, passing to Newton's fundamental insights, and ending with Einstein's general relativity, all the while showing how mathematical advances spurred scientific ones, and vice versa. Stewart brings clarity and conciseness to this oft-told story—the chapter runs just fifteen pages. The other eighteen chapters discuss such topics as the origins of our solar system, planetary orbits, the origins and composition of comets, the composition and evolution of stars, and space exploration.



Things to Make and Do in the Fourth Dimension: A Mathematician's Journey Through Narcissistic Numbers, Optimal Dating Algorithms, at Least Two Kinds of Infinity, and More, by Matt Parker (Penguin, July 2015). Matt Parker has an unusual job title: stand-up mathematician. A stand-up comedian and a mathematician, he has become well known to devotees of the Numberphile videos produced by his fellow Australian, Brady Haran. In the many Numberphile videos in which Parker appears, he brings out the fun side of mathematics, and he does the same in his book *Things to Make and Do in the Fourth Dimension*. While it covers some of the usual topics one might find in a popular mathematics book, such as Platonic solids and Cantor's diagonalization argument, there are plenty of lesser-known topics as well, such as tiling in three dimensions, mathematical card tricks, and the classification of finite simple groups. Parker's objective is not so much to instruct as to encourage readers to take a hand at trying some math problems, and having fun with them.



Chaotic Fishponds and Mirror Universes: The Strange Maths Behind the Modern World, by Richard Elwes (Quercus, paperback, 2016). Originally published in 2013, this book has now come out in a paperback edition. Elwes, a mathematician at the University of Leeds, is the publicity officer of the European Mathematical Society and author of five books popularizing mathematics, including *Maths 1001: Absolutely Everything that Matters in Maths* (2010) and *Maths in 100 Key Breakthroughs* (2013). "Even the most entrenched math-hater has an awareness that it plays a central role in today's world," he writes in the introduction to *Chaotic Fishponds and Mirror Universes*. "But that is where the details are likely to become hazy… yes, important, but where exactly is it used, and in what ways?" This is the question Elwes sets out to answer in the book. He devotes one chapter apiece to thirty-five scientific and technological phenomena—from population growth, to weather prediction, to social networks—and exposes how greatly our understanding of them depends on mathematics. Elwes's own enthusiasm for mathematics and irreverent sense of humor can be seen in a video in which he sings a song he wrote, *The Grothendieck Song*, while accompanying himself on the piano; the link is on his website at `https://richardelwes.co.uk/2015/01/02/the-grothendieck-song/`.

Suggestions for the BookShelf can be sent to `notices-booklist@ams.org`.

We try to feature items of broad interest. Appearance of a book in the *Notices* BookShelf does not represent an endorsement by the *Notices* or by the AMS. For more, visit the AMS Reviews webpage `www.ams.org/news/math-in-the-media/reviews`.

Disruptions of the Academic Math Employment Market

Amy Cohen

Communicated by Steven J. Miller

Note: The opinions expressed here are not necessarily those of Notices. *Responses on the* Notices *webpage are invited.*

The employment structure for PhD mathematicians is undergoing challenging changes, as reported by the Joint Data Committee over the last few years. This article addresses two of these challenges in light of results from the AMS annual survey [1] and from the Conference Board of the Mathematical Sciences [2].

(1) **More Postdocs and Fewer Jobs**. The number of postdocs in mathematics is increasing while the number of academic jobs potentially leading to tenure in doctoral departments of mathematics is stagnating. Therefore, research-focused departments should educate graduate students and postdoctoral fellows for a wider range of career opportunities and responsibilities. Departments with postdocs should record where postdocs find their next—and, if possible, subsequent—employment.

(2) **Recent Hiring Off Tenure Track**. Over half of recent hiring of full-time PhD mathematicians by all US universities and 4-year colleges has been off the tenure track: 811 out of 1,551 for fall 2014 [1a]. The mathematical community should discuss the roles of PhDs in full-time non-tenure-track positions. In particular, an *ad hoc* committee from the AMS and the MAA should discuss, articulate, and disseminate responsible practices. Details will surely vary across various sectors of higher education. Broad awareness of the issues by employers and by job seekers will be at least as important as details of the report.

Data and Discussion Related to (1)

There is currently no systematic tracking of what jobs mathematicians take immediately after completing a postdoc. The main logical possibilities are tenure-track faculty jobs, further postdocs, full-time non-tenure-track faculty jobs, and nonacademic jobs. We are left to make estimates. Assuming 4 percent growth per year, the reported 491 new postdocs in 2013 implies about 450 in 2011, finishing in 2014. Alternatively, dividing the Data Committee's total of 1,398 in 2013 by an average 3-year length (or a bit more than 3 to account for 4 percent growth) also yields about 450, with about 400 in doctoral departments.

Table 1. Recruitment and Hiring 2013–14 to Start Fall 2014 [1a]

Doctoral Math Departments Only			All Math Departments	
Tenure-Track			*Tenure-Track*	
Vacancies posted	Positions filled		Vacancies posted	Positions filled
315	265		885	740
*Full-Time Non-tenure-track**			*Full-Time Non-tenure-track**	
Vacancies posted	Positions filled		Vacancies posted	Positions filled
485	485		856	811
*It is unclear how many postdoc positions are posted as "vacancies."				

At most 265 of those 400 or 450 postdocs got tenure-track jobs in doctoral departments in 2014. Table 1 indicates that fewer did, since some of those tenure-track postings were for department chairs or for distinguished professorships, jobs that rarely go to early-career mathematicians. Some took jobs in Masters or Bachelors departments with high research expectations.

New PhDs are increasingly taking first jobs outside academia (see Table 2). It is reasonable to conjecture that a similar pattern may obtain for postdocs.

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The author gratefully acknowledges astute comments and suggestions from the referees and editors. They helped to improve earlier versions of this article.

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Table 2. Nonacademic employment of new math PhDs reported by survey year [1d]. The table omits PhDs in applied mathematics, statistics, and biostatistics. It also omits those whose status is "not seeking," "still seeking," or "unknown."

Year of survey (at right)	'10–11	'11–12	' 12–13	'13–14
Type of nonacademic employer (below)				
Research institutes & not-for-profit organizations (US)	23	33	26	31
Government agencies (US)	48	32	48	39
Business & industry (US)	98	160	174	184
Non-US nonacademic	14	7	17	15
TOTALS	183	232	265	269
Percentage of all PhDs granted by math departments	16%	20%	22%	22%

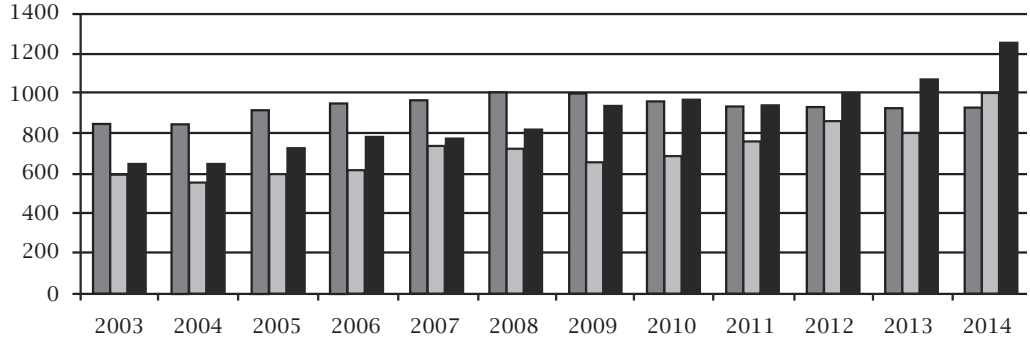


Figure 1. The former plurality of tenure-eligible faculty (mid-grey) among full-time untenured doctoral faculty in doctoral departments has been surpassed by postdocs (black) and others (silver) [1b].

As shown in Figure 1, there are now fewer tenure-eligible faculty than postdocs or full-time doctoral faculty off the tenure track. The decline in tenure-eligible numbers cannot be explained solely by declining enrollments. The tenure-eligible faculty numbers declined with the recession of 2008 and have stagnated since. A similar pattern for tenure-eligible and full-time non-tenure-track faculty holds in departments where a Masters is the highest degree awarded. The situation in departments that award no degree beyond a Bachelors is less stable. The number of postdocs in both Masters and Bachelors departments is small.

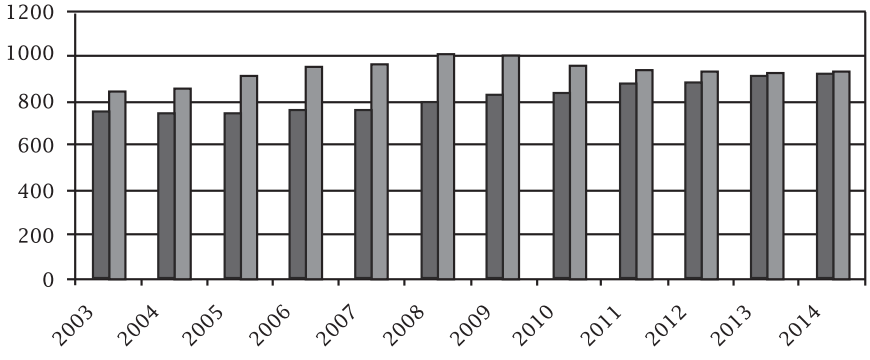


Figure 2. The ratio of tenure-eligible faculty (light grey) in doctoral institutions to thousands of undergraduate mathematics enrollments (dark grey) has been decreasing since 2009 [1b].

As shown in Figure 2, the decline in the number of tenure-eligible faculty in doctoral departments cannot be attributed to a decline in undergraduate enrollments in math courses.

Postdocs obtaining tenure-track jobs will face a range of expectations for communicating mathematics with individuals attracted by applications outside mathematics or with individuals who are not natural mathematics learners. Outside academia, they must communicate with superiors, subordinates, teams from other parts of the organization, clients, and others. People will come to them with concerns that are not clearly expressed in mathematical terms. The mathematician must clarify the problem, tease out the mathematical content, and collaborate to provide a solution that is comprehensible and applicable. Inside academia, they will see students pursuing careers (at Bachelors, Masters, or doctoral levels) outside mathematics, but requiring mathematical preparation. The great power of abstraction is not easily harnessed by nonmathematical thinkers. Mathematics faculty are expected to help students learn how to generalize from examples and how to specialize from general theory. Departments whose graduate and postdoctoral programs have goals beyond placing their students in top-tier research jobs will be able to make a broader case that they are serving the nation's need for a mathematically educated workforce.

Data and Discussion Related to (2)

Why is there such growth in hiring PhD mathematicians for full-time jobs off the tenure track? Many institutional pressures are active. There is increased enrollment at undergraduate levels at and beyond calculus [2]. The teaching loads of research-active mathematicians have declined. Teaching-intensive faculty are needed to meet enrollment pressure not only at entry level but beyond. Enrollment in undergraduate mathematics at sophomore through senior levels may be due to the pursuit of jobs that pay well and the fact that many well-paid jobs are in professions that require math. Deans have also noted that experienced full-time teaching-intensive faculty can generate more tuition revenue per salary dollar. A panel consisting of Sue Geller, Ellen Kirkman, and David Manderscheid [3] at the 2015 Joint Mathematics Meetings reported on the development of "career tracks" for full-time doctoral math faculty off the tenure track.

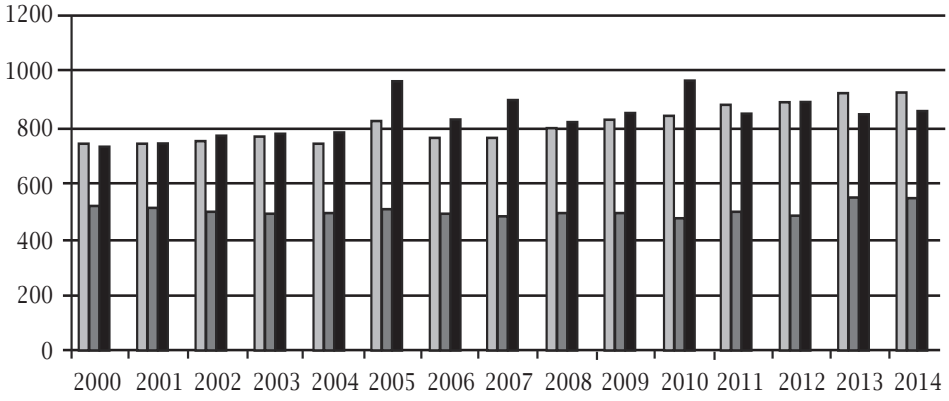


Figure 3. Undergraduate enrollments in mathematics courses, in thousands, by department type: doctoral (silver), Masters (mid-grey), and Bachelors (black) [1b].

Ellen Kirkman serves on the Joint Data Committee and heads the CBMS surveys [2].

Over the last five years, doctoral and Masters departments accounted for just over 60 percent of total undergraduate enrollment in mathematics courses. In 2010–14 undergraduate enrollments in doctoral departments averaged 887,000 compared to 881,000 in Bachelors departments. Currently, 52 percent of tenure-eligible math faculty are at Bachelors institutions, 18 percent at Masters institutions, and 30 percent at doctoral institutions. Within doctoral institutions, 79 percent of tenure-eligible jobs are at public institutions providing broad undergraduate education. Thus, the doctoral and postdoctoral education of mathematicians whose aspirations include tenured academic positions should respect the teaching component as well as the scholarly component of a professorial career [1b]. Graduate students and postdocs with the greatest research potential may have the least opportunity for TA training or other explicit preparation for later teaching. Too great an early focus on research accomplishments may needlessly hinder later professional success. While institutions of higher education often have large remedial enrollments in mathematics, full-time doctoral mathematicians are generally not assigned at or below the level of precalculus [2]. Their mathematical facility may impede insight into what needs explanation and what counts as an explanation.

Postdoctoral education should not focus exclusively on research productivity

As noted in Table 1, hiring of PhD mathematicians for full-time jobs has recently been split almost evenly between tenure-eligible positions and non-tenure-track positions. In doctoral departments, non-tenure-track hiring outnumbers tenure-eligible hiring by almost two-to-one. While postdocs are not on tenure track, data shows that non-tenure-track hiring cannot be explained solely in terms of postdocs.

As reported by Ellen Kirkman [3], all sectors of higher education increasingly employ doctoral mathematicians on "full-time non-tenure-track career ladders." These faculty members take on roles that were formerly the primary responsibility of tenure-track faculty, for example, teaching upper-level undergraduate courses, developing or coordinating multisection courses, and mentoring undergraduate research. Thus, non-tenure-track positions have increased far beyond the traditional postdocs and adjuncts.

If non-tenure-track faculty are to continue to supply high-quality undergraduate instruction, good policies and practices are essential. The "best" graduate students may have had fellowships rather than TA experience. Postdocs carry light teaching loads and often get little mentoring for teaching. Crucial issues related to managing non-tenure-track faculty include (a) mentoring and professional development, (b) advertising vacancies, and (c) granting course reductions for scholarly activity, service, and guiding independent study or undergraduate research.

Conclusions

The health of the mathematical community requires that graduate students and early-career mathematicians see a broad range of paths to respected and satisfying careers, whether inside or outside academia. Regardless of whether we address challenge (1) or (2), postdoctoral education should not focus exclusively on research productivity [1]. The full range of professorial and nonacademic careers requires much more. The AMS should encourage departments to help postdocs prepare for (a) communicating mathematics clearly and engagingly in writing and speaking; (b) refereeing papers, reviewing for MathSciNet, writing proposals for grants, and understanding the review process; and (c) understanding nonacademic as well as academic employment opportunities.

Communicating clearly and engagingly in many venues is crucial for getting jobs and keeping them both in academic and nonacademic settings. In higher education there are seminars and conferences, teaching in classrooms, guiding independent study, directing research, and consulting. In business, industry, and government, mathematicians engage in similar activities, even if not in courses for credit toward a degree. Service to the organization and to professional societies can be expected in both career tracks. Attention to these activities will help the early-career mathematician move ahead productively and provide concrete detail for letters of recommendation. Our colleagues on the President's Council of Advisors on Science and Technology called for more explicit attention to the authentic applications of mathematics and suggested that mathematicians could be beneficially replaced

by scientists and engineers in teaching mathematics to their majors [4].

For mathematics in the United States to flourish, we must stay attractive to students with mathematical talent and retain support from colleagues in science and engineering as well as the American public. To this end, we should enhance the educational and mentoring components of our research postdoc system and articulate responsible practices to prepare early-career doctoral mathematicians for the full range of professional opportunities and expectations both inside and outside academia. As untenured full-time doctoral mathematicians take on an increasing proportion of instruction beyond calculus, we should ensure that these colleagues can pursue their research and other scholarly interests to incorporate new mathematics and new applications into their teaching. We cannot turn back the tides of change, but we can and must cope with them constructively.

Credit

Photo of Claire Gardner, Amy Cohen, Linda Cozad, and Heather Pentifallo, courtesy of Cecilia Arias.

References

[1] www.ams.org/profession/data/annual-survey/ with links noted. [1a] Hiring and Recruitment 2014; [1b] Departmental Profiles; [1c] Starting Salaries, Faculty Salaries, & Private Communications from colleagues where categories are not broken out; [1d] New Doctoral Recipients.

[2] R. Blair, E. Kirkman, and J. Maxwell, *Statistical Abstract of Undergraduate Programs in the Mathematical Sciences in the US*, Conference Board of the Mathematical Sciences, AMS, 2013.

[3] S. Geller, E. Kirkman, and D. Manderscheid, MAA-AMS Panel on Career Tracks for Full-Time Non-tenure-track Faculty. Org. by A. Cohen, D. Manderscheid, and J. Walker, JMM2015

[4] https://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final_feb.pdf

A group problem-solving session at a summer institute for middle school teachers. From left to right: Claire Gardner, Amy Cohen, Linda Cozad, Heather Pentifallo.

ABOUT THE AUTHOR

Amy Cohen (second from left)

Amy Cohen taught in the Berkeley public schools, at Cal State Hayward, and at Cornell before spending forty-three years on the mathematics faculty at Rutgers University before retiring as full professor. She likes people who like to learn.

Mathematics People

Simons Foundation Investigators Named

The Simons Foundation has named seventeen mathematicians, theoretical physicists, and theoretical computer scientists as Simons Investigators for 2016. The Simons Investigators program provides a stable base of support for outstanding scientists, enabling them to undertake long-term study of fundamental questions. The names and institutions of the awardees whose work involves the mathematical sciences and brief excerpts from the prize citations follow.


Vladimir Markovic

VLADIMIR MARKOVIC of the California Institute of Technology has made fundamental contributions to the theory of three-dimensional manifolds, resolving several long-standing problems, among them the proof of the Thurston conjecture concerning immersed almost-geodesic surfaces in closed hyperbolic three-manifolds.


James McKernan

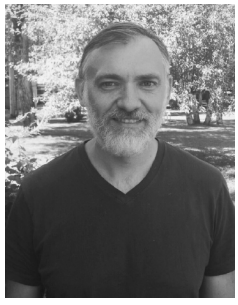
JAMES MCKERNAN of the University of California San Diego, in collaboration with Caucher Birkar, Paolo Cascini, and Christopher D. Hacon, has established one of the cornerstones of the minimal model program: the finite generation of canonical rings in all dimensions.


Bjorn Poonen

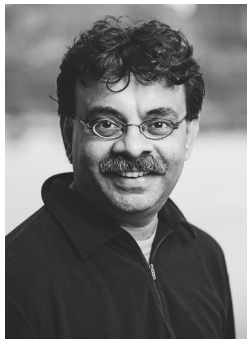
BJORN POONEN of the Massachusetts Institute of Technology has contributed decisively to many areas revolving broadly around the study of Diophantine equations. Among his achievements are the construction of examples of threefolds without rational points but vanishing local and global obstructions, new heuristics concerning rational points on elliptic curves, and results about rational points on curves of higher genus. Outside of mathematics, Poonen serves as the leader of the tenor section of the chorus Musica Sacra, based in Cambridge, Massachusetts.


Mina Aganagic

MINA AGANAGIC of the University of California Berkeley applies insights from quantum physics to mathematical problems in geometry and topology. She has made deep and influential conjectures in enumerative geometry, knot theory, and mirror symmetry using predictions from string theory and from *M*-theory.


Anton Kapustin

The work of ANTON KAPUSTIN of the California Institute of Technology lies at the interface of physics and mathematics. He applied ideas from gauge theory to the study of the geometric Langlands program in mathematics and has applied sophisticated mathematics to the classification of exotic quantum states of matter. Kapustin tells the *Notices*: "I grew up in Moscow while the Soviet Union was still in existence. My father, from whom I have inherited my love for jazz and classical music, is a pianist and a composer, while my mother worked as an interpreter for many years. Nevertheless, they encouraged my interest in physics and math since early age. While in grade school, I enjoyed solving physics problems from the *Kvant* magazine, but the math problems seemed too artificial and remote from the real world. Now I know better."


Madhu Sudan

MADHU SUDAN of Harvard University is known for his work in computational complexity theory. He has made fundamental contributions in the areas of probabilistically checkable proofs, non-approximability of optimization problems, and computational aspects of error-correcting codes. More recently, he initiated the study of universal semantic communication.

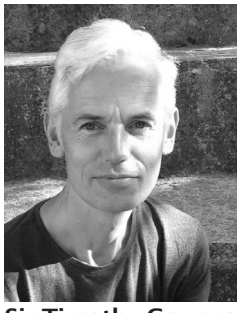

Ingrid Daubechies

INGRID DAUBECHIES of Duke University constructed the first example of what mathematicians

call "wavelets," which have had an immense impact on pure and applied mathematics. She has made and continues to make creative applications of wavelets to a large variety of problems in engineering and other fields.

—From a Simons Foundation announcement

Gowers Awarded Sylvester Medal


Sir Timothy Gowers

Sir Timothy Gowers of the University of Cambridge has been awarded the 2016 Sylvester Medal of the Royal Society of London "for his groundbreaking results in the theory of Banach spaces, pure combinatorics, and additive number theory." The Sylvester Medal is awarded in even-numbered years "for the encouragement of mathematical research." The award carries a cash prize of 1,000 pounds (approximately US$1,300). The prize will be awarded at the Royal Society's Anniversary Day in November 2016.

Gowers tells the AMS: "I have five children, ranging in age from five to twenty-three. I come from a family of musicians and enjoy playing jazz piano."

Gowers is interviewed in the Graduate Student Section (page 1026) and featured on The Back Page (page 1033).

—From a Royal Society announcement

International Mathematical Olympiad


Left to right: Ankan Bhattacharya, Allen Liu, Ashwin Sah, Michael Kural, Yuan Yao, Junyao Peng.

A team from the United States won first place at the fifty-seventh International Mathematical Olympiad (IMO) held in Hong Kong, July 6–16, 2016, finishing with 214 points out of a possible 252.

The members of the US team were:

- Ankan Bhattacharya (International Academy East, Troy, Michigan),
- Michael Kural (Greenwich High School, Greenwich, Connecticut),
- Allen Liu (Penfield Senior High School, Penfield, New York),
- Junyao Peng (Princeton International School of Mathematics and Science, Princeton, New Jersey),
- Ashwin Sah (Jesuit High School, Portland, Oregon),
- Yuan Yao (Phillips Exeter Academy, Exeter, New Hampshire),

all of whom were awarded gold medals for their individual scores. Liu and Yao each earned perfect test scores. Liu also received gold medals in the 2014 and 2015 competitions. The team's leader was Po-Shen Loh of Carnegie Mellon University, interviewed in the September *Notices* Graduate Student Section (p. 905).

Total Points: 252
1. United States — 214
2. Republic of Korea — 207
3. China — 204

The IMO is the world championship mathematics competition for high school students, in which the brightest mathematics students from more than one hundred countries compete. The six US team members were selected through a series of competitions organized by the Mathematical Association of America (MAA), culminating with the USA Mathematical Olympiad. The IMO consists of solving six extremely challenging mathematical problems in a nine-hour competition administered over two days. The 2017 IMO will be held in Rio de Janeiro, Brazil, July 12–24, 2017.

—From an MAA announcement

Scholze Awarded Leibniz Prize


Peter Scholze

Peter Scholze of the University of Bonn has been awarded one of ten 2016 Gottfried Wilhelm Leibniz Prizes by the German Research Foundation (DFG). The prize carries a cash award of 2.5 million euros (approximately US$2,800,000). The prize citation reads: "At twenty-seven, Peter Scholze is the youngest researcher to receive the Leibniz Prize in its more than thirty-year history. Scholze is already considered to be one of the world's leading mathematicians and a rare talent which only emerges every few decades. In recent years he has already answered fundamental

questions in arithmetic algebraic geometry which had remained unsolved for decades. This is especially true of his proof of the so-called Langlands conjecture for p-adic local bodies. His theory of so-called perfectoid spaces has dramatically expanded the spectrum of methods in mathematics. These and other aspects of Scholze's work have been praised as both perspicuous and elegant, and have won him the highest recognition throughout the mathematical community." The Leibniz Prizes aim to improve the working conditions of outstanding researchers and expand the research possibilities open to them, free them from administrative work, and enable them to recruit highly qualified early-career researchers. The prizes were awarded in March 2016.

—From a DFG announcement

Prizes of the London Mathematical Society

The London Mathematical Society (LMS) has awarded a number of prizes for 2016.

The De Morgan Medal was awarded to SIR TIMOTHY GOWERS of the University of Cambridge for his seminal contributions to functional analysis, additive number theory, and combinatorics, as well as for his numerous activities on the national and international mathematical stages.

The Fröhlich Prize was awarded to DOMINIC JOYCE of the University of Oxford for his profound and wide-ranging contributions to differential and algebraic geometry.

The Senior Berwick Prize was awarded jointly to KEISUKE HARA of Mynd, Inc., and MASANORI HINO of the University of Kyoto in recognition of their paper "Fractional order Taylor's series and the neo-classical inequality," *Bulletin of the London Mathematical Society* **42** (2010).

The Anne Bennett Prize was awarded to JULIA WOLF of the University of Bristol in recognition of her outstanding contributions to additive number theory, combinatorics, and harmonic analysis and to the mathematical community.

Whitehead Prizes were awarded to the following individuals:

AREND BAYER of the University of Edinburgh for his breakthroughs in the study of stability conditions on derived categories and their associated moduli spaces and for his pioneering applications of this work to birational geometry.

GUSTAV HOLZEGEL of Imperial College London for his work on the celebrated black hole stability problem in general relativity, especially his pioneering papers on asymptotically (anti) de Sitter black holes.

JASON MILLER of the University of Cambridge for his landmark contributions to the geometric understanding of the two-dimensional free field and its relation to SLE curves.

CAROLA-BIBIANE SCHÖNLIEB of the University of Cambridge for her spectacular contributions to the mathematics of image analysis.

—From an LMS announcement

Prizes Awarded at the ECM

Several prizes were awarded at the Seventh European Congress of Mathematicians, held July 18–22, 2016, in Berlin, Germany. Each of the prizewinners also gave a prize lecture at the Congress.

PATRICE HAURET of Michelin Tires was awarded the Felix Klein Prize. The prize citation reads, "Patrice Hauret's research and teaching in the field of applied mathematics have made extremely useful contributions to industrial needs: He has advanced the modeling and simulation of tires for Michelin. And he has dealt with the interaction of solids with flows (as the air spinning of filaments), and multiscale-approaches, as required, e.g., in the simulation of filters of any kind."

JEREMY GRAY of Open University was awarded the Otto Neugebauer Prize. The citation reads, "Jeremy Gray is one of the (if not the) leading historians of modern mathematics. His highly original, extensive, and deep body of work on nineteenth- and twentieth-century mathematics has greatly advanced our knowledge about this period."

In addition, EMS prizes were awarded to the following individuals:

SARA ZAHEDI, Royal Institute of Technology, Sweden, "for her outstanding research regarding the development and analysis of numerical algorithms for partial differential equations with a focus on applications to problems with dynamically changing geometry."

MARK BRAVERMAN, Princeton University, "for his important contributions to several fields at the interface of mathematics and computer science with answers to many basic questions on the computability of objects that arise in dynamical systems, on computing of Riemann mappings and a remarkable solution of the Linial-Nisan conjecture."

VINCENT CALVEZ, Ecole Normale Supérieure de Lyon, "for his pioneering work at the intersection between mathematics and biology with fundamental contributions to mathematical analysis and development of new mathematical models with applications in biology and biophysics."

GUIDO DE PHILIPPIS, SISSA Trieste, Italy, "for his outstanding contributions to the regularity of solutions of Monge-Ampére equation and optimal maps and for his deep work on quantitative stability inequalities for the first eigenvalue of the Laplacian and rigidity in some isoperimetric type inequalities."

PETER SCHOLZE, University of Bonn, "for his original and groundbreaking contributions at the interface of arithmetic algebraic geometry and the theory of automorphic forms, for example, with his new proof of the local Langlands conjecture for p-adic local fields and his theory of perfectoid spaces."

PÉTER VARJÚ, University of Cambridge, "for his deep work on arithmetic combinatorics and its applications to spectral gap estimates and equidistribution, including a solution to a long-standing problem regarding equidistribution of random walks on the isometry group of Euclidean spaces, his contribution to the study of spectral gap on quotients of arithmetic groups, self similar sets and measures."

THOMAS WILLWACHER, ETH Zurich, "for his striking and important research in a variety of mathematical fields: homotopical algebra, geometry, topology and mathematical physics, including deep results related to Kontsevich's formality theorem and the relation between Kontsevich's graph complex and the Grothendieck-Teichmüller Lie algebra."

JAMES MAYNARD, Oxford University, "for his remarkable and deep results in number theory, mainly dealing with nontrivial aspects of the theory of primes and in particular his original and new proof and improved estimate of the famous, so called, 'small gaps between primes theorem.'"

HUGO DUMINIL-COPIN, Institut des Hautes Études Scientifiques, "for his outstanding research in statistical physics, in particular on critical phenomena for models in dimensions below the critical one, including Fortuin-Kasteleyn percolation, Ising and Potts models, self-avoiding walks and to harmonic analysis in disordered media."

GEORDIE WILLIAMSON, Max Planck Institute for Mathematics, "for his fundamental contributions to representation theory of Lie algebras and algebraic groups, for example, with the elegant proof of Soergel's conjecture on bimodules associated to Coxeter groups and the counter-examples to expected bounds in Lusztig's conjectured character for rational representations of algebraic groups."

—From an ECM announcement

2016 SIAM Prizes

The Society for Industrial and Applied Mathematics (SIAM) has awarded several prizes for 2016.

The John von Neumann Lectureship has been awarded to DONALD KNUTH of Stanford University. The lectureship is awarded for outstanding and distinguished contributions to the field of applied mathematical sciences and for the effective communication of these ideas to the community.

The Richard C. DiPrima Prize was awarded to BLAKE H. BARKER of Brown University. The prize is given to an early career researcher who has done outstanding research in applied mathematics.

The Prize for Distinguished Service to the Profession was awarded to LINDA PETZOLD of the University of California Santa Barbara. The prize is awarded to an applied mathematician who has made distinguished contributions to the furtherance of applied mathematics on the national level.

The George Pólya Prize in Combinatorics was awarded to JOZSEF BALOGH, University of Illinois, Urbana-Champaign; ROBERT MORRIS, IMPA; WOJCIECH SAMOTIJ, Tel Aviv University; DAVID SAXTON, University of Cambridge; and ANDREW THOMASON, DPMMS, Cambridge University. The prize is given every four years for a notable application of combinatorial theory.

The W. T. and Idalia Reid Prize in Mathematics was awarded to IOANNIS G. KEVREKIDIS of Princeton University. The prize is given for research in or other contributions to the broadly defined areas of differential equations and control theory.

The I. E. Block Community Lectureship was awarded to TADASHI TOKIEDA of the University of Chicago. The lecture is intended to encourage public appreciation of the excitement and vitality of science.

The Award in the Mathematical Contest in Modeling was given to Southwest Jiaotong University and Wuhan University, both in China. It is awarded to two of the teams judged "Outstanding" in the Mathematical Contest in Modeling (MCM).

The Outstanding Paper Prizes are given for outstanding papers published in SIAM journals. The 2016 prizes were awarded to the following individuals:

• BOAZ BARAK, MARK BRAVERMAN, XI CHEN, and ANUP RAO for their paper "How to compress interactive communication," *SIAM Journal on Computing* **42** (2013).

• NICOLA MASTRONARDI and PAUL VAN DOOREN for their paper "The antitriangular factorization of symmetric matrices," *SIAM Journal on Matrix Analysis and Applications* **34** (2013).

• XIAOCHUAN TIAN and QIANG DU for their paper "Analysis and comparison of different approximations to nonlocal diffusion and linear peridynamic equations," *SIAM Journal on Numerical Analysis* **51** (2013).

The SIAM Student Paper Prizes are given to the most outstanding papers submitted to the SIAM student paper competition. The 2016 prizes were awarded to the following individuals:

• MARIO BERLJAFA, University of Manchester, for the paper "Generalized rational Krylov decompositions with an application to rational approximation."

• NATALIE STANLEY, University of North Carolina at Chapel Hill, for the paper "Clustering network layers with the strata multilayer stochastic block model."

• FATMA TERZIOGLU, Texas A&M University, for the paper "Some inversion formulas for the cone transform."

—From SIAM announcements

Jim Douglas Jr.

Jim Douglas Jr.

Jim Douglas Jr., the Compere and Marcella Loveless Distinguished Professor Emeritus of Computational Mathematics at Purdue University, died on April 27, 2016, after a brief illness.

After earning a PhD in mathematics from Rice University, Jim began his career at Humble Oil,

which later became part of ExxonMobil. Together with Henry Rachford and Don Peaceman, Jim developed the alternating-direction implicit method for solving finite-difference approximations to certain partial differential equations. This work inspired a great deal of further research and continues to find new applications in modern-day convex optimization and data analysis problems. Jim returned to Rice as a faculty member in 1957 and was eventually named the W. L. Moody Professor. He moved to the University of Chicago in 1967, where he turned his attention to the mathematical understanding of the finite element method for partial differential equations. In 1987, Jim was appointed Director of the Center for Applied Mathematics and named the Compere and Marcella Loveless Distinguished Professor of Computational Mathematics at Purdue.

During his distinguished career, Jim wrote more than two hundred papers with more than seventy coauthors. He was a Fellow of both SIAM and AMS and was the recipient of the Cedric K. Ferguson Medal from the Society of Petroleum Engineers, the Robert Earll McConnell Award from the American Institute of Mining, Metallurgical, and Petroleum Engineers, and a Commemorative Medal from Charles University, Prague.

Jim was a dedicated mentor to dozens of students and postdocs, many of whom became leaders in computational science.

—Gregery T. Buzzard
Purdue University

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Photo of the US IMO team courtesy of MAA announcement.

Mathematics Opportunities

Call for Proposals for the 2018 AMS Short Courses

The AMS Short Course Subcommittee invites submissions of preliminary proposals for Short Courses on fields of application of mathematics, to be given at the 2018 Joint Mathematics Meetings. Members are also invited to submit names of colleagues who they think would conduct an inspiring short course. A Short Course consists of a coherent sequence of survey lectures and discussions on a single theme. A Short Course ordinarily extends over a period of two days immediately preceding the Joint Mathematics Meetings held in January. Usually there are about six different lecturers, and it is anticipated that the proceedings of the Short Course will be published in the series *Proceedings of Symposia in Applied Mathematics*.

Preliminary proposals may be as short as one page. After reviewing the preliminary proposals, the Subcommittee may ask for more details from some of the proposers. Proposals should be sent via e-mail to Associate Executive Director (aed-mps@ams.org) with a cc to Robin Hagan Aguiar (rha@ams.org). For full consideration for the 2018 Short Courses, proposals should be submitted by **December 19, 2016**.

—AMS Associate Executive Director

**The most up-to-date listing of NSF funding opportunities from the Division of Mathematical Sciences can be found online at:* www.nsf.gov/dms *and for the Directorate of Education and Human Resources at* www.nsf.gov/dir/index.jsp?org=ehr. *To receive periodic updates, subscribe to the DMSNEWS listserv by following the directions at* www.nsf.gov/mps/dms/about.jsp.

*NSF Project ADVANCE

The goal of the National Science Foundation's (NSF) ADVANCE program is to increase the representation and advancement of women in academic science and engineering careers, thereby contributing to the development of a more diverse science and engineering workforce. ADVANCE encourages institutions of higher education and the broader science, technology, engineering, and mathematics (STEM) community, including professional societies and other STEM-related not-for-profit organizations, to address various aspects of STEM academic culture and institutional structure that may differentially affect women faculty and academic administrators. Since 2001, the NSF has invested over US$130 million to support ADVANCE projects at more than one hundred institutions and organizations in forty-one states, the District of Columbia, and Puerto Rico. Additional information about ADVANCE programs, as well as application deadlines, can be found at www.nsf.gov/funding/pgm_summ.jsp?pims_id=5383&org=DMS&sel_org=DMS&from=fund.

—From an NSF announcement

*NSF Conferences and Workshops in the Mathematical Sciences

The National Science Foundation (NSF) supports conferences, workshops, and related events (including seasonal schools and international travel by groups). Proposals for such activities may request funding of any amount

and for durations of up to three years. Proposals may be submitted only by universities and colleges and by nonprofit nonacademic institutions. For full information, including deadlines for each disciplinary program, see the web page http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=11701&org=DMS&sel_org=DMS&from=fund.

—From an NSF announcement

News from IPAM

The Institute for Pure and Applied Mathematics (IPAM) is a National Science Foundation (NSF) mathematics institute located at the University of California Los Angeles. IPAM holds long programs (three months) and workshops (three to five days) throughout the academic year for junior and senior mathematicians and scientists who work in academia, research laboratories, and industry. In the summer, IPAM offers an industrial research experience for undergraduates and a summer school for graduate students and postdocs.

IPAM seeks program proposals from the math and science communities. Please send your idea for a workshop, long program, or summer school to `director@ipam.ucla.edu`.

IPAM's upcoming programs are listed below. We accept applications for funding for workshops and long programs. You may register and attend a workshop without IPAM support as well. Please go to `www.ipam.ucla.edu` for detailed information on each program, and to find application and registration forms.

The current long program is **Understanding Many-Particle Systems with Machine Learning**. The three remaining workshops in the program are listed below. You may register online, and the application for Workshop IV is open through **October 10, 2016**.

October 24–28, 2016: Workshop II: Collective Variables in Classical Mechanics.

November 14–18, 2016: Workshop III: Collective Variables in Quantum Mechanics.

December 5–9, 2016: Workshop IV: Synergies between Machine Learning and Physical Models.

2017 Winter Workshops. You may apply for support or register for each workshop online.

January 9–13, 2017: Turbulent Dissipation, Mixing and Predictability.

January 23–27, 2017: Beam Dynamics.

January 30–February 3, 2017: Big Data Meets Computation.

February 6–10, 2017: Emerging Wireless Networks.

February 27–March 2, 2017: Regulatory and Epigenetic Stochasticity in Development and Disease.

March 6–10, 2017: Gauge Theory and Categorification.

March 20–June 9, 2017: **Computational Issues in Oil Field Applications**. This long program is still accepting applications for full or partial participation. You may also register or apply for funding to attend a workshop.

March 21–24, 2017: Computational Issues in Oil Field Applications Tutorials.

April 3–7, 2017: Workshop I: Multiphysics, Multiscale, and Coupled Problems in Subsurface Physics.

May 1–5, 2017: Workshop II: Full Waveform Inversion and Velocity Analysis.

May 22–26, 2017: Workshop III: Data Assimilation, Uncertainty Reduction, and Optimization for Subsurface Flow.

Undergraduate students may apply for our **Research in Industrial Projects for Students (RIPS)** summer program, featuring "real world" problems proposed by companies such as Google, AMD, and the Aerospace Corporation. The website and application form will be posted in November. Applications are due **February 13, 2017**.

The 2017–2018 long programs will be "Complex High-Dimensional Energy Landscapes" (fall) and "Quantitative Linear Algebra" (spring). More information on these programs, including a schedule of workshops and application and registration forms, are available online.

—IPAM announcement

Mathematical Sciences Research Institute Berkeley, CA

MSRI invites applications for Research Members and Postdoctoral Fellows in the following programs:
Geometric Functional Analysis and Applications (August 14–December 15, 2017),
Geometric and Topological Combinatorics (August 14–December 15, 2017),
Group Representation Theory and Applications (January 16–May 25, 2018),
Enumerative Geometry Beyond Numbers (January 16– May 25, 2018).
Research Memberships are intended for researchers who will be making contributions to a program and who will be in residence for one or more months. Postdoctoral Fellowships are intended for recent PhDs.

MSRI uses MathJobs.Org to process applications. Interested candidates must apply online beginning August 1, 2016. To receive full consideration, applications must be complete, including all letters of support, by **December 1, 2016**. Application information can be found at `www.msri.org/application`.

It is the policy of MSRI actively to seek to achieve diversity in its programs and workshops. Thus, a strong effort is made to remove barriers that hinder equal opportunity, particularly for those groups that have been historically underrepresented in the mathematical sciences.

Programs [are] funded by the National Science Foundation.

—MSRI announcement

Inside the AMS

AMS Congressional Fellow Named

Catherine Paolucci

Catherine Paolucci of the State University of New York (SUNY) at New Paltz has been awarded the 2016–2017 AMS Congressional Fellowship. She is a member of both the Department of Mathematics and the Department of Teaching and Learning and serves as the secondary mathematics education coordinator.

Her research is primarily in mathematics teacher education, although she has recently been investigating ways to enhance mathematical learning for students at all levels using 3-D design and 3-D printing. The development of the International Mathematics Enrichment Project (IMEP), which offers future teachers an opportunity to provide mathematics enrichment for children in South Africa, also reflects her commitment to developing innovative programs that increase access to STEM education for all learners.

Paolucci has served on the standard-setting committee for New York State's Mathematics Content Specialty Test for teacher certification and has led university policy revisions regarding the mathematical content studied by future teachers. Additionally, she led the development of Ireland's first specialized undergraduate degree program in mathematics education at the National University of Ireland, Galway.

The Congressional Fellowship program is administered by the American Association for the Advancement of Science (AAAS) and provides an opportunity for scientists and engineers to learn about federal policy making while contributing their knowledge and analytical skills to the process. Fellows spend a year working on the staff of a member of Congress or a congressional committee, working as a special legislative assistant in legislative and policy areas requiring scientific and technical input. The Fellowship program includes an orientation on congressional and executive branch operations and a year-long professional development program.

The Fellowship is designed to provide a unique public policy learning experience to demonstrate the value of science-government interaction and to bring a technical background and external perspective to the decision-making process in Congress.

For more information on the AMS-AAAS Congressional Fellowship, go to `bit.ly/AMSCongressionalFellowship`.

—AMS Washington Office

From the AMS Public Awareness Office

AMS Pledges Support of arXiv. The AMS is pleased to be the first professional society and publisher to become a supporter of the arXiv. The Society's five-year pledge, announced in July, recognizes the value of this open-access digital repository of scientific research for authors and researchers worldwide. Donald E. McClure, then AMS Executive Director, said, "The AMS donation is a tangible expression of the Society's admiration for the value the arXiv represents to the mathematics research community. It is a great resource for the open and rapid dissemination of research." Mathematical sciences were added to the arXiv in 1997 to facilitate growth in areas of mathematics not covered at the time. Since then `arXiv.org` has become very important for the mathematics community, and the cooperation between the arXiv and the AMS, especially MathSciNet™, continues to grow. The Society's pledge signifies its commitment to ensuring the continued success of this scholarly communication forum that is free to all end-users and to the individual researchers who deposit their content in the arXiv.

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

Photo Credit

Photo of Catherine Paolucci is courtesy of the Paolucci family.

MATHEMATICS CALENDAR

This section contains new announcements of worldwide meetings and conferences of interest to 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. New announcements only are published in the print Mathematics Calendar featured in each *Notices* issue.

An announcement will be published in the *Notices* if it contains a call for papers and specifies the place, date, subject (when applicable). A second announcement will be published only if there are changes or necessary additional information. Asterisks (*) mark those announcements containing revised information.

In general, print announcements of meetings and conferences carry only the date, title and location of the event.

The complete listing of the Mathematics Calendar is available at: www.ams.org/meetings/calendar/mathcal

All submissions to the Mathematics Calendar should be done online via: www.ams.org/cgi-bin/mathcal/mathcal-submit.pl

Any questions or difficulties may be directed to mathcal@ams.org.

September 2016

29 – 30 **1st Croatian Combinatorial Conference**
Location: *University of Zagreb, Zagreb, Croatia.*
URL: www.grad.hr/crocodays/index.html

October 2016

3 – 7 **Probabilistic Methods in Dynamical Systems and Applications**
Location: *Centre de recherches mathématiques Université de Montréal Pavillon André-Aisenstadt 2920, Chemin de la tour, 5th floor Montréal (Québec) Canada.*
URL: www.crm.umontreal.ca/2016/Methods16/index_e.php

11 – 14 **14th RECOMB Comparative Genomics Satellite Workshop**
Location: *Hotel de l'Institut de tourisme et d'hotellerie du Québec* www.ithq.qc.ca/hotel *3535 St-Denis St. Montréal (Québec).*
URL: www.crm.umontreal.ca/2016/Genomics16/index_e.php

14 – 16 **1st Northeastern Analysis Meeting**
Location: *College at Brockport, State University of New York, Brockport, NY 14420.*
URL: https://www.brockport.edu/academics/conferences/northeastern_analysis/

14 – 16 **2016 Paul J. Sally Jr. Midwest Representation Theory Conference**
Location: *University of Iowa, Iowa City.*
URL: homepage.divms.uiowa.edu/~mkrishna/2016MRTC-WEB/index.html

17 – 21 **Conference on 4-Manifolds and Knot Concordance**
Location: *Max Planck Institute for Mathematics, Bonn, Germany.*
URL: people.brandeis.edu/~aruray/4manifoldsconference

25 – 27 **International Conference on Modelling, Computing and Technological Innovations (ICMCTI-2016)**
Location: *University Institute of Technology, The University of Burdwan, Golpabag (North), Burdwan-713104, West Bengal, India.*
URL: uit.buruniv.ac.in/notifications_files/First%20Announcement%20of%20ICMCTI%202016.pdf

27 – 28 **Ahlfors Lectures 2016, Andrei Okounkov (Columbia University)**
Location: *Harvard University Science Center Cambridge, MA.*
URL: math.harvard.edu/conferences/ahlfors16

November 2016

4 – 6 **56th Meeting of the Texas Geometry and Topology Conference**
Location: *Texas A&M University, College Station, TX, USA.*
URL: www.math.tamu.edu/conferences/tgtc

6 – 11 **The 20th Midrasha Mathematicae—60 Faces to Groups**
Location: *Hebrew University, Jerusalem, Israel.*
URL: www.as.huji.ac.il/schools/math20

12 – 12 **The Seventh Dr. George Bachman Memorial Conference**
Location: *St. John's University, 8000 Utopia Parkway, Jamaica, NY 11439, USA.*

December 2016

8 – 10 **International Conference on "Recent Advances in Mathematical Sciences and its Applications (RAMSA-2016)"**
Location: *Jaypee Institute of Information Technology, Noida A/10, Sector-62, Noida-201307, India.*
URL: www.ramsa2k16.co.in/Maths%20Conference/home.php

12 – 16 **Australasian Conference on Combinatorial Mathematics and Combinatorial Computing**
Location: *The University of Newcastle, Newcastle, Australia.*
URL: https://40accmcc.newcastle.edu.au

14 – 23 **Interactions Between Topological Recursion, Modularity, Quantum Invariants and Low-Dimensional Topology**
Location: *MATRIX, University of Melbourne, Creswick, Australia.*
URL: www.matrix-inst.org.au/events/interactions-between-topological-recursion-modularity-quantum-invariants-and-low-dimensional-topology

March 2017

13 – 17 **SLE, GFF and LQG in NYC**
Location: *Columbia University, New York, NY.*
URL: sites.google.com/site/slegfflqg17

May 2017

10 – 12 **5th International Conference on Mathematics and Engineering**
Location: *Yildiz Technical University, Istanbul, Turkey.*
URL: www.yildiz.edu.tr

June 2017

19 – 21 **2nd IMA Conference on Nonlinearity and Coherent Structures**
Location: *University of East Anglia, Norwich, UK.*
URL: ima.org.uk/conferences/conferences_calendar/2nd-ima-conference-nonlinearity-coherent-structures.html

July 2017

10 – 12 **SIAM Conference on Control and Its Applications (CT17)**
Location: *David Lawrence Convention Center (DLCC) Pittsburgh, PA, USA.*
URL: www.siam.org/meetings/ct17

12 – 22 **CIMPA Research School on Noncommutative Geometry and Applications to Quantum Physics**
Location: *International Center of Interdisciplinary Science Education (ICISE) in Quy Nhon, Vietnam.*
URL: ncg2017.cpt.univ-mrs.fr/index.php

24 – August 4 **Summer Graduate School: Automorphic Forms and the Langlands Program**
Location: *Mathematical Sciences Research Institute, Berkeley, CA.*
URL: www.msri.org/summer_schools/792

July 2018

16 – 20 **International Conference on Formal Power Series and Algebraic Combinatorics (FPSAC 2018)**
Location: *Dartmouth College, Hanover, NH, USA.*
URL: fpsac.org/

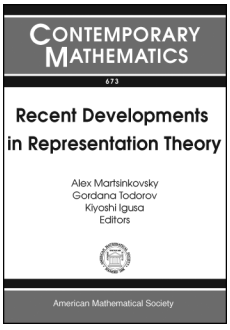
August 2018

13 – December 14 **Hamiltonian Systems, from Topology to Applications Through Analysis**
Location: *Mathematical Sciences Research Institute, Berkeley, CA.*
URL: www.msri.org/programs/305

New Publications Offered by the AMS

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

Algebra and Algebraic Geometry



Recent Developments in Representation Theory

Alex Martsinkovsky, *Northeastern University, Boston, MA*, **Gordana Todorov**, *Northeastern University, Boston, MA*, and **Kiyoshi Igusa**, *Brandeis University, Waltham, MA*, Editors

This volume contains selected expository lectures delivered at the Maurice Auslander Distinguished Lectures and International Conference, held May 1–6, 2014, at the Woods Hole Oceanographic Institute, Woods Hole, MA.

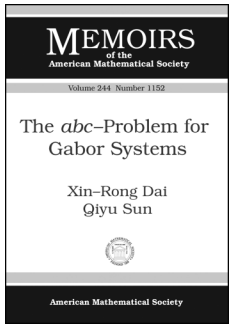
Several significant developments of the last decade in representation theory of finite-dimensional algebras are related to combinatorics. Three of the five lectures in this volume deal, respectively, with the Catalan combinatorics, the combinatorics of Gelfand-Zetlin polytopes, and the combinatorics of tilting modules. The remaining papers present history and recent advances in the study of left orders in left Artinian rings and a survey on invariant theory of Artin-Schelter regular algebras.

Contents: V. V. Bavula, Orders in Artinian rings, Goldie's Theorem, and the largest left quotient ring of a ring; **E. E. Kirkman**, Invariant theory of Artin-Schelter regular algebras: a survey; **C. M. Ringel**, The Catalan combinatorics of the hereditary artin algebras; **E. Smirnov**, Grassmannians, flag varieties, and Gelfand-Zetlin polytopes; **L. Unger**, On the combinatorics of the set of tilting modules.

Contemporary Mathematics, Volume 673

September 2016, 249 pages, Softcover, ISBN: 978-1-4704-1955-4, LC 2016001389, 2010 *Mathematics Subject Classification:* 16G10, 16G20, 16G70, 16T05, 14N15, **AMS members US$86.40**, List US$108, Order code CONM/673

Analysis



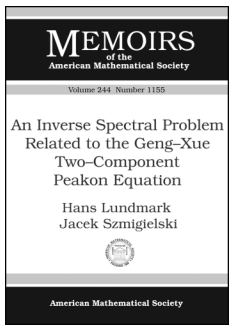
The *abc*-Problem for Gabor Systems

Xin-Rong Dai, *Sun Yat-sen University, Guangzhou, China*, and **Qiyu Sun**, *University of Central Florida, Orlando, Florida*

Contents: Introduction; Gabor frames and infinite matrices; Maximal invariant sets; Piecewise linear transformations; Maximal invariant sets with irrational time Shifts; Maximal invariant sets with rational time shifts; The *abc*-problem for Gabor systems; Appendix A. Algorithm; Appendix B. Uniform sampling of signals in a shift-invariant space; Bibliography.

Memoirs of the American Mathematical Society, Volume 244, Number 1152

October 2016, 99 pages, Softcover, ISBN: 978-1-4704-2015-4, LC 2016031123, 2010 *Mathematics Subject Classification:* 42C15, 42C40; 37A05, 94A20, **Individual member US$47.40**, List US$79, Institutional member US$63.20, Order code MEMO/244/1152



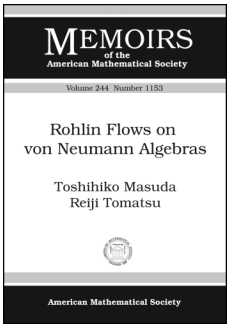
An Inverse Spectral Problem Related to the Geng–Xue Two-Component Peakon Equation

Hans Lundmark, *Linköping University, Sweden*, and **Jacek Szmigielski**, *University of Saskatchewan, Saskatoon, Canada*

Contents: Introduction; Forward spectral problem; The discrete case; The inverse spectral problem; Concluding remarks; Appendix A. Cauchy biorthogonal polynomials; Appendix B. The forward spectral problem on the real line; Appendix C. Guide to notation; Bibliography.

Memoirs of the American Mathematical Society, Volume 244, Number 1155

October 2016, 87 pages, Softcover, ISBN: 978-1-4704-2026-0, 2010 *Mathematics Subject Classification:* 34A55, **Individual member US$47.40**, List US$79, Institutional member US$63.20, Order code MEMO/244/1155



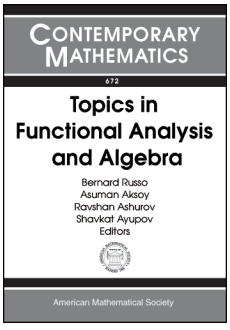
Rohlin Flows on von Neumann Algebras

Toshihiko Masuda, *Kyushu University, Fukuoka, Japan*, and **Reiji Tomatsu**, *Hokkaido University, Japan*

Contents: Introduction; Preliminary; Flows on ultraproduct von Neumann algebras; Rohlin flows; Classification of Rohlin flows; Applications; Characterization of Rohlin property; Concluding remarks and problems; Appendix; Bibliography; Index.

Memoirs of the American Mathematical Society, Volume 244, Number 1153

October 2016, 111 pages, Softcover, ISBN: 978-1-4704-2016-1, LC 2016031075, 2010 *Mathematics Subject Classification:* 46L40; 46L55, **Individual member US$49.80**, List US$83, Institutional member US$66.40, Order code MEMO/244/1153



Topics in Functional Analysis and Algebra

Bernard Russo, *University of California, Irvine, CA*, **Asuman Güven Aksoy**, *Clarmont-McKenna College, Claremont, CA*, **Ravshan Ashurov**, *National University of Uzbekistan, Tashkent, Uzbekistan*, and **Shavkat Ayupov**, *National University of Uzbekistan, Tashkent, Uzbekistan*, Editors

The USA-Uzbekistan Conference on Analysis and Mathematical Physics, focusing on contemporary issues in dynamical systems, mathematical physics, operator algebras, and several complex variables, was hosted by California State University, Fullerton, from May 20–23, 2014. The main objective of the conference was to facilitate scientific communication and collaboration between mathematicians from the USA and Uzbekistan.

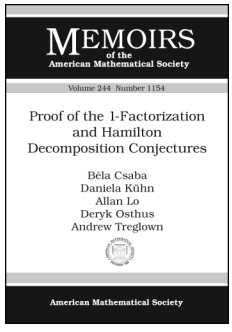
This volume contains the proceedings of the Special Session on Algebra and Functional Analysis. The theory of operator algebras is the unified theme for many papers in this volume. Out of four extensive survey papers, two cover problems related to derivation of various algebras of functions. The other two surveys are on classification of Leibniz algebras and on evolution algebras. The sixteen research articles are devoted to certain analytic topics, such as minimal projections with respect to numerical radius, functional equations and discontinuous polynomials, Fourier inversion for distributions, Schrödinger operators, convexity and dynamical systems.

Contents: R. Abdullaev, Tracial and Arens algebras associated with finite von Neumann algebras; **J. M. Almira** and **Z. Boros**, A dichotomy property for the graphs of monomials; **A. G. Aksoy** and **G. Lewicki**, Characterization conditions and the numerical index; **R. Ashurov** and **A. Butaev**, On generalized localization of Fourier inversion for distributions; **S. Ayupov** and **K. Kudaybergenov**, Derivations, loal and 2-local derivations on algebras of measurable operators; **S. Ayupov**, **K. Kudaybergenov**, and **A. M. Peralta**, A survey on local and 2-local derivations on C^*- and von Neumann algebras; **C.-H. Chu** and **B. Russo**, Cohomology of Jordan triples via Lie algebras; **G. Djabbarov**, Extreme boundary of the space semi-additive functionals on the three-point set; **N. Ganikhodjaev**, Algebras with genetic realization and corresponding evolutionary population dynamics; **R. N. Ganikhodzhaev** and **A. T. Pirnapasov**, Quadratic homeomorhpisms of the two-dimensional simplex and their trajectories; **A. A. Katz** and **O. Friedman**, On universal representations and universal enveloping locally C^*-algebras for loally JB-algebras; **A. Khalmukhamedov**, Complex powers of the Schrödinger operator with singular potential; **A. K. Khudoyberdiyev** and **Z. K. Shermatova**, Description of solvable Leibniz algebras with four dimensional nilradical; **I. S. Rakhimov**, On classification problem of Loday algebras; **I. M. Rikhsiboev**, On the classification of left-symmetric dialgebras; **J. P. Tian**, Invitation to research of new mathematics from biology: Evolution algebras.

Contemporary Mathematics, Volume 672

September 2016, 272 pages, Softcover, ISBN: 978-1-4704-1928-8, LC 2015047941, 2010 *Mathematics Subject Classification:* 17Axx, 17D92, 39Bxx, 42Bxx, 46A55, 46Lxx, 47A12, 47F05, 47Hxx, **AMS members US$86.40**, List US$108, Order code CONM/672

Discrete Mathematics and Combinatorics



Proof of the 1-Factorization and Hamilton Decomposition Conjectures

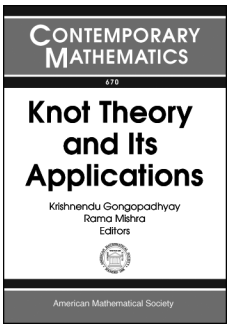
Béla Csaba, *University of Szeged, Hungary*, **Daniela Kühn**, *University of Birmingham, United Kingdom*, **Allan Lo**, *University of Birmingham, United Kingdom*, **Deryk Osthus**, *University of Birmingham, United Kingdom*, and **Andrew Treglown**, *University of Birmingham, United Kingdom*

Contents: Introduction; The two cliques case; Exceptional systems for the two cliques case; The bipartite case; Approximate decompositions; Bibliography.

Memoirs of the American Mathematical Society, Volume 244, Number 1154

October 2016, 164 pages, Softcover, ISBN: 978-1-4704-2025-3, 2010 *Mathematics Subject Classification:* 05C70, 05C45, **Individual member US$54**, List US$90, Institutional member US$72, Order code MEMO/244/1154

Geometry and Topology



Knot Theory and Its Applications

Krishnendu Gongopadhyay, *Indian Institute of Science Education and Research, Mohali, Punjab, India*, and **Rama Mishra**, *Indian Institute of Science Education and Research, Pune, India*, Editors

This volume contains the proceedings of the ICTS program Knot Theory and Its Applications (KTH-2013), held from December 10–20, 2013, at IISER Mohali, India.

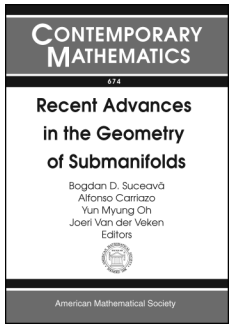
The meeting focused on the broad area of knot theory and its interaction with other disciplines of theoretical science. The program was divided into two parts. The first part was a week-long advanced school which consisted of minicourses. The second part was a discussion meeting that was meant to connect the school to the modern research areas.

This volume consists of lecture notes on the topics of the advanced school, as well as surveys and research papers on current topics that connect the lecture notes with cutting-edge research in the broad area of knot theory.

Contents: *Lecture notes:* **L. H. Kauffman**, Knot theory; **S. V. Jablan** and **R. Sazdanovic**, From Conway notation to LinKnot; **S. Kamada**, Surface-knots; **L. H. Kauffman**, An introduction to Khovanov homology; **A. Kawauchi**, Knot theory for spatial graphs attached to a surface; **J. H. Przytycki**, Knots and graphs: Two centuries of interaction; *Research expositions:* **B. Audoux**, On the welded tube map; **V. G. Bardakov** and **P. Bellingeri**, On representations of braids as automorphisms of free groups and corresponding linear representations; **N. Chbili**, Ribbon graphs and Temperley-Lieb algebra; **N. Kamada**, On twisted knots; **K. Morimoto**, Tunnel numbers of knots; **A. Shimizu**, The warping matrix of a knot diagram; **S. Vikash** and **P. Madeti**, On Arf invariant and trivializing number.

Contemporary Mathematics, Volume 670

October 2016, 357 pages, Softcover, ISBN: 978-1-4704-2257-8, LC 2015043281, 2010 *Mathematics Subject Classification:* 57Mxx, **AMS members US$110.40**, List US$138, Order code CONM/670



Recent Advances in the Geometry of Submanifolds

Dedicated to the Memory of Franki Dillen (1963–2013)

Bogdan D. Suceavă, *California State University, Fullerton, CA*, **Alfonso Carriazo**, *University of Seville, Spain*, **Yun Myung Oh**, *Andrews University, Berrien Springs, MI*, and **Joeri Van der Veken**, *KU Leuven, Belgium*, Editors

This volume contains the proceedings of the AMS Special Session on Geometry of Submanifolds, held from October 25–26, 2014, at San Francisco State University, San Francisco, CA, and the AMS Special Session on Recent Advances in the Geometry of Submanifolds: Dedicated to the Memory of Franki Dillen (1963–2013), held from March 14–15, 2015, at Michigan State University, East Lansing, Ml.

The focus of the volume is on recent studies of submanifolds of Riemannian, semi-Riemannian, Kaehlerian and contact manifolds. Some of these use techniques in classical differential geometry, while others use methods from ordinary differential equations, geometric analysis, or geometric PDEs. By brainstorming on the fundamental problems and exploring a large variety of questions studied in submanifold geometry, the editors hope to provide mathematicians with a working tool, not just a collection of individual contributions.

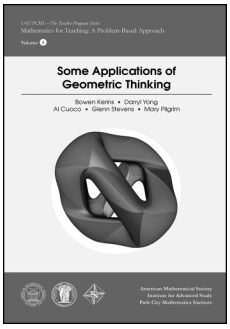
This volume is dedicated to the memory of Franki Dillen, whose work in submanifold theory attracted the attention of and inspired many geometers.

Contents: **B.-Y. Chen**, **J. Van der Veken**, and **L. Vrancken**, In memory of Franki Dillen; **L. Verstraelen**, Natural extrinsic geometrical symmetries—An introduction; **A. Carriazo**, A survey on semi-Riemannian generalized Sasakian-space-forms; **B.-Y. Chen**, A survey on Ricci solitons on Riemannian submanifolds; **K. Enomoto** and **J.-I. Itoh**, The total absolute curvature and the total absolute torsion of open curves in the Euclidean spaces; **B. Foreman**, Vertex-type curves in constant angle surfaces of $\mathcal{H}yp^2 \times \mathbb{R}$; **W. Goemans** and **I. Van de Woestyne**, Clelia curves, twisted surfaces and Plücker's conoid in Euclidean and Minkowski 3-space; **T. A. Ivey**, Stark hypersurfaces in complex projective space; **Y. H. Kim**, Submanifolds related to Gauss map and some differential operators; **Z. Lu** and **D. Wenzel**, The normal Ricci curvature inequality; **I. Mihai**, On the generalized Winten inequality for submanifolds in complex and Sasakian space forms; **Y.-L. Ou**, Some recent progress of biharmonic submanifolds; **A. Romero** and **R. M. Rubio**, A nonlinear inequality involving the mean curvature of a spacelike surface in 3-dimensional GRW spacetimes and Calabi-Bernstein type problems; **R. Sharma** and **S. Deshmukh**, On Lagrangian submanifolds of the nearly Kaehler 6-sphere; **J. Van der Veken**, Ideal Lagrangian submanifolds; **L. Vrancken**, Complete Lagrangian ideal $\delta(2)$ submanifolds in the complex projective space; **S. W. Wei**, Comparison theorems in Riemannian geometry with applications.

Contemporary Mathematics, Volume 674

September 2016, approximately 207 pages, Softcover, ISBN: 978-1-4704-2298-1, LC 2016003595, 2010 *Mathematics Subject Classification:* 53A04, 53B25, 53C25, 53C40, 53C42, 53C50, 53D12, 53D15, 58C40, 58E35, **AMS members US$86.40**, List US$108, Order code CONM/674

Math Education



Some Applications of Geometric Thinking

Bowen Kerins, *Education Development Center, Inc., Waltham, MA*, **Darryl Yong**, *Harvey Mudd College, Claremont, CA*, **Al Cuoco**, *Education Development Center, Inc., Waltham, MA*, **Glenn Stevens**, *Boston University, MA*, and **Mary Pilgrim**, *Colorado State University, Fort Collins, CO*

Designed for precollege teachers by a collaborative of teachers, educators, and mathematicians, *Some Applications of Geometric Thinking* is based on a course offered in the Summer School Teacher Program at the Park City Mathematics Institute.

But this book isn't a "course" in the traditional sense. It consists of a carefully sequenced collection of problem sets designed to develop several interconnected mathematical themes, and one of the goals of the problem sets is for readers to uncover these themes for themselves.

The goal of *Some Applications of Geometric Thinking* is to help teachers see that geometric ideas can be used throughout the secondary school curriculum, both as a hub that connects ideas from all parts of secondary school and beyond—algebra, number theory, arithmetic, and data analysis—and as a locus for applications of results and methods from these fields.

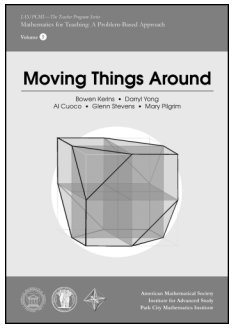
Some Applications of Geometric Thinking is a volume of the book series "IAS/PCMI—The Teacher Program Series" published by the American Mathematical Society. Each volume in this series covers the content of one Summer School Teacher Program year and is independent of the rest.

Titles in this series are co-published with the Institute for Advanced Study/Park City Mathematics Institute. Members of the Mathematical Association of America (MAA) and the National Council of Teachers of Mathematics (NCTM) receive a 20% discount from list price.

Contents: Problem sets; Facilitator guide; Solutions.

IAS/PCMI—The Teacher Program Series, Volume 4

November 2016, approximately 222 pages, Softcover, ISBN: 978-1-4704-2925-6, LC 2015022685, 2010 *Mathematics Subject Classification:* 00-01; 00A07, **AMS members US$23.20**, List US$29, Order code SSTP/4



Moving Things Around

Bowen Kerins, *Education Development Center, Waltham, MA*, **Darryl Yong**, *Harvey Mudd College, Claremont, CA*, **Al Cuoco**, *Education Development Center, Waltham, MA*, **Glenn Stevens**, *Boston University, MA*, and **Mary Pilgrim**, *Colorado State University, Fort Collins, CO*

Designed for precollege teachers by a collaborative of teachers, educators, and mathematicians, *Moving Things Around* is based on a course offered in the Summer School Teacher Program at the Park City Mathematics Institute.

But this book isn't a "course" in the traditional sense. It consists of a carefully sequenced collection of problem sets designed to develop several interconnected mathematical themes, and one of the goals of the problem sets is for readers to uncover these themes for themselves.

The goal of *Moving Things Around* is to help participants make what might seem to be surprising connections among seemingly different areas: permutation groups, number theory, and expansions for rational numbers in various bases, all starting from the analysis of card shuffles. Another goal is to use these connections to bring some coherence to several ideas that run throughout school mathematics—rational number arithmetic, different representations for rational numbers, geometric transformations, and combinatorics. The theme of seeking structural similarities is developed slowly, leading, near the end of the course, to an informal treatment of isomorphism.

Moving Things Around is a volume of the book series "IAS/PCMI—The Teacher Program Series" published by the American Mathematical Society. Each volume in this series covers the content of one Summer School Teacher Program year and is independent of the rest.

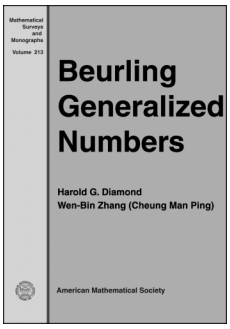
Titles in this series are co-published with the Institute for Advanced Study/Park City Mathematics Institute. Members of the Mathematical Association of America (MAA) and the National Council of Teachers of Mathematics (NCTM) receive a 20% discount from list price.

Contents: Problem sets; Facilitator notes; Solutions.

IAS/PCMI—The Teacher Program Series, Volume 5

November 2016, approximately 152 pages, Softcover, ISBN: 978-1-4704-2926-3, LC 2015022685, 2010 *Mathematics Subject Classification:* 00-01, **AMS members US$23.20**, List US$29, Order code SSTP/5

Number Theory



Beurling Generalized Numbers

Harold G. Diamond, *University of Illinois, Urbana, IL*, and **Wen-Bin Zhang (Cheung Man Ping)**, *University of the West Indies, Kingston, Jamaica*

"Generalized numbers" is a multiplicative structure introduced by A. Beurling to study how independent prime number theory is from the additivity of the natural numbers. The results and techniques of this theory apply to other systems having the character of prime numbers and integers; for example, it is used in the study of the prime number theorem (PNT) for ideals of algebraic number fields.

Using both analytic and elementary methods, this book presents many old and new theorems, including several of the authors' results, and many examples of extremal behavior of g-number systems. Also, the authors give detailed accounts of the L^2 PNT theorem of J. P. Kahane and of the example created with H. L. Montgomery, showing that additive structure is needed for proving the Riemann hypothesis.

Other interesting topics discussed are propositions "equivalent" to the PNT, the role of multiplicative convolution and Chebyshev's prime number formula for g-numbers, and how Beurling theory provides an interpretation of the smooth number formulas of Dickman and de Bruijn.

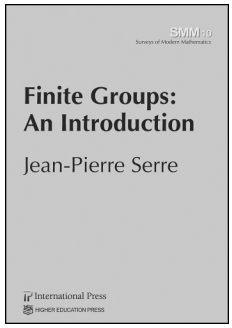
Contents: Overview; Analytic machinery; **dN** as an exponential and Chebyshev's identity; Upper and lower estimates of $\mathbf{N}(\mathbf{x})$; Mertens' formulas and logarithmic density; O-density of g-integers; Density of g-integers; Simple estimates of $\pi(\mathbf{x})$; Chebyshev bounds—Elementary theory; Wiener-Ikehara Tauberian theorems; Chebyshev bounds—Analytic methods; Optimality of a Chebyshev bound; Beurling's PNT; Equivalences to the PNT; Kahane's PNT; PNT with remainder; Optimality of the dlVP remainder term; The Dickman and Buchstab functions; Bibliography; Index.

Mathematical Surveys and Monographs, Volume 213

October 2016, 244 pages, Hardcover, ISBN: 978-1-4704-3045-0, LC 2016022110, 2010 *Mathematics Subject Classification:* 11N80, **AMS members US$88**, List US$110, Order code SURV/213

New AMS-Distributed Publications

Algebra and Algebraic Geometry



Finite Groups: An Introduction

Jean-Pierre Serre, *College of France, Paris, France*

Finite group theory is remarkable for the simplicity of its statements—and the difficulty of their proofs. It is essential in several branches of mathematics, notably number theory.

Finite Groups: An Introduction is an elementary textbook on finite group theory. Written by the eminent French mathematician Jean-Pierre Serre (a principal contributor to algebraic geometry, group theory, and number theory), this textbook is based upon a course given by Serre at l'École Normale Supérieure de Jeunes Filles, Paris, in 1978–1979.

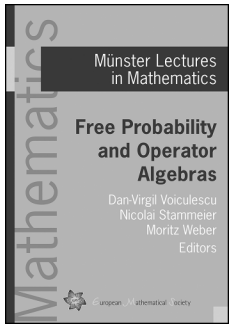
Each of the ten chapters is followed by a series of exercises.

A publication of International Press of Boston, Inc. Distributed worldwide by the American Mathematical Society.

International Press of Boston, Inc.

June 2016, 194 pages, Softcover, ISBN: 978-1-57146-320-3, 2010 *Mathematics Subject Classification:* 20-XX; 20-01, **AMS members US$30.40**, List US$38, Order code INPR/99

Analysis



Free Probability and Operator Algebras

Dan-Virgil Voiculescu, *University of California Berkeley*, **Nicolai Stammeier**, *University of Oslo, Oslo Blindern, Norway*, and **Moritz Weber**, *University of Saarbrücken, Germany*, Editors

Free probability is a probability theory dealing with variables having the highest degree of noncommutativity, an aspect found in many areas (quantum mechanics, free group algebras, random matrices, etc.). Thirty years after its foundation, it is a well-established and very active field of mathematics. Originating from Voiculescu's attempt to solve the free group factor problem in operator algebras, free probability has important connections

with random matrix theory, combinatorics, harmonic analysis, representation theory of large groups, and wireless communication.

These lecture notes arose from a master class in Münster, Germany and present the state of free probability from an operator algebraic perspective. This volume includes introductory lectures on random matrices and combinatorics of free probability (Speicher), free monotone transport (Shlyakhtenko), free group factors (Dykema), free convolution (Bercovici), easy quantum groups (Weber), and a historical review with an outlook (Voiculescu). To make it more accessible, the exposition features a chapter on the basics of free probability and exercises for each part.

This book is aimed at master students to early career researchers familiar with basic notions and concepts from operator algebras.

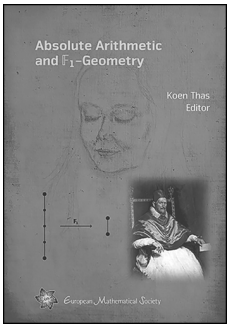
This item will also be of interest to those working in probability and statistics.

A publication of the European Mathematical Society (EMS). Distributed within the Americas by the American Mathematical Society.

EMS Münster Lectures in Mathematics, Volume 1

July 2016, 148 pages, Softcover, ISBN: 978-3-03719-165-1, 2010 *Mathematics Subject Classification:* 46L54; 60B20, 47C15, 20G42, **AMS members US$30.40**, List US$38, Order code EMSMLM/1

Discrete Mathematics and Combinatorics



Absolute Arithmetic and $\mathbb{F}_1$-Geometry

Koen Thas, *Ghent University, Belgium*, Editor

It has been known for some time that geometries over finite fields, their automorphism groups and certain counting formulae involving these geometries have interesting guises when one lets the size of the field go to 1. On the other hand, the nonexistent field with one element, $\mathbb{F}_1$, presents itself as a ghost candidate for an absolute basis in Algebraic Geometry to perform the Deninger-Manin program, which aims at solving the classical Riemann Hypothesis.

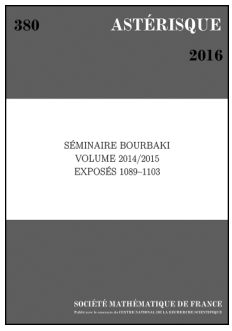
This book, which is the first of its kind in the $\mathbb{F}_1$-world, covers several areas in $\mathbb{F}_1$-theory and is divided into four main parts: Combinatorial Theory, Homological Algebra, Algebraic Geometry and Absolute Arithmetic. Topics treated include the combinatorial theory and geometry behind $\mathbb{F}_1$, categorical foundations, the blend of different scheme theories over $\mathbb{F}_1$ which are presently available, motives and zeta functions, the Habiro topology, Witt vectors and total positivity, moduli operads, and at the end, even some arithmetic.

Each chapter is carefully written by an expert. In addition to elaborating on known results, the authors introduce brand-new results, open problems and conjectures. The diversity of the contents, together with the mystery surrounding the field with one element, should attract any mathematician, regardless of speciality.

This item will also be of interest to those working in number theory and algebra and algebraic geometry.

July 2016, 397 pages, Hardcover, ISBN: 978-3-03719-157-6, 2010 *Mathematics Subject Classification:* 05E18, 11M26, 13F35, 13K05, 14A15, 14A20, 14A22, 14G15, 14G40, 14H10, **AMS members US$70.40**, List US$88, Order code EMSAAFG

Geometry and Topology



Séminaire Bourbaki: Volume 2014/2015 Exposés 1089–1103

A note to readers: This book is in French.

This 67th volume of the Bourbaki Seminar contains the texts of the fifteen survey lectures done during 2014/2015: combinatorics, category theory, higher topos theory, geometric measure theory, partial differential equations, spectral theory, differential geometry, ergodic theory, geometric group theory, algebraic geometry, Galois representations, and rational points.

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.

Astérisque, Number 380

June 2016, 497 pages, Softcover, ISBN: 978-2-85629-836-7, 2010 *Mathematics Subject Classification:* 05, 11, 14, 18, 20, 35, 37, 46, 49, 53, **AMS members US$89.60**, List US$112, Order code AST/380

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Description: Appointments are for two years with one-year terminal extension expected. The academic year runs from approximately October 1 to June 1. Instructors typically are expected to teach one course per quarter for the full academic year and to devote the rest of their time to research. During the summer months there are no duties except research.

Eligibility: Open to persons who have recently received their doctorates in mathematics.

Deadline: January 1, 2017.

Application information: Please apply online at `mathjobs.org`. You can also find information about this position at `pma.caltech.edu/content/mathematics-postdoctoral-scholars`. To avoid duplication of paperwork, your application may also be considered for an Olga Taussky and John Todd Instructorship. Caltech is an Affirmative Action/Equal Opportunity Employer. Women, minorities, veterans, and disabled persons are encouraged to apply.

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Description: There are three terms in the Caltech academic year. The fellow is typically expected to teach one course in two terms each year, and is expected to be in residence even during terms when not teaching. The initial appointment is for three years with an additional three-year terminal extension expected.

Eligibility: Offered to a candidate within six years of having received the PhD who shows strong research promise in one of the areas in which Caltech's mathematics faculty is currently active.

Deadline: January 1, 2017.

Application information: Please apply online at `mathjobs.org`. You can also find information about this position at `pma.caltech.edu/content/mathematics-postdoctoral-scholars`. To avoid duplication of paperwork, your application may also be considered for an Olga Taussky and John Todd Instructorship. Caltech is an Affirmative Action/Equal Opportunity Employer. Women, minorities, veterans, and disabled persons are encouraged to apply.

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CALIFORNIA INSTITUTE OF TECHNOLOGY
Olga Taussky and John Todd Instructorships in Mathematics

Description: Appointments are for three years. There are three terms in the Caltech academic year, and instructors typically are expected to teach one course in all but two terms of the total appointment. These two terms will be devoted to research. During the summer months there are no duties except research.

Eligibility: Offered to persons within three years of having received the PhD who show strong research promise in one of the areas in which Caltech's mathematics faculty is currently active.

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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: December 2016—September 29, 2016; January 2017— October 31, 2016; February 2017—November 23, 2016; March 2017—January 2, 2017; April 2017—January 30, 2017; May 2017—March 2, 2017; June 2017—April 28, 2017.

US laws prohibit discrimination in employment on the basis of color, age, sex, race, religion, or national origin. "Positions Available" advertisements from institutions outside the US 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 US 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 US and Canada or 401-455-4084 worldwide for further information.

Submission: Promotions Department, AMS, P.O. Box 6248, Providence, Rhode Island 02904; or via fax: 401-331-3842; or send email to `classads@ams.org`. AMS location for express delivery packages is 201 Charles Street, Providence, Rhode Island 02904. Advertisers will be billed upon publication.

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Department of Mathematics
Irvine, CA 92697-3875

The Department of Mathematics at the University of California, Irvine invites applications from outstanding candidates for multiple positions, including: tenure-track Assistant Professors, Lecturer with Potential Security of Employment (LPSOE) and Visiting Assistant Professors (VAP). Applicants must hold a PhD.

Tenure-track Assistant Professor position candidates should have demonstrated excellence in research and teaching. The LPSOE series requires, in addition to excellent teaching and service, that the candidate makes outstanding and externally recognized contributions to the development of his or her specific discipline and/or of pedagogy. VAP candidates must show strong promise in research and teaching.

Applications are welcome at any time. The review process starts November 1, 2016 and will continue until positions are filled. Please visit www.mathjobs.org for details on positions and the application process.

The University of California, Irvine is an Equal Opportunity/Affirmative Action Employer advancing inclusive excellence. All qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, national origin, disability, age, protected veteran status, or other protected categories covered by the UC nondiscrimination policy.

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UNIVERSITY OF CALIFORNIA, LOS ANGELES
Department of Mathematics
Faculty Positions 2017–18

Tenured/Tenure-Track positions 2017–18 (subject to administrative approval)

The Department of Mathematics at the University of California, Los Angeles, invites applications for tenure-track or tenured faculty positions starting July 1, 2017. Outstanding candidates in all areas of mathematics may be considered. Applicants must possess a PhD and should have outstanding accomplishments in both research and teaching. Duties include mathematical research, undergraduate and graduate teaching, and departmental and university service. Level of appointment will be based on qualifications, with appropriate salary per UC pay scales.

The department is especially interested in candidates who can contribute to the diversity & excellence of the academic community through teaching and service.

Applications and supporting documentation for all positions must be submitted online via www.mathjobs.org. Applications will be accepted until the position is filled. To guarantee full consideration, the application should be received by November 15, 2016.

Temporary Faculty Positions 2017–18
The Department of Mathematics at the University of California, Los Angeles, invites applications for temporary and visiting appointments in the categories 1–4 below. Depending on the level, candidates must give evidence of potential or demonstrated distinction in scholarship and teaching. Applicants must possess a PhD and should have outstanding accomplishments in both research and teaching. Postdoctoral Positions:

(1) E.R. Hedrick Assistant Professorships: Appointments are for three years. The teaching load is four one-quarter courses per year.

(2) Computational and Applied Mathematics (CAM) Assistant Professorships: Appointments are for three years. The teaching load is normally reduced by research funding to two one-quarter courses per year.

(3) Program in Computing (PIC) Assistant Adjunct Professorships: Applicants for these positions must show very strong promise in teaching and research in an area related to computing. The teaching load is four one-quarter programming courses each year and one additional course every two years. Initial appointments are for one year and possibly longer, up to a maximum service of four years.

(4) Assistant Adjunct Professorships and Research Postdocs: Appointments are normally for one year, with the possibility of renewal. Strong research and teaching background required. The teaching load for is six one-quarter courses per year.

(5) RTG Assistant Adjunct Professorship in Analysis: Salary is $59,400, and appointments are for three years. This position is limited to US citizens or permanent residents who have received a PhD within 18 months of June 1, 2017. The successful recipient will receive a summer stipend of $10,000 for two summers and $9,000 over three years for travel, equipment, and supplies. The teaching load is three one-quarter courses per year.

Appointments will be effective July 1, 2017 or later. Applications will be accepted until all positions are filled. For fullest consideration, all application materials should be submitted on or before November 15, 2016.

Applications and supporting documentation must be submitted online via www.mathjobs.org.

All letters of evaluation are subject to UCLA campus policies on confidentiality. Refer potential reviewers to the UCLA statement of confidentiality at www.apo.ucla.edu/policies/the-call/summary-of-procedures/summary-10-statement-of-confidentiality.

Lecturer Positions in Mathematics
The UCLA Department of Mathematics receives on an ongoing basis applications for quarter positions (Fall/Winter/Spring or for Summer Session) for Lecturers to teach undergraduate Mathematics, Financial Actuarial Mathematics, or Math Education courses. Positions are very limited and temporary. Responsibilities include lecturing, conducting office hours, writing and grading exams and supervising teaching assistants. Previous teaching experience at the college level or extensive actuary experience is required and a PhD is preferred. Applications will be accepted until all positions are filled.

The University of California is an Equal Opportunity/Affirmative Action Employer. All qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, national origin, disability, age or protected veteran status. For the complete University of California nondiscrimination and affirmative action policy see: UC Nondiscrimination and Affirmative Action Policy, policy.ucop.edu/doc/4000376/NondiscrimAffirmAct.

The University of California asks that applicants complete the Equal Opportunity Employer survey for Letters and Science at the following URL: cis.ucla.edu/facultysurvey/. Under Federal Law, the University of California may employ only individuals who are legally authorized to work in the United States as established by providing documents specified in the Immigration Reform and Control Act of 1986.

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IOWA

IOWA STATE UNIVERSITY OF SCIENCE AND TECHNOLOGY
Professor and Chairperson of Mathematics

The Department of Mathematics at Iowa State University invites applications for the position of Chairperson at the rank of tenured full Professor.

Primary responsibilities of the department chair are to provide visionary leadership; to encourage excellence and innovation in research, teaching, and service; to advance professional development of faculty, staff, and students; to promote productive relationships with all external constituents including alumni, and industry and government agencies; to foster productive interdisciplinary relationships with a variety of entities across the university community; and to facilitate faculty efforts to attract extramural grant and contract funding.

The successful applicant will also have the opportunity to maintain his or her own

program of scholarship in a manner that is consistent with a primary administrative appointment.

The successful candidate will have excellent verbal and written communication skills; strong organizational and time management skills; and excellent interpersonal skills. The candidate will possess the supervisory and leadership skills needed to lead and advance a diverse community of accomplished teachers and scholars.

The Department of Mathematics houses an active research environment consisting of about 35 tenure eligible faculty, 20 long-term non-tenure faculty, 10 other faculty and postdoctoral associates, and 80 graduate students. The department offers undergraduate degrees, MS and PhD programs in Mathematics and Applied Mathematics, and also an MSM (Master of School Mathematics) program for current secondary mathematics teachers. The department was the 2015 recipient of the AMS Award for an Exemplary Program or Achievement in a Mathematics Department in recognition of diversity efforts at all levels of the Department. As part of the College of Liberal Arts and Sciences, the department is strongly committed to advancing the frontiers of knowledge in both pure and applied mathematics. Members of the faculty are active in cross-campus collaboration, as well as in professional organizations including the AMS, SIAM, and the MAA. For further information about the department, please visit our website at www.math.iastate.edu.

Iowa State University is classified as a Carnegie Foundation Doctoral/Research University-Extensive, a member of the Association of American Universities (AAU), and ranked by *US News and World Report* as one of the top public universities in the nation. Over 36,000 students are enrolled and served by over 6,200 faculty and staff (see www.iastate.edu). Ames, Iowa is a progressive community of 60,000, located approximately 30 minutes north of Des Moines, and recently voted the best college town in the nation (see www.visitames.com).

The University is committed to achieving inclusive excellence through a diverse workforce, is responsive to the needs of dual-career couples and is dedicated to supporting work-life satisfaction through an array of flexible policies.

To apply go to the Iowa State University Employment Opportunities website at www.iastatejobs.com/postings/19914. If you have questions, please e-mail employment@iastate.edu or call 515-294-4800 or Toll Free: 1-877-477-7485.

All offers of employment, oral and written, are contingent upon the University's verification of credentials and other information required by federal and state law, ISU policies/procedures, and may include the completion of a background check.

Iowa State University is an affirmative action/equal opportunity employer and strongly encourages women and members of underrepresented groups to apply.

000031

MASSACHUSETTS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Cambridge, MA

The Mathematics Department at MIT is seeking to fill positions in Pure and Applied Mathematics, and Statistics at the level of Assistant Professor or higher beginning July 2017 (for the 2017–2018 academic year, or as soon thereafter as possible). Appointments are based primarily on exceptional research qualifications. Appointees will be required to fulfill teaching duties and pursue their own research program. PhD in Mathematics or related field required by employment start date.

For more information and to apply, please visit www.mathjobs.org. To receive full consideration, submit applications by December 1, 2016. MIT is an Equal Opportunity, Affirmative Action Employer.

000036

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Cambridge, MA

The Mathematics Department at MIT is seeking to fill positions in Pure and Applied Mathematics, and Statistics at the level of Instructor beginning July 2017 (for the 2017–2018 academic year). Appointments are based primarily on exceptional research qualifications. Appointees will be expected to fulfill teaching duties and pursue their own research program. PhD in Mathematics or related field required by employment start date.

For more information and to apply, please visit www.mathjobs.org. To receive full consideration, submit applications by December 1, 2016. MIT is an Equal Opportunity, Affirmative Action Employer.

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WILLIAMS COLLEGE
Tenure-Track Assistant Professor of Mathematics

The Williams College Department of Mathematics and Statistics invites applications for two tenure-track positions in mathematics, beginning fall 2017, at the rank of assistant professor (in an exceptional case, a more advanced appointment may be considered). We are seeking highly qualified candidates who have demonstrated excellence in teaching and research and who are committed to working with an increasingly diverse student body. The teaching load is four 12-week semester courses per year and a pass-fail Winter Study class every other January. Preference will be given to candidates who will have a PhD in mathematics by September 2017. We welcome applications from members of groups traditionally underrepresented in the field.

Applicants can apply electronically at MathJobs.Org. Evaluations of applications will begin on or after November 15 and will continue until the position is filled. All offers of employment are contingent upon completion of a background check dean-faculty.williams.edu/prospective-faculty/background-check-policy.

For more information on the Department of Mathematics and Statistics, visit math.williams.edu/.

Williams College is a coeducational liberal arts institution located in the Berkshire Hills of western Massachusetts. The college has built its reputation on outstanding teaching and scholarship and on the academic excellence of its approximately 2,000 students. Please visit the Williams College website (www.williams.edu).

Beyond meeting fully its legal obligations for nondiscrimination, Williams College is committed to building a diverse and inclusive community where members from all backgrounds can live, learn, and thrive.

000038

NEW JERSEY

INSTITUTE FOR ADVANCED STUDY
School of Math
Princeton, NJ 08540

The School of Mathematics at the Institute for Advanced Study has a limited number of memberships with financial support for research during the 2017–18 academic year. The School frequently sponsors special programs. However, these programs comprise no more than one-third of the memberships so that each year a wide range of mathematics is supported. Candidates must give evidence of ability in research comparable at least with that expected for the PhD degree, but otherwise can be at any career stage. Successful candidates will be free to devote themselves full time to research. About half of our members will be postdoctoral researchers within 5 years of their PhD We expect to offer some two-year postdoctoral positions. Up to 8 von Neumann Fellowships will be available for each academic year. To be eligible for the von Neumann Fellowships, applications should be at least 5, but no more than 15 years following the receipt of their PhD. The Veblen Research Instructorship is a three-year position in partnership with the department of Mathematics at Princeton University. Three-year instructorships will be offered each year to candidates in

pure and applied mathematics who have received their PhD within the last 3 years. Usually the first and third year of the instructorship will be spent at Princeton University and will carry regular teaching responsibilities. The second year is spent at the Institute and dedicated to independent research of the instructor's choice. Candidates interested in a Veblen instructorship position may apply directly at the IAS website https://application.ias.edu or they may apply through MathJobs.org. If they apply at MathJobs.org, they must also complete the application form at https://applications.ias.edu but do not need to submit a second set of reference letters. Questions about the application procedure should be addressed to applications@math.ias.edu. In addition, there are also two-year postdoctoral positions in computer science and discrete mathematics offered jointly with the following institutions: The Department of Computer Science at Princeton University, www.cs.princeton.edu, DIMACS at Rutgers, The State University of New Jersey, www.dimacs.rutgers.edu and the Simons Foundation Collaboration on Algorithms and Geometry, www.simonsfoundation.org/mathematics-and-physical-science/algorithms-and-geometry-collaboration/. School term dates for 2017–18 academic year are: term I, Monday September 25 to Friday December 22, 2017; term II, Monday January 15, 2018, to Friday, April 13, 2018. During the 2017–18 year, the School will have a special program on Locally Symmetric Spaces: Analytical and Topological Aspects. Akshay Venkatesh of Stanford University will be the Distinguished Visiting Professor. The topology of locally symmetric spaces interacts richly with number theory via the theory of automorphic forms (Langlands program). Many new phenomena seem to appear in the non-Hermitian case (e.g., torsion cohomology classes, relations with mixed motives and algebraic K-theory, derived nature of deformation rings). One focus of the program will be to try to better understand some of these phenomena. Much of our understanding of this topology comes through analysis Hodge theory). Indeed harmonic analysis on locally symmetric spaces plays a foundational role in the theory of automorphic forms and is of increasing importance in analytic number theory. A great success of such harmonic analysis is the Arthur–Selberg trace formula; on the other hand, the analytic aspects of the trace formula are not fully developed, and variants such as the relative trace formula are not as well understood. Thus analysis on such spaces, interpreted broadly, will be another focus of the program.

000023

PRINCETON UNIVERSITY
Applied and Computational Mathematics

ID: PACMPOSTDOC2017

The Program in Applied and Computational Mathematics invites applications for Postdoctoral Research Associates or more senior to join in research efforts of interest to its faculty. Domains of interest include nonlinear partial differential equations, computational fluid dynamics and material science, dynamical systems, numerical analysis, stochastic problems and stochastic analysis, graph theory and applications, mathematical biology, financial mathematics and mathematical approaches to signal analysis, information theory, and structural biology and image processing. Appointments are possible for up to three years, renewable yearly, if funding is available and performance is satisfactory. For details on specific faculty members and their research interests, please go to www.pacm.princeton.edu/sites/default/files/Faculty%20interests.pdf. Princeton University is an equal opportunity employer and all qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, national origin, disability status, protected veteran status, or any other characteristic protected by law.

Applicants should apply via the web at https://www.mathjobs.org/jobs/jobs/8919 and submit a cover letter, CV, bibliography/publications list, statement of research and three letters of recommendation. Applicants should have a recently-completed or soon-to-be completed doctorate. This position is subject to the University background check policy. Responses will only be sent to applicants from whom we seek further information. Princeton University is an equal opportunity employer and complies with applicable EEO and affirmative action regulations. For information about applying to Princeton and how to self-identify please go to www.princeton.edu/dof/about_us/dof_job_openings/.

000034

NEW YORK

CORNELL UNIVERSITY
Tenure or Tenure-Track Position

The Department of Mathematics at Cornell University invites applications for one tenure-track Assistant, Associate, or Full Professor position, starting July 1, 2017. While we particularly invite applications in logic, topology and analysis, candidates from all areas will be considered. Diversity and Inclusion are a part of Cornell University's heritage. We are an employer and educator recognized for valuing AA/EEO, Protected Veterans, and Individuals with Disabilities. We actively encourage applications of women, persons of color, and persons with disabilities. Applicants must apply electronically at www.mathjobs.org. For information about our positions and application instructions, see: www.math.cornell.edu/Positions/positions.html. Applicants will be automatically considered for all eligible positions. **Deadline November 1, 2016**. Early applications will be regarded favorably.

000040

CORNELL UNIVERSITY
H. C. Wang Assistant Professor

The Department of Mathematics at Cornell University invites applications for at least one H. C. Wang Assistant Professor, nontenure track, nonrenewable, 3-year position beginning July 1, 2017. Successful candidates are expected to pursue independent research at Cornell and teach three courses per year. A PhD in mathematics is required. Diversity and Inclusion are a part of Cornell University's heritage. We're an employer and educator recognized for valuing AA/EEO, Protected Veterans, and Individuals with Disabilities. We actively encourage applications of women, persons of color, and persons with disabilities. Applicants must apply electronically at www.mathjobs.org. For information about our positions and application instructions, see: www.math.cornell.edu/Positions/positions.html. Applicants will be automatically considered for all eligible positions. Deadline **December 1, 2016**. Early applications will be regarded favorably.

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PENNSYLVANIA

PENN STATE
Department of Mathematics

The Department of Mathematics is seeking outstanding applicants for one tenure or tenure-track faculty position specializing in big data research in the general area of computational mathematics and numerical analysis. Preference will be given to candidates with a strong background in probability and an established record in development, analysis and application of probabilistic and stochastic algorithms. A PhD is required. Applicants must complete the Penn State application at psu.jobs/job/64862 and must submit an application through MathJobs.Org (www.mathjobs.org/jobs) with the following materials in order for the application to be complete: (1) at least three reference letters, one of which should address in detail the candidate's abilities as a teacher, (2) Curriculum Vitae, (3) Publication List, (4) Research Statement, and (5) Teaching Statement. We encourage applications from individuals of diverse backgrounds. Review of applications will begin

November 15, 2016 and continue until all positions are filled.

CAMPUS SECURITY CRIME STATISTICS: For more about safety at Penn State, and to review the Annual Security Report which contains information about crime statistics and other safety and security matters, please go to www.police.psu.edu/clery/, which will also provide you with detail on how to request a hard copy of the Annual Security Report.

Penn State is an Equal Opportunity, Affirmative Action Employer, and is committed to providing employment opportunities to all qualified applicants without regard to race, color, religion, age, sex, sexual orientation, gender identity, national origin, disability or protected veteran status.

000028

PENN STATE
Department of Mathematics

The Department of Mathematics is seeking outstanding applicants for one tenure or tenure-track faculty position in all areas of pure and applied mathematics. A PhD is required. Applicants must complete the Penn State application at psu.jobs/job/64592 and must submit an application through MathJobs.Org (www.mathjobs.org/jobs) with the following materials in order for the application to be complete: (1) at least three reference letters, one of which should address in detail the candidate's abilities as a teacher, (2) Curriculum Vitae, (3) Publication List, (4) Research Statement, and (5) Teaching Statement. We encourage applications from individuals of diverse backgrounds. Review of applications will begin November 15, 2016 and continue until all positions are filled.

CAMPUS SECURITY CRIME STATISTICS: For more about safety at Penn State, and to review the Annual Security Report which contains information about crime statistics and other safety and security matters, please go to www.police.psu.edu/clery/, which will also provide you with detail on how to request a hard copy of the Annual Security Report.

Penn State is an Equal Opportunity, Affirmative Action Employer, and is committed to providing employment opportunities to all qualified applicants without regard to race, color, religion, age, sex, sexual orientation, gender identity, national origin, disability or protected veteran status.

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RHODE ISLAND

BROWN UNIVERSITY
J. D. Tamarkin Assistant Professorships

One or more three-year nontenured non-renewable appointments, beginning July 1, 2017. The teaching load is one course one semester and two courses the other semester, and consists of courses of more than routine interest. Candidates are required to have received a PhD degree or equivalent by the start of their appointment, and they may have up to three years of prior academic and/or postdoctoral research experience.

Applicants should have strong research potential and a commitment to teaching. Field of research should be consonant with the current research interests of the department.

For full consideration, applicants must submit a curriculum vitae, an AMS Standard Cover Sheet and three letters of recommendation by December 1, 2016. Applicants are encouraged to identify Brown faculty with similar research interests. Please submit all application materials on line at www.mathjobs.org. E-mail inquiries should be addressed to juniorsearch@math.brown.edu. Brown University is committed to fostering a diverse and inclusive academic global community; as an EEO/AA employer, Brown considers applicants for employment without regard to, and does not discriminate on the basis of, gender, race, protected veteran status, disability, or any other legally protected status.

000033

TENNESSEE

VANDERBILT UNIVERSITY
Nashville, Tennessee
Non Tenure-Track
Assistant Professor Positions

We invite applications for several visiting and non-tenure-track assistant professor positions in the research areas of the Mathematics Department beginning fall 2017. These positions will have variable terms and teaching loads but most will be three-year appointments with a 2-2 teaching load. We anticipate that some of these appointments will carry a 1-1 teaching load and provide a stipend to support research.

We are looking for individuals with outstanding research potential and a strong commitment to excellence in teaching. Preference will be given to recent doctorates. Submit your application and supporting materials electronically through the AMS website MathJobs.Org via the link www.mathjobs.org/jobs. Alternatively, application materials may be sent to: NTT Appointments Committee, Vanderbilt University, Department of Mathematics, 1326 Stevenson Center, Nashville, TN 37240. These materials should include a letter of application, a curriculum vitae, a publication list, a research statement, a teaching statement, at least four letters of recommendation and the AMS Cover Sheet. One of the letters must discuss the applicant's teaching qualifications. Reference letter writers should be asked to submit their letters online through MathJobs.Org. Evaluation of the applications will commence on December 1, 2016 and continue until the positions are filled. For information about the Department of Mathematics at Vanderbilt University, please consult the web at as.vanderbilt.edu/math/.

Vanderbilt University is committed to recruiting and retaining an academically and culturally diverse community of exceptional faculty. Vanderbilt is an AA/EO employer and particularly encourages applications from minorities and women.

000029

WISCONSIN

UNIVERSITY OF WISCONSIN–MADISON
Department of Mathematics

The Department of Mathematics is accepting applications for a faculty position beginning August 28, 2017 contingent upon budgetary approval. Rank will be as assistant professor (tenure-track) or associate professor (tenured). Area of specialization open. PhD in mathematics or related field required prior to start of appointment. Faculty members are expected to contribute to the research, teaching, and service missions of the department. Appointment with tenure requires evidence of excellence in scholarly research, teaching and service. Candidates for a tenure-track position should exhibit evidence of outstanding research potential, normally including significant contributions beyond the doctoral dissertation. The teaching responsibility is three courses per academic year, including both undergraduate and graduatelevel courses, and a strong commitment to excellence in instruction is also expected. Additional departmental information is available on our website: www.math.wisc.edu. An application packet should include a completed AMS Standard Cover Sheet, a curriculum vitae that includes a publication list, and brief descriptions of research and teaching. Application packets should be submitted electronically to www.mathjobs.org. Arrangements should be made to have three to four letters of recommendation, at least one of which must discuss the applicant's teaching experiences and capabilities and potential, sent to the above url address. To ensure full consideration, application packets must be received by November 1, 2016. Applications will be accepted until the position is filled. The Department of Mathematics is committed to increasing the number of women and under represented individuals. The University of Wisconsin - Madison is an Affirmative Action, Equal Opportunity Employer and encourages applications from women and minorities. Unless confidentiality is requested in writing, information regarding the applicants must be released upon request. Finalists cannot be guaranteed

confidentiality. A background check will be required prior to employment.

000032

HONG KONG

THE UNIVERSITY OF HONG KONG
Tenure-Track Professor/Associate Professor/ Assistant Professor (2 posts) in the Department of Mathematics (Ref.: 201600853)

Applications are invited for two tenure-track appointments as Professor/Associate Professor/Assistant Professor in the Department of Mathematics, to commence from September 1, 2017, or as soon as possible thereafter. The appointments will initially be made on a three-year term basis, with the possibility of renewal.

The Department of Mathematics provides a solid general undergraduate education in mathematics, offers supervision in graduate study for students with a strong interest in and a capacity for mathematics, and engages in teaching and research aiming at a high international standing. Information about the Department can be obtained at www.hku.hk/math/.

Candidates in all areas of Applied Mathematics will be considered, with preference given to those working in the areas of Optimization (with applications in Big Data Science) and Scientific Computing (with applications in Financial Mathematics). The appointees will be expected to teach undergraduate and postgraduate courses, supervise research students, and also actively engage in outreach and service.

A globally competitive remuneration package commensurate with the appointee's qualifications and experience will be offered. At current rates, salaries tax does not exceed 15% of gross income. The appointments will attract a contract-end gratuity and University contribution to a retirement benefits scheme, totalling up to 15% of basic salary, as well as annual leave, and medical benefits. Housing benefits will be provided as applicable.

Applicants should send a completed application form, together with an up-to-date CV containing information on educational and professional experience, a complete list of publications, a survey of past research and teaching experience, a research plan for the next few years, and a statement on teaching philosophy to: scmath@hku.hk. They should also arrange for submission, to the same e-mail address as stated above, three reference letters from senior academics. One of these senior academics should be asked to comment on the applicant's ability in teaching, or the applicant should arrange to have an additional reference letter on his/her teaching sent to the same e-mail address as stated above. Please indicate clearly which level they wish to be considered for and the reference number in the subject of the e-mail. Application forms (341/1111) can be downloaded at www.hku.hk/apptunit/form-ext.doc and further particulars can be obtained at jobs.hku.hk/. **Review of applications will start from December 1, 2016, and continue until June 30, 2017**. The University thanks applicants for their interest, but advises that only candidates shortlisted for interviews will be notified of the application result.

The University is an Equal Opportunities Employer and is committed to a Non-Smoking Policy.

000020

THE UNIVERSITY OF HONG KONG
Tenure-Track Professor (1 post) in the Department of Mathematics (Ref.: 201600852)

Applications are invited for a tenure-track appointment as Professor in the Department of Mathematics, to commence from September 1, 2017, or as soon as possible thereafter. The appointment will initially be made on a three-year term basis, with the possibility of renewal.

The Department of Mathematics provides a solid general undergraduate education in mathematics, offers supervision in graduate study for students with a strong interest in and a capacity for mathematics, and engages in teaching and research aiming at a high international standing. Information about the Department can be obtained at www.hku.hk/math/.

Candidates in all areas of Pure Mathematics will be considered, with preference given to those working in Algebra, Representation Theory, and related areas. The appointee will be expected to teach undergraduate and postgraduate courses, supervise research students, and also actively engage in outreach and service.

A globally competitive remuneration package commensurate with the appointee's qualifications and experience will be offered. At current rates, salaries tax does not exceed 15% of gross income. The appointments will attract a contract-end gratuity and University contribution to a retirement benefits scheme, totalling up to 15% of basic salary, as well as annual leave, and medical benefits. Housing benefits will be provided as applicable.

Applicants should send a completed application form, together with an up-to-date CV containing information on educational and professional experience, a complete list of publications, a survey of past research and teaching experience, a research plan for the next few years, and a statement on teaching philosophy to: scmath@hku.hk. They should also arrange for submission, to the same e-mail address as stated above, three reference letters from senior academics. One of these senior academics should be asked to comment on the applicant's ability in teaching, or the applicant should arrange to have an additional reference letter on his/her teaching sent to the same e-mail address as stated above. Please indicate clearly which level they wish to be considered for and the reference number in the subject of the e-mail. Application forms (341/1111) can be downloaded at www.hku.hk/apptunit/form-ext.doc and further particulars can be obtained at jobs.hku.hk/. **Review of applications will start from December 1, 2016, and continue until June 30, 2017**. The University thanks applicants for their interest, but advises that only candidates shortlisted for interviews will be notified of the application result.

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000021

SINGAPORE

NATIONAL UNIVERSITY OF SINGAPORE (NUS)
Department of Mathematics

The Department of Mathematics at the National University of Singapore (NUS) invites applications for tenured and tenure-track positions at all levels, beginning in August 2017. NUS is a leading global university centred in Asia. The Department of Mathematics has about 60 faculty members and teaching staff whose expertise cover major areas of contemporary mathematical research. We seek promising scholars and established mathematicians with outstanding track records in any field of pure and applied mathematics. The Department, housed in a spacious building equipped with state-of-the-art facilities, offers internationally competitive salary with start-up research grants, as well as an environment conducive to active research, with ample opportunities for career development. The teaching load for junior faculty is kept especially light. The Department is particularly interested in, but not restricted to, considering applicants specializing in any of the following areas:

1. Optimization and Quantitative Finance with strong interest in data-related research
2. Applied analysis with focus on PDE and its applications
3. Algebraic/arithmetic geometry
4. Homogeneous dynamics
5. Geometric analysis

Please submit your application at www.mathjobs.org/jobs/jobs/8868:

1. Cover Letter
2. Curriculum Vitae/Publication List
3. Personal Data Consent Form

www.nus.edu.sg/careers/

potentialhires/applicationprocess/NUS-Personal-Data-Consent-for-Job-Applicants.pdf.

4. Research Statement (max. 3 pages)

5. Teaching Statement (max. 3 pages)

6. Evaluation on teaching from faculty members or students of your current institution, where applicable;

7. Three or more Reference Letters (to be submitted at MathJobs.Org by the reference writers).

Review process will begin on October 15, 2016, and will continue until positions are filled. Enquiries may be sent to search@math.nus.edu.sg.

For further information about the department, please visit www.math.nus.edu.sg.

000030

2016 Canadian Mathematical Society Winter Meeting

Sheraton on the Falls, Niagara Falls, Ontario

Scientific Director

Hans Boden (McMaster University)
Bartosz Protas (McMaster University)

PRIZES

Adrien Pouliot Award
Coxeter-James Prize
Doctoral Prize
G. de B. Robinson Award
Graham Wright Award for Distinguished Service
Jeffery-Williams Prize

HIGHLIGHTS

AARMS-CMS Student Poster Session
Contributed Papers
Education Sessions
Over 20 Scientific Sessions
CMS Awards Banquet overlooking Niagara Falls

cms.math.ca/Events/winter16/
#CMSWinter
Registration now open!

pims FIELDS CRM AARMS

Mathematical Sciences Employment Center

Hyatt Regency Atlanta, Atlanta, Georgia
January 4–7, 2017

The Employment Center offers a convenient, safe and practical meeting place for employers and job seekers attending the Joint Meetings. The focus of the Employment Center is on PhD-level mathematical scientists and those that seek to hire them from academia, business, and government.

Employment Center Web Services

Employment Center registration information should be accessed through the MathJobs.org system. The website and all information will be available beginning in early September 2016 and will remain accessible through January 7, 2017 (the last day of the Employment Center). While some schools may delay appointment setting until late December 2016, virtually all scheduling will be done before any Joint Mathematics Meetings (JMM) travel takes place, so applicants should expect few or no additional appointments to be available after arrival. Registering on-site, for applicants, serves no real purpose.

No Admittance Without a JMM Badge

All applicants and employers planning to enter the Employment Center—even just for one interview—must present a 2017 Joint Meetings Registration badge. Meeting badges are obtained by registering for the JMM and paying a meeting registration fee. The Advanced Registration deadline is December 20, 2016. See the JMM website at: `jointmathematicsmeetings.org/jmm` for registration instructions and rates.

Employers: Choose a Table

There are three table types available for employers, based on the number of interviewers who will be present at any given time:

• One or two interviewers per table in the "Quiet Area" (US $350), each additional table (US$195).

• Three to six interviewers per table in the "Committee Table" area (US $440), each additional table (US$215).

• Free electricity is supplied to every table with purchase of the table.

• "One Day Tables" allow for on-site interviewing for one day without placing an ad. These tables, which can accommodate up to three interviewers, may only be purchased starting December 21, 2016 through January 6, 2017. The fee is US$195. Please register online at `www.mathjobs.org` and choose the "EC-One Day Table purchase."

Employers: Schedule an Interview

All Employment Center data and registration must be entered on the MathJobs.org site. An existing account can be used for accessing Employment Center services and for paying applicable fees. If no account exists, participants can start an account solely for Employment Center use.

Employers are expected to create their own interview schedules as far in advance as possible by using the assisted-e-mail system in MathJobs.org or by using other means of communication. Please do not schedule an interview to begin until fifteen minutes after the Employment Center opens (See schedule below).

Please mark appointments as confirmed in your MathJobs.org account, as this will allow the appointments to display in the applicants' schedules. At the time of

2017 Employment Center Schedule:

December 20, 2016 is the deadline for table registration. After this date only "One Day Tables" will be available for purchase. This is also the deadline to register for the JMM badge, needed for admittance to the EC, at Advanced Registration Prices.

HOURS of OPERATION (Please note there is no access to the EC prior to the opening times listed)**:**

Wednesday, January 4, 2017–8:00 am–5:30 pm

Thursday, January 5, 2017–8:00 am–5:30 pm

Friday, January 6, 2017–8:00 am–5:30 pm

Saturday, January 7, 2017–9:00 am–12:00 noon

Location: Centennial Ballroom, Lower Level 1, Hyatt Regency Atlanta, 265 Peachtree Street NE, Atlanta, Georgia.

Do not schedule an interview to begin until 15 minutes after opening.

Steve Schneider Photography.

interview, meet the applicant in the on-site waiting area and escort him or her to your table.

Employers: How to Register

• Registration runs early September 2016 through December 20, 2016 at the following website: www.mathjobs.org. After December 20, only "One-Day Tables" will be available. They should be reserved and paid for through MathJobs.org.

• Use your existing MathJobs.org account or create a new Employer account at www.mathjobs.org. Once a table is reserved, the ad can be placed at any time (or never) and will run until late January.

• For new users of MathJobs.org, click the NEW EMPLOYER link on the main page of www.mathjobs.org. Choose your table type and fill out the New Employer Form.

• For existing users of MathJobs.org, go to www.mathjobs.org. Log into your existing account. Purchase a table by clicking the "EmpCent" logo in the menus along the top tool bar. Use the "buy tables" link. Then post a job using the NewJob link or attach an existing job to your table.

• Each person who will need to enter the Employment Center area must have a meeting badge (obtained by registering for the JMM and paying a meeting registration fee).

To display an ad on-site, and use no Employment Center services at all, submit your one-page paper ad on-site in Atlanta to the Employment Center staff. There is no fee for this service.

For complete information, visit www.ams.org/emp-reg/.

Applicants: Making the Decision to Attend

• Past attendees have pointed out that all interviews are arranged in advance, and there is no opportunity to make connections on-site if it has not happened before the meeting.

• The Employment Center offers no guarantees of interviews or jobs. Hiring decisions are not made during or immediately following interviews. In the current job market, the ratio of applicants to employers is about 7:1, and many applicants go completely unnoticed.

• There will ordinarily be no research-oriented postdoctoral positions listed or discussed at the Employment Center.

• Interviews will go to applicants who applied to jobs during the fall and are now being sought out by the institutions for in-person meetings during the JMM.

• There will be no opportunity to speak to employers without a prearranged interview, and no walk-up job information tables. Scheduling of interviews will be complete prior to the JMM.

The majority of Employment Center employers are academic departments of mathematical sciences seeking to meet a short list of applicants who applied for their open positions during the fall. Each year, a few government or industry employers are present. Often, they are seeking US citizens only due to existing contracts.

All job postings are available on the website in advance, and now that this electronic service is in place, there is no other messaging conducted on paper.

In a recent survey, 50 percent of respondents reported being invited for at least one on-campus visit to an employer they had interviewed with at the Employment Center. Please visit the Employment Center website for further advice, information and program updates at www.ams.org/emp-reg.

Applicants: How to Register

• Early registration is vital since most employers will finalize schedules before arriving in Atlanta.

• To register, applicants should log into their MathJobs.org accounts or create a new account, look for the EmpCent icon across the top tool bar and mark that they will be attending by clicking the link, "click here if you are attending the Employment Center." You can then upload documents and peruse the list of employers attending and the positions available. You do not have the option to request an interview with an employer. However, if you are interested in any position, you can apply to the job. The employer will be aware that you are also attending the event and will contact you directly if interested in setting up an interview.

There are no Employment Center fees for applicants; however, admission to the Employment Center room requires a 2017 JMM badge, obtainable by registering (and paying a fee) for the JMM. To register for the meeting, go to the website: jointmathematicsmeetings.org/jmm.

It is possible to attend one or more privately arranged interviews without an official Employment Center registration; however, a meeting badge is required to access the interview room.

Applicants should keep track of their interview schedules and note their busy times in their accounts. If invited for an interview at a conflicting time, please suggest an alternate time or ask the employer to offer a new time.

For complete information, visit www.ams.org/emp-reg.

Questions about the Employment Center registration and participation can be directed to Pamela Morin, AMS Membership and Programs Department, at 800-321-4267, ext. 4060 or by e-mail to emp-info@ams.org.

AMS Short Course in Atlanta, GA

AMS Short Course on Random Growth Models

This two-day course will take place on Monday and Tuesday, January 2 and 3, before the Joint Meetings actually begin. It is co-organized by **Michael Damron**, Georgia Institute of Technology, **Firas Rassoul-Agha**, University of Utah, and **Timo Seppäläinen**, University of Wisconsin–Madison. The speakers also include **Ivan Corwin**, Columbia University; **Jack Hanson**, CUNY; and **Philippe Sosoe**, Harvard University.

The objective of the course is to give an overview of recent exciting progress in the study of a class of stochastic growth models called first- and last-passage percolation (FPP and LPP). The issues involve limit shapes, geodesics, and fluctuations.

Stochastic growth models have been studied since the 1960s and have their roots in theoretical physics and biology. Such systems describe the behavior of growing interfaces, the spread of bacterial colonies, traffic and queues in tandem, and random paths in a random potential. Studies of these models have led to exciting new mathematical phenomena. The order of magnitude of stochastic fluctuations and their limit laws differ from those in the classical Gaussian central limit theorem. Instead we find limit laws from random matrix theory, which is becoming the paradigm for describing complex dependencies.

Much progress has been made in a few exactly solvable special cases of the random growth models. Out of this effort has arisen a new distinct subject, integrable probability, with a deep algebraic component. However, thus far the tools of integrable probability apply only in the exactly solvable setting where special structures are present. On the broader class of models, researchers have had success with approaches that combine probability with ideas of a functional analytic and geometric nature. Examples include the use of concentration of measure and Busemann functions to study geodesics and prove fluctuation bounds, and curvature bounds in the derivation of the Kardar-Parisi-Zhang (KPZ) scaling relation.

The goal of the course is to survey these recent breakthroughs. The course is intended for a broad audience: from graduate students and researchers in probability to mathematicians interested in an introduction to the topic. For a light introduction to the subject, the reader is invited to turn to the accompanying article "Random Growth Models" on page 1004.

Introduction to Random Growth Models

(*2 lectures*)

Michael Damron, *Georgia Institute of Technology*

Random growth models come from physics and biology and describe, for instance, the motion of interfaces or the spread of infections. Mathematically, they give interesting examples of nontraditional limiting behavior: whereas independent statistical trials follow Gaussian laws, infection times in growth models can be related to eigenvalues of random matrices, and the Tracy-Widom distribution.

Michael Damron

Two main examples are first-passage percolation (FPP) and directed last-passage percolation (LPP). In these models an infection is set on a d-dimensional lattice and spreads across edges of this lattice according to nonnegative (random) *passage times* (t_e) on the edges in FPP and on the vertices in LPP. In the first case the infection takes a path of minimal passage time, whereas in the second it takes a directed path of maximal passage time. An infection started at a site x takes time $T(x, y)$ to infect y, and at time t an infection started at the origin has occupied a region $B(t)$ of the lattice.

In this course we will present some of the main areas of study for these percolation models, including existence and properties of limiting shapes, fluctuations

and second-order behavior for infection times, scaling exponents, connections to Busemann functions from geometry, and exactly solvable systems from integrable probability. These two introductory lectures will focus on basic probability needed for the course and the first topic above, convergence of the rescaled infected region $B(t)/t$ to a limiting shape $\boldsymbol{B}$ as $t\to\infty$. This limiting shape $\boldsymbol{B}$ depends on the distribution of the passage times (t_e), but due to its being defined using the subadditive ergodic theorem (and not the usual ergodic theorem), it is known explicitly only in a handful of solvable cases. Even basic conjectured properties, such as the shape being nonpolygonal (proved however in LPP) and having differentiable boundary, are generally not verified. However, recently advances have been made characterizing these shapes via variational formulas.

After discussing limiting shapes, we will move to the convergence rate to the limit and its representation in terms of random and nonrandom errors. These errors are connected to the geometry of optimal infection paths, or geodesics. For example, it is believed that the symmetric difference between $B(t)/t$ and $\boldsymbol{B}$ has width of order $t^{\varsigma-1}$ for a dimension-dependent exponent ς, whereas the geodesic from x to y should deviate from the straight line connecting these points by $\|x-y\|^{\xi}$ for an exponent ξ, related to ς by $\varsigma=2\xi-1$.

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Infinite Geodesics, Asymptotic Directions, and Busemann Functions

Jack Hanson, *The City College of New York*

Jack Hanson

In the model of first-passage percolation (FPP) on the d-dimensional lattice, a finite geodesic between vertices x and y is a path from x to y of minimal weight; equivalently, it is an optimizing path for the metric $T(x, y)$. Finite geodesics can also be seen as paths through which the infection spreads in the model's growth process. An infinite geodesic is an infinite path whose finite subpaths are finite geodesics. There are many natural questions about the structure of infinite geodesics, including the number of distinct infinite geodesics, whether they are asymptotically confined to sectors or allowed to backtrack significantly, and whether a doubly infinite geodesic ("bigeodesic") can exist. These questions are closely related to the properties of finite geodesics between distant points.

Much can be said about these questions under an unproven curvature assumption on the model's limiting shape $\boldsymbol{B}$, for instance, that every infinite geodesic has an asymptotic direction. Busemann functions were brought to the model as a tool for proving similar statements under minimal assumptions. Busemann functions allowed the first proof that there exist more than two disjoint infinite geodesics without any unverified assumptions. They also shed light on the questions of directedness and bigeodesics mentioned above, as well as coexistence properties of competing infections.

Generally, Busemann functions take the form $B(x,y)=\lim_{k\to\infty}[T(x,z_k)-T(y,z_k)]$ for some sequence (z_k) of lattice points, for instance, the sequence of points lying along an infinite geodesic. $B(x,y)$ encodes the relative favorability of the points x and y for infecting z_k for k large, and so the asymptotic behavior of B governs the regions through which geodesics to (z_k) prefer to pass. We will discuss the limiting behavior of Busemann functions and its relationship to the limiting behavior of geodesics to the points z_k. We also will discuss the existence of the limit defining B and techniques for handling these existence questions.

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Concentration in First-Passage Percolation

Philippe Sosoe, *Harvard University*

Philippe Sosoe

In first-passage percolation (FPP) the passage time from the origin to vertex x is defined as $T(0,x)=\min_\gamma \sum_{e\in\gamma} t_e$, the minimal passage time of paths γ that connect 0 to x. t_e is the random passage time attached to edge e of the lattice. The order of fluctuations of $T(0,x)$ for $\|x\|_1 \gg 1$ has been the subject of intense investigation. It is believed that the variance of the passage time grows as $\|x\|_1^{2\zeta}$, for some $\zeta>0$. In two dimensions, the exponent ζ is expected to be typical of the Kardar-Parisi-Zhang (KPZ) universality class $\zeta=1/3$. This relation has been confirmed rigorously for some special models of last-passage percolation, but it remains mysterious in the case of first-passage percolation. In general dimension the fluctuations are even less understood. There are no widely accepted conjectures for the value of the exponent ζ that governs the growth of the variance or for its behavior as the dimension increases to infinity. In addition, little is known about lower bounds for the variance.

This lecture discusses known bounds on the order of the fluctuations in FPP in $\mathbb{Z}^d$, for general dimension d, focusing on variants of two main results: first, exponential concentration on a linear scale for the passage times, as was proved by Kesten. This was later improved to Gaussian concentration by Talagrand using his theory of concentration of measure. After reviewing some basic probabilistic tools, we will explain how Kesten and Talagrand's results now follow from standard methods in concentration inequalities.

Second, we will present an upper bound of order $\|x\|_1/\log\|x\|_1$ for the variance of $T(0,x)$. Such a bound was first derived by Benjamini, Kalai, and Schramm (BKS) for Bernoulli edge weights. The BKS result was generalized to other edge weight distributions, first by Benaïm-Rossignol and then by Damron, Hanson, and Sosoe.

Although it is expected to be far from the truth, this sublinear upper bound remains the best known to date. We will explain how it follows by supplementing standard concentration results with the key observation from the original BKS paper that individual edge weight variables have *small influence* on the overall passage time.

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Busemann Functions, Geodesics, and the Competition Interface for Directed Percolation

Firas Rassoul-Agha

Firas Rassoul-Agha, *University of Utah*

In the planar directed last-passage percolation model (LPP) independent and identically distributed random weights ω_x are put on the vertices of the square lattice. Only paths that take up or right steps are considered. The weight (or passage time) of a path γ *is* the sum of the weights at the sites it traverses: $T(\gamma)=\sum_{x\in\gamma}\omega_x$. The last-passage time $T(x,y)=\max_\gamma T(\gamma)$ from x to y is the maximal passage time of all upright paths connecting x and y. A path between x and y is a geodesic if it has maximal weight. Directed LPP has the advantage over undirected FPP in that in the planar case there are exactly solvable cases that provide a window to the deeper properties of the entire class of models.

Several different much-studied stochastic models can be formulated in this last-passage language: (i) the corner growth model, which is a randomly growing cluster on the lattice; (ii) queues in series; and (iii) one of the most fundamental interacting particle systems, namely, TASEP, or the totally asymmetric simple exclusion process. By letting two infections from different seeds compete for space, the growth model can be turned into a model of competition.

In this talk we show how the Busemann function limit can be proved with the help of results from queueing theory. As is the case for first-passage percolation, these Busemann functions carry information about the large-scale behavior of the system. They provide equations for the limiting shape function $g(x)=\lim_{n\to\infty} n^{-1}T(0,nx)$ and can be used to prove existence, uniqueness, and coalescence of geodesics under mild regularity assumptions on the limiting shape. Busemann functions can also be used to study the interface between the two growing infections.

The special solvable case is the one whose vertex weights are exponentially or geometrically distributed Then the probability distribution of the Busemann functions becomes fairly explicit. This leads to a number of precise results, such as closed-form expressions for the limit shape function g and for the limiting angle of the competition interface.

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Stationary Versions and Fluctuation Exponents for Exactly Solvable Models

Timo Seppäläinen, *University of Wisconsin–Madison*


Timo Seppäläinen

The planar random growth models discussed in this course are expected to be members of the *Kardar-Parisi-Zhang (KPZ) universality class*. This means that on large scales the stochastic fluctuations of these systems obey the same laws, regardless of the particular details of the models, as long as the random passage times out of which the models are built do not behave too wildly. At the crudest level we measure the order of magnitude of fluctuations in terms of *fluctuation exponents* relative to the size of the system. To take a basic example, let $S_n = X_1 + \cdots + X_n$ be a random walk with independent and identically distributed mean zero increments X_k. Then the mean square of S_n satisfies $E(S_n^2) = n \cdot E(X_1^2)$. Thus on average S_n grows at rate $n^{1/2}$; in other words, the fluctuation exponent is $1/2$.

The KPZ class has different exponent values: the passage time $T(0,nx)$ is expected to have fluctuations of order $n^{1/3}$, and the distance at which spatial correlations occur is supposed to be of order $n^{2/3}$. At the level of genuine universality this remains a mathematical conjecture. However, among directed growth models in two dimensions there are special *exactly solvable* ones where fortuitous coincidences of combinatorics and probability permit rigorous derivation of these exponents. The oldest such is the corner growth model with exponentially distributed passage times on the lattice vertices. One manifestation of the exact solvability is the existence of tractable *stationary* versions of the models. Stationarity means that the probability laws are suitably invariant under lattice translations. Stationarity allows us to capture long-term behavior.

The exponent $2/3$ appears when we ask about the fluctuations of the geodesics. Macroscopically, at the level of deterministic law of large numbers limits, the optimal path from 0 to x is a straight line. At the microscopic level, the optimal random path from 0 to nx is expected to fluctuate in a band of width of order $n^{2/3}$ around its straight line limit. This we can also partially prove in exactly solvable models.

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KPZ Fluctuations in Exactly Solvable Models

Ivan Corwin, *Columbia University*


Ivan Corwin

Some random growth models admit concise and exact formulas describing expectations of various observables of interest. These models and their solvability spring from certain algebraic structures such as representation theory and quantum integrable systems. By studying these examples, we are able to gain predictions for the universal behaviors of a much wider class of random growth models, the so-called Kardar-Parisi-Zhang (KPZ) universality class.

We will touch on some of the models discussed earlier in the short course and on some new ones, such as directed last-passage percolation, positive temperature directed polymers, the (totally) asymmetric simple exclusion process, the KPZ stochastic partial differential equation, and others. We sketch a proof of the asymptotic fluctuation scaling and statistics for one of these models and indicate how this generalizes to the broader class.

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Registration

There are separate fees to register for this Short Course. Advanced registration fees for members are US$112; nonmembers US$170; and students/unemployed or emeritus members US$60. These fees are in effect until **December 20, 2016**. If you choose to register on-site, the fees for members are US$146; nonmembers US$200, and students/unemployed or emeritus members US$81. Advanced registration starts on **September 6, 2016**. On-site registration will take place on Monday, January 2, 2017, at a location to be announced.

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MEETINGS & CONFERENCES OF THE AMS

OCTOBER TABLE OF CONTENTS

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 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.

The most up-to-date meeting and conference information can be found online at: **www.ams.org/meetings/**.

Important Information About AMS Meetings: Potential organizers, speakers, and hosts should refer to page 88 in the January 2016 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 similarily coded material (such as accent marks in text) must be typeset in LaTeX. Visit **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.

MEETINGS IN THIS ISSUE

Conferences in Cooperation with the AMS

Indian Mathematics Consortium

December 14–17, 2016

Banaras Hindu University

Varanasi, India

See **www.ams.org/meetings/** *for the most up-to-date information on these conferences.*

ASSOCIATE SECRETARIES OF THE AMS

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Western Section: Michel L. Lapidus, Department of Mathematics, University of California, Surge Bldg., Riverside, CA 92521-0135; e-mail: lapidus@math.ucr.edu; telephone: 951-827-5910.

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 `www.ams.org/meetings/`.

Final programs for Sectional Meetings will be archived on the AMS website accessible from the stated URL.

Denver, Colorado

University of Denver

October 8–9, 2016

Saturday – Sunday

Meeting #1122

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: August 2016
Program first available on AMS website: To be announced
Issue of *Abstracts*: Volume 37, Issue 3

Deadlines

For organizers: Expired
For abstracts: Expired

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Henry Cohn, Microsoft Research New England, *The sphere packing problem in dimensions 8 and 24*.

Ron Hadani, University of Texas at Austin, *Representation theoretic patterns in three dimensional cryo-electron microscopy*.

Chelsea Walton, Temple University, *Quantum Symmetry*.

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at `www.ams.org/cgi-bin/abstracts/abstract.pl`.

Above and Beyond Fluid Flow studies: In celebration of the 60th birthday of Prof. William Layton, **Traian Iliescu**, Virginia Polytechnic Institute and State University, **Alexander Labovsky**, Michigan Technological University, **Monika Neda**, University of Nevada, Las Vegas, and **Leo Rebholz**, Clemson University.

Algebraic Combinatorics, **Anton Betten**, Colorado State University, **Jason Williford**, University of Wyoming, and **Bangteng Xu**, Eastern Kentucky University.

Algebraic Logic, **Nick Galatos**, University of Denver, and **Peter Jipsen**, Chapman University.

Analysis on Graphs and Spectral Graph Theory, **Paul Horn** and **Mei Yin**, University of Denver.

Aspects of PDE Arising from Modeling of the Flows in Porous Media, **Akif Ibraguimov**, Texas Tech University, **Viktoria Savatorova**, University of Nevada, Las Vegas, and **Aleksey Telyakovskiy**, University of Nevada, Reno.

Discontinuous Galerkin methods for partial differential equations: Theory and applications, **Mahboub Baccouch**, University of Nebraska at Omaha.

Floer Theoretic Invariants of 3-manifolds and Knots, **Jonathan Hanselman**, University of Texas at Austin, and **Kristen Hendricks**, University of California, Los Angeles.

Foundations of Numerical Algebraic Geometry, **Abraham Martin del Campo**, CIMAT, Guanajuato, Mexico, and **Frank Sottile**, Texas A&M University.

Groups and Representation Theory, **C. Ryan Vinroot**, College of William and Mary, **Julianne Rainbolt**, Saint Louis University, and **Amanda Schaeffer Fry**, Metropolitan State University of Denver.

Integrable Systems and Soliton Equations, **Anton Dzhamay**, University of Northern Colorado, and **Patrick Shipman**, Colorado State University.

Nonassociative Algebra, **Izabella Stuhl**, University of Debrecen and University of Denver, and **Petr Vojtěchovský**, University of Denver.

Noncommutative Geometry and Fundamental Applications, **Frederic Latremoliere**, University of Denver.

Nonlinear Wave Equations and Applications, **Mark J. Ablowitz**, University of Colorado Boulder, and **Barbara Prinari**, University of Colorado Colorado Springs.

Nonlinear and Stochastic Partial Differential Equations, **Michele Coti Zelati**, University of Maryland, **Nathan Glatt-Holtz**, Tulane University, and **Geordie Richards**, University of Rochester.

Operator Algebras and Applications, **Alvaro Arias**, University of Denver.

Quantum Algebra, **Chelsea Walton**, Temple University, **Ellen Kirkman**, Wake Forest University, and **James Zhang**, University of Washington, Seattle.

Random Matrices, Integrable Systems, and Applications, **Sean D. O'Rourke**, University of Colorado Boulder, and **David Renfrew**, University of California, Los Angeles.

Recent Advances in Structural and Extremal Graph Theory, **Michael Ferrara**, **Stephen Hartke**, **Michael Jacobson**, and **Florian Pfender**, University of Colorado Denver.

Recent Trends in Semigroup Theory, **Michael Kinyon**, University of Denver, and **Ben Steinberg**, City College of New York.

Set Theory of the Continuum, **Natasha Dobrinen** and **Daniel Hathaway**, University of Denver.

Unimodularity in Randomly Generated Graphs, **Florian Sobieczky**, University of Denver.

Vertex Algebras and Geometry, **Andrew Linshaw**, University of Denver, and **Thomas Creutzig** and **Nicolas Guay**, University of Alberta.

Zero Dimensional Dynamics, **Nic Ormes** and **Ronnie Pavlov**, University of Denver.

Minneapolis, Minnesota

University of St. Thomas (Minneapolis campus)

October 28–30, 2016

Friday – Sunday

Meeting #1123

Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: August 2016
Program first available on AMS website: To be announced
Issue of *Abstracts*: Volume 37, Issue 4

Deadlines

For organizers: Expired
For abstracts: Expired

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Thomas Nevins, University of Illinois at Urbana-Champaign, *Algebraic Symplectic Varieties, Classical and Quantum*.

Charles Rezk, University of Illinois Urbana-Champaign, *On Some Approximations to Homotopy Theory*.

Christof Sparber, Department of Mathematics, Statistics & Computer Science, University of Illinois at Chicago, *Semiclassical quantum dynamics via Bohmian trajectories*.

Samuel N. Stechmann, University of Wisconsin-Madison, *Stochastic PDEs for Tropical Weather and Climate*.

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at `www.ams.org/cgi-bin/abstracts/abstract.pl`.

Advances in Algebraic Coding Theory, **Sarah E. Anderson**, University of St. Thomas, and **Katie Haymaker**, Villanova University.

Chip-Firing and Divisors on Graphs and Complexes, **Caroline Klivans**, Brown University, and **Gregg Musiker** and **Victor Reiner**, University of Minnesota.

Combinatorial Matrix Theory, **Adam Berliner**, St. Olaf College, **Brenda Kroschel**, University of St. Thomas, and **Nathan Warnberg**, University Wisconsin-LaCrosse.

Combinatorial Representation Theory, **Michael Chmutov**, University of Minnesota, **Tom Halverson**, Macalester College, and **Travis Scrimshaw**, University of Minnesota.

Discrete Structures: Analysis and Applications (IMA Reunion), **Leslie Hogben** and **Ryan Martin**, Iowa State University, and **Elisabeth Werner**, Case Western Reserve University.

Effective Mathematics in Discrete and Continuous Worlds, **Wesley Calvert**, Southern Illinois University, and **Timothy McNicholl**, Iowa State University.

Enumerative Combinatorics, **Eric Egge**, Carleton College, and **Joel Brewster Lewis**, University of Minnesota.

Extremal and Probabilistic Combinatorics, **Andrew Beveridge**, Macalester College, **Jamie Radcliffe**, University of Nebraska Lincoln, and **Michael Young**, Iowa State University.

Geometric Flows, Integrable Systems and Moving Frames, **Joseph Benson**, St. Olaf College, **Gloria Mari-Beffa**, University of Wisconsin-Madison, **Peter Olver**, University of Minnesota, and **Rob Thompson**, Carleton College.

Integrable Systems and Related Areas, **Sam Evens**, University of Notre Dame, **Luen-Chau Li**, Pennsylvania State University, and **Zhaohu Nie**, Utah State University.

Knotting in Physical Systems, in celebration of Kenneth C. Millett's 75th birthday, **Jorge Alberto Calvo**, Ave Maria University, and **Eric Rawdon**, University of St. Thomas.

Mathematics and Physics of Tornado Modeling, **Pavel Belik**, Augsburg College, and **Douglas P. Dokken**, **Kurt Scholz**, and **Misha Shvartsman**, University of St. Thomas.

Modeling and Predicting the Atmosphere, Oceans, and Climate, **Sam Stechmann**, University of Wisconsin-Madison.

Multi-scale Phenomena in Linear and Nonlinear Partial Differential Equations, **Zaher Hani**, Georgia Tech, and **Christof Sparber**, University of Illinois at Chicago.

New Developments in the Analysis of Nonlocal Operators, **Donatella Danielli** and **Arshak Petrosyan**, Purdue University, and **Camelia Pop**, University of Minnesota.

Noncommutative Algebras and Their Representations, **Miodrag Iovanov** and **Ryan Kinser**, University of Iowa, and **Peter Webb**, University of Minnesota.

Quantum Field Theories and Geometric Representation Theory, **Emily Cliff**, University of Oxford, and **Thomas Nevins**, University of Illinois at Urbana-Champaign.

Representation Theory, Automorphic Forms and Related Topics, **Kwangho Choiy**, Southern Illinois University, **Dihua Jiang**, University of Minnesota, and **Shuichiro Takeda**, University of Missouri.

Symplectic Geometry and Contact Geometry, **Tian-Jun Li** and **Cheuk Yu Mak**, University of Minnesota, and **Ke Zhu**, Minnesota State University.

The Topology of 3- and 4-Manifolds, **Maggy Tomova**, University of Iowa, and **Alexander Zupan**, University of Nebraska-Lincoln.

Topology and Arithmetic, **Tyler Lawson** and **Craig Westerland**, University of Minnesota, Twin Cities.

Topology and Physics, **Ralph Kaufmann**, Purdue University, and **Alexander Voronov**, University of Minnesota, Twin Cities.

Women in Analysis and Partial Differential Equations, **Svitlana Mayboroda**, University of Minnesota.

p-Adic Analysis in Number Theory, **C. Douglas Haessig**, University of Rochester, and **Steven Sperber**, University of Minnesota.

Raleigh, North Carolina

North Carolina State University

November 12–13, 2016

Saturday – Sunday

Meeting #1124

Southeastern Section
Associate secretary: Brian D. Boe
Announcement issue of *Notices*: September 2016
Program first available on AMS website: September 22, 2016
Issue of *Abstracts*: Volume 37, Issue 4

Deadlines

For organizers: Expired
For abstracts: Expired

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Ricardo Cortez, Tulane University, *Mathematical and Computational Modeling of Microorganism Swimming*.

Gaven J. Martin, Massey University, *Siegel's problem on small volume lattices* (AMS-NZMS Maclaurin Lecture).

Jason Metcalfe, University of North Carolina at Chapel Hill, *Local Energy Decay for the Wave Equation*.

Agnes Szanto, North Carolina State University, *Certification of Approximate Roots of Exact Polynomial Systems*.

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at `www.ams.org/cgi-bin/abstracts/abstract.pl`.

Advances in Numerical Methods for Partial Differential Equations, **Andreas Aristotelous**, West Chester University, and **Thomas Lewis**, The University of North Carolina at Greensboro.

Algebraic Structures Motivated by and Applied to Knot Theory, **Jozef H. Przytycki**, The George Washington University, and **Radmila Sazdanovic**, North Carolina State University.

Applied Algebraic Geometry, **Seth Sullivant** and **Agnes Szanto**, North Carolina State University.

Commutative Ring Theory (in honor of Jay Shapiro's retirement), **Neil Epstein**, George Mason University, and **Alan Loper**, Ohio State University.

Contemporary Geometric Methods in Mechanics and Control, **Vakhtang Putkaradze**, University of Alberta, and **Dmitry Zenkov**, North Carolina State University.

Control, Optimization, and Differential Games, **Lorena Bociu**, North Carolina State University, and **Tien Khai Nguyen**, Penn State University.

Difference Equations and Applications, **Michael A. Radin**, Rochester Institute of Technology, and **Youssef Raffoul**, University of Dayton.

Geometry and Topology in Image and Shape Analysis, **Irina Kogan**, North Carolina State University, and **Facundo Mémoli**, The Ohio State University.

Graphs, Hypergraphs, and Set Systems, **David Galvin**, University of Notre Dame, and **Clifford Smyth**, University of North Carolina Greensboro.

Harmonic Analysis and Dispersive PDE, **Robert Booth**, **Jason Metcalfe**, and **Katrina Morgan**, University of North Carolina.

Homological Methods in Commutative Algebra, **Alina Iacob** and **Saeed Nasseh**, Georgia Southern University.

Low-dimensional Topology, **Caitlin Leverson**, Georgia Tech, **Tye Lidman**, North Carolina State University, and **Leonard Ng**, Duke University.

Mathematical Modeling of Infectious Disease and Immunity, **Lauren Childs**, Virginia Tech and Harvard Chan School of Public Health, and **Stanca Ciupe**, Virginia Tech.

Mathematical String Theory, **Paul Aspinwall**, Duke University, **Ilarion Melnikov**, James Madison University, and **Eric Sharpe**, Virginia Tech.

Metric and Topological Oriented Fixed Point Theorems, **Clement Boateng Ampadu**, Boston, MA, **Sartaj Ali**, National College of Business Administration and Economics, Lahore, Pakistan, **Xiaorong Liu**, University of Colorado at Boulder, and **Xavier Alexius Udo-Utun**, University of Uyo, Uyo, Nigeria.

Nonlinear Boundary Value Problems, **Maya Chhetri**, UNC Greensboro, and **Stephen Robinson**, Wake Forest University.

Recent Advances in Stochastic Processes and Stochastic Computation, **Jianfeng Lu** and **James Nolen**, Duke University, and **Kostas Spiliopoulous**, Boston University.

Representations of Lie Algebras, Quantum Groups and Related Topics, **Naihuan Jing** and **Kailash C. Misra**, North Carolina State University.

Set Theoretic Topology, **Alan Dow**, UNC-Charlotte, and **Jerry Vaughan**, UNC-Greensboro.

Structural and Computational Graph Theory, **Stephen Harte**, University of Colorado Denver, and **Bernard Lidický**, Iowa State University.

The Analysis of Inverse Problems and their Applications, **Shitao Liu**, Clemson University, and **Loc Nguyen**, University of North Carolina.

Varieties, Their Fibrations and Automorphisms in Mathematical Physics and Arithmetic Geometry, **Jimmy Dillies** and **Enka Lakuriqi**, Georgia Southern University, and **Tony Shaska**, Oakland University.

Atlanta, Georgia

Hyatt Regency Atlanta and Atlanta Marriott Marquis

January 4–7, 2017
Wednesday–Saturday

Meeting #1125

Joint Mathematics Meetings, including the 123rd Annual Meeting of the AMS, 100th Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association of Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
AMS Associate Secretary: Brian Boe
Announcement issue of *Notices*: November 2016
Program first available on AMS website: To be announced

Deadlines

For organizers: Expired
For abstracts: September 20, 2016
The scientific information listed below may be dated. For the latest information, see www.ams.org/meetings/national.html.

Joint Invited Addresses

Ingrid Daubechies, Duke University, *Mathematics for art investigation* (MAA-AMS-SIAM Gerald and Judith Porter Public Lecture); Saturday, 3:00 pm.

Lisa Jeffrey, University of Toronto, *Cohomology of Symplectic Quotients,* (AWM-AMS Noether Lecture); Thursday, 10:05 am.

Donald Richards, Pennsylvania State University, *Distance Correlation Coefficients: A New Tool for Detecting Association and Measuring Correlation Between Data Sets* (AMS-MAA Invited Address); Friday, 11:10 am.

Alice Silverberg, University of California, Irvine, *Through the Cryptographer's Looking Glass, and What Alice Found There* (AMS-MAA Invited Address); Wednesday, 11:10 am.

Joint Prize Session

In order to showcase the achievements of recipients of the various prizes, the AMS and MAA are co-sponsoring this event at 4:25 pm on Thursday. A cash bar reception will immediately follow. All participants are invited to attend. The AMS, MAA, and SIAM will announce the JPBM Communications Award winner. The AMS, MAA, and SIAM will award the Frank and Brennie Morgan Prize for Outstanding Research in Mathematics by an Undergraduate Student. The AMS will announce the Böcher Memorial Prize, Levi L. Conant Prize, the Frank Nelson Cole Prize in Number Theory, the Joseph L. Doob Prize, the Leonard Eisenbud Prize for Mathematics and Physics, the Ruth Lyttle Satter Prize, and the Leroy P. Steele Prizes. The MAA will award the Beckenbach Book Prize, the Euler Book Prize, Deborah and Franklin Tepper Haimo Awards for Distinguished College or University Teaching of Mathematics, the Robbins Prize, and the Yueh-Gin Gung and Dr. Charles Y. Hu Award for Distinguished Service to Mathematics. The AWM will present the Louise Hay Award for Contributions to Mathematics Education, the M. Gweneth Humphreys Award for Mentorship of Undergraduate Women in Mathematics, and the Birman Prize in Geometry and Topology.

123nd Meeting of the AMS

AMS Invited Addresses

Tobias Colding, Massachusetts Institute of Technology, *Title to be announced*; Saturday, 9:00 am.

Carlos E. Kenig, University of Chicago, *Overview: The focusing energy critical wave equation* (AMS Colloquium Lectures: Lecture I), Wednesday, 1:00 pm.

Carlos E. Kenig, University of Chicago, *The focusing energy critical wave equation*: *the radial case in 3 space dimensions* (AMS Colloquium Lectures: Lecture II); Thursday, 1:00 pm.

Carlos E. Kenig, University of Chicago, *The focusing energy critical wave equation: the non-radial case* (AMS Colloquium Lectures: Lecture III); Friday, 1:00 pm.

John Preskill, California Institute of Technology, *Title to be announced* (AMS Josiah Willard Gibbs Lecture), Wednesday, 8:30 pm.

Barry Simon, California Institute of Technology, *Spectral Theory Sum Rules, Meromorphic Herglotz Functions and Large Deviations*; Wednesday, 10:05 am.

Gigliola Staffilani, Massachusetts Institute of Technology, *The many faces of dispersive and wave equations*; Thursday, 2:15 pm.

Richard Taylor, Institute for Advanced Study, *Galois groups and locally symmetric spaces*; Thursday, 3:20 pm.

Anna Wienhard, Heidelberg University, *A tale of rigidity and flexibility–discrete subgroups of higher rank Lie groups*; Friday, 10:05 am.

AMS Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at `jointmathematicsmeetings.org/meetings/abstracts/abstract.pl?type=jmm`.

Some sessions are co-sponsored with other organizations. These are noted within the parentheses at the end of each listing, where applicable.

Advanced Mathematical Programming and Applications, **Ram N. Mohapatra**, University of Central Florida, **Ram U. Verma**, University of North Texas, and **Gayatri Pany**, Indian Institute of Technology.

Advances in Mathematics of Ecology, Epidemiology and Immunology of Infectious Diseases, **Abba Gumel**, Arizona State University.

Advances in Numerical Analysis for Partial Differential Equations, **Thomas Lewis**, University of North Carolina at Greensboro, and **Amanda Diegel**, Louisiana State University.

Advances in Operator Algebras, **Michael Hartglass**, University of California, Riverside, **David Penneys**, University of California, Los Angeles, and **Elizabeth Gillaspy**, University of Colorado, Boulder.

Algebraic Statistics (a Mathematics Research Communities Session) **Daniel Irving Bernstein**, North Carolina State University, **Nathaniel Bushek**, University of Alaska, Anchorage, and **Mateja Raic**, University of Illinois at Chicago.

An Amicable Combination of Algebra and Number Theory (Dedicated to Dr. Helen G. Grundman), **Eva Goedhart**, Lebanon Valley College, **Pamela E. Harris**, Williams College, **Daniel P. Wisniewski**, DeSales University, and **Alejandra Alvarado**, Eastern Illinois University.

Analysis of Fractional, Stochastic, and Hybrid Dynamic Systems and their Applications, **Aghalaya S. Vatsala**, University of Louisiana, **Gangaram S. Ladde**, University of South Florida, and **John R. Graef**, University of Tennessee at Chattanooga.

Analytic Number Theory and Arithmetic, **Robert Lemke Oliver**, Tufts University, **Paul Pollack**, University of Georgia, and **Frank Thorne**, University of South Carolina.

Analytical and Computational Studies in Mathematical Biology, **Yanyu Xiao**, University of Cincinnati, and **Xiang-Sheng Wang**, Southeast Missouri State University.

ApREUF: Applied Research Experience for Undergraduate Faculty, **Shenglan Yuan**, LaGuardia Community College, CUNY, **Jason Callahan**, St. Edwards University, **Eva Strawbridge**, James Madison University, and **Ami Radunskaya**, Pomona College.

Applications of Partially Ordered Sets in Algebraic, Topological, and Enumerative Combinatorics, **Rafael S. González D'León**, University of Kentucky, and **Joshua Hallam**, Wake Forest University.

Arithmetic Properties of Sequences from Number Theory and Combinatorics, **Eric Rowland**, Hofstra University, and **Armin Straub**, University of South Alabama.

Automorphic Forms and Arithmetic, **Frank Calegari**, University of Chicago, **Ana Caraiani**, Princeton University, and **Richard Taylor**, Institute for Advanced Study.

Bases in Function Spaces: Sampling, Interpolation, Expansions and Approximations, **Shahaf Nitzan** and **Christopher Heil**, Georgia Institute of Technology, and **Alexander V. Powell**, Vanderbilt University.

Character Varieties (a Mathematics Research Communities Session), **Nathan Druivenga**, University of Kentucky, **Brett Frankel**, Northwestern University, and **Ian Le**, Perimeter Institute for Theoretical Physics.

Coding Theory for Modern Applications, **Christine A. Kelley**, University of Nebraska-Lincoln, **Iwan M. Duursma**, University of Illinois Urbana-Champaign, and **Gretchen L. Matthews**, Clemson University.

Combinatorial and Cohomological Invariants of Flag Manifolds and Related Varieties, **Martha Precup**, Northwestern University, and **Rebecca Goldin**, George Mason University.

Commutative Algebra: Research for Undergraduate and Early Graduate Students, **Nicholas Baeth**, University of Central Missouri, and **Courtney Gibbons**, Hamilton College.

Complex Analysis and Special Functions, **Brock Williams**, Texas Tech University, **Kendall Richards**, Southwestern University, and **Alex Solynin**, Texas Tech University.

Continued Fractions, **James McLaughlin**, West Chester University, **Geremías Polanco**, Hampshire College, and **Nancy J. Wyshinski**, Trinity College.

Control and Long Time Behavior of Evolutionary PDEs, **Louis Tebou**, Florida International University, and **Luz de Teresa**, Instituto de Matemáticas, UNAM.

Discrete Geometry and Convexity (Dedicated to András Bezdek on the occasion of his 60th birthday), **Krystyna Kuperberg**, Auburn University, **Gergely Ambrus**, Renyi Institute of Mathematics, **Braxton Carrigan**, Southern Connecticut State University, and **Ferenc Fodor**, University of Szeged.

Discrete Structures in Number Theory, **Anna Haensch**, Duquesne University, and **Adriana Salerno**, Bates College.

Dynamical Systems, **Jim Wiseman**, Agnes Scott College, and **Aimee Johnson**, Swarthmore College.

Dynamics of Fluids and Nonlinear Waves, **Zhiwu Lin**, **Jiayin Jin**, and **Chongchun Zeng**, Georgia Institute of Technology.

Ergodic Theory and Dynamical Systems, **Mrinal Kanti Roychowdhury**, University of Texas Rio Grande Valley, and **Tamara Kucherenko**, City College of New York.

Fusion Categories and Quantum Symmetries, **Julia Plavnik**, Texas A&M University, **Paul Bruillard**, Pacific Northwest National Laboratory, and **Eric Rowell**, Texas A&M University.

Gaussian Graphical Models and Combinatorial Algebraic Geometry, **Rainer Sinn**, Georgia Institute of Technology, **Seth Sullivant**, North Carolina State University, and **Josephine Yu**, Georgia Institute of Technology.

Graphs and Matrices, **Sudipta Mallik**, Northern Arizona University, **Keivan Hassani Monfared**, University of Calgary, and **Bryan Shader**, University of Wyoming.

Group Actions and Geometric Structures, **Anna Wienhard**, Universität Heidelberg, and **Jeffrey Danciger**, University of Texas at Austin.

Group Representations and Cohomology, **Hung Nguyen**, The University of Akron, **Nham Ngo**, The University of Arizona, **Andrei Pavelescu**, University of South Alabama, and **Paul Sobaje**, University of Georgia.

Harmonic Analysis (In Honor of Gestur Olafsson's 65th Birthday), **Jens Christensen**, Colgate University, and **Susanna Dann**, Technische Universität Wien-Vienna, Austria.

History of Mathematics, **Adrian Rice**, Randolph-Macon College, **Sloan Despeaux**, Western Carolina University, and **Daniel Otero**, Xavier University (AMS-MAA-ICHM).

Hopf Algebras and their Actions, **Henry Tucker**, University of California, San Diego, **Susan Montgomery**, University of Southern California - Los Angeles, and **Siu-Hung Ng**, Louisiana State University.

Inverse Problems and Applications, **Vu Kim Tuan** and **Amin Boumenir**, University of West Georgia.

Inverse Problems and Multivariate Signal Analysis, **M. Zuhair Nashed**, University of Central Florida, **Willi Freeden**, University of Kaiserslautern, and **Otmar Scherzer**, University of Vienna.

Lie Group Representations, Discretization, and Gelfand Pairs (a Mathematics Research Communities Session), **Matthew Dawson**, CIMAT, **Holley Friedlander**, Dickenson College, **John Hutchens**, Winston-Salem State University, and **Wayne Johnson,** Truman State University.

Mapping Class Groups and their Subgroups, **James W. Anderson**, University of Southampton, UK, and **Aaron Wootton**, University of Portland.

Mathematics and Music, **Mariana Montiel**, Georgia State University, and **Robert Peck**, Louisiana State University.

Mathematics in Physiology and Medicine (a Mathematics Research Communities Session), **Kamila Larripa**, Humboldt State University, **Charles Puelz**, Rice University, **Laura Strube**, University of Utah, and **Longhua Zhao**, Case Western Reserve University.

Mathematics of Cryptography, **Nathan Kaplan** and **Alice Silverberg**, University of California, Irvine (AMS-MAA).

Mathematics of Signal Processing and Information, **Rayan Saab**, University of California, San Diego, and **Mark Iwen**, Michigan State University.

Measure and Measurable Dynamics (In Memory of Dorothy Maharam, 1917–2014), **Cesar Silva**, Williams College.

Minimal Integral Models of Algebraic Curves, **Tony Shaska**, Oakland University.

NSFD Discretizations: Recent Advances, Applications, and Unresolved Issues, **Talitha M. Washington**, Howard University, and **Ronald E. Mickens**, Clark Atlanta University.

New Developments in Noncommutative Algebra & Representation Theory, **Ellen Kirkman**, Wake Forest University, and **Chelsea Walton**, Temple University.

Nonlinear Systems and Applications, **Wenrui Hao**, Ohio State University.

Open & Accessible Problems for Undergraduate Research, **Allison Henrich**, Seattle University, **Michael Dorff**, Brigham Young University, and **Nicholas Scoville**, Ursinus College.

Operator Theory, Function Theory, and Models, **William Ross**, Florida Gulf Coast University, and **Alberto Condori**, University of Richmond.

Orthogonal Polynomials, **Doron Lubinsky** and **Jeff Geronimo**, Georgia Institute of Technology.

PDE Analysis on Fluid Flows, **Xiang Xu**, Old Dominion University, and **Geng Chen** and **Ronghua Pan**, Georgia Institute of Technology.

PDEs for Fluid flow: Analysis and Computation, **Thinh Kieu**, University of North Georgia, **Emine Celik**, Texas Tech University, and **Hashim Saber**, University of North Georgia.

Partition Theory and Related Topics, **Amita Malik**, University of Illinois at Urbana-Champaign, **Dennis Eichhorn**, University of California, Irvine, and **Tim Huber**, University of Texas-Rio Grande Valley.

Problems in Partial Differential Equations, **Alex Himonas**, University of Notre Dame, and **Dionyssios Mantzavinos**, State University of New York at Buffalo.

Public School Districts and Higher Education Mathematics Partnerships, **Virgil U. Pierce** and **Aaron Wilson**, University of Texas Rio Grande Valley.

Pure and Applied Talks by Women Math Warriors Presented by EDGE (Enhancing Diversity in Graduate Education), **Candice Price**, University of San Diego, and **Amy Buchman**, Tulane University.

Quantum Groups, **Shuzhou Wang** and **Angshuman Bhattacharya**, University of Georgia.

Quaternions, **Johannes Familton**, Borough of Manhattan Community College, **Terrence Blackman**, Medgar Evers College, and **Chris McCarthy**, Borough of Manhattan Community College.

RE(UF)search on Graphs and Matrices, **Cheryl Grood**, Swarthmore College, **Daniela Ferrero**, Texas State University, and **Mary Flagg**, University of St. Thomas.

Random Matrices, Random Percolation and Random Sequence Alignments, **Ruoting Gong**, Illinois Institute of Technology, and **Michael Damron**, Georgia Institute of Technology.

Real Discrete Dynamical Systems with Applications, **M. R. S. Kulenovic**, University of Rhode Island, and **Abdul-Aziz Yakubu**, Howard University.

Recent Advances in Mathematical Biology, **Zhisheng Shuai**, University of Central Florida, **Guihong Fan**, Columbus State University, **Andrew Nevai**, University of Central Florida, and **Eric Numfor**, Augusta University.

Recent Progress on Nonlinear Dispersive and Wave Equations, **Dana Mendelson**, **Carlos Kenig**, and **Hao Jia**, University of Chicago, **Andrew Lawrie**, University of California, Berkeley, **Gigliola Staffilani**, Massachusetts Institute of Technology, and **Magdalena Czubak**, University of Colorado Boulder.

Representations and Related Geometry in Lie Theory, **Laura Rider**, Massachusetts Institute of Technology, and **Amber Russell**, Butler University.

Research in Mathematics by Undergraduates and Students in Post-Baccalaureate Programs, **Darren A. Narayan**, Rochester Institute of Technology, **Tamas Forgacs**, California State University, Fresno, and **Ugur Abdulla**, Florida Institute of Technology (AMS-MAA-SIAM).

Sheaves in Topological Data Analysis, **Mikael Vejdemo-Johansson**, CUNY College of Staten Island, **Elizabeth Munch**, University at Albany, SUNY, and **Martina Scolamiero**, École polytechnique fédérale de Lausanne.

Spectral Calculus & Quasilinear Partial Differential Equations, **Shijun Zheng**, Georgia Southern University, **Marius Beceanu**, State University of New York-Albany, and **Tuoc Van Phan**, University of Tennessee, Knoxville.

Spin Glasses and Disordered Media, **Antonio Auffinger**, Northwestern University, **Aukosh Jagannath**, New York University, and **Dmitry Panchenko**, University of Toronto.

Statistical Methods in Computational Topology and Applications, **Yu-Min Chung** and **Sarah Day**, College of William & Mary.

Stochastic Matrices and Their Applications, **Selcuk Koyuncu**, University of North Georgia, and **Lei Cao**, Georgian Court University.

Stochastic Processes and Modelling, **Erkan Nane**, Auburn University, and **Jebessa B. Mijena**, Georgia College and State University.

Symmetries, Integrability, and Beyond, **Maria Clara Nucci**, Università di Perugia, Italy, and **Sarah Post**, University of Hawaií at Manoa.

Symplectic Geometry, Moment Maps and Morse Theory, **Lisa Jeffrey**, University of Toronto, and **Tara Holm**, Cornell University (AMS-AWM).

Teaching Assistant Development Programs: Why and How?, **Solomon Friedberg**, Boston College, **Jessica Deshler**, West Virginia University, **Jeffrey Remmel**, University of California, San Diego, and **Lisa Townsley**, University Of Georgia.

The Mathematics of the Atlanta University Center, **Talitha M. Washington**, Howard University, **Monica Jackson**, American University, and **Colm Mulcahy**, Spelman College (AMS-NAM).

The Modeling First Approach to Teaching Differential Equations, **Chris McCarthy**, City University of New York, and **Brian Winkel**, US Military Academy, West Point.

Theory and Applications of Numerical Algebraic Geometry, **Daniel Brake**, University of Notre Dame, **Robert Krone**, Queen's University, and **Jose Israel Rodriguez**, University of Chicago.

Topics in Graph Theory, **Songling Shan**, Vanderbilt University, and **Xiaofeng Gu**, University of West Georgia.

Topology, Representation Theory, and Operator Algebras (A Tribute to Paul Baum), **Efton Park** and **Jose Carrion**, Texas Christian University.

Women in Analysis (In Honor of Cora Sadosky), **Alexander Reznikov**, Vanderbilt University, **Oleksandra Beznosova** and **Hyun-Kyoung Kwon**, University of Alabama, and **Katharine Ott**, Bates College.

Women in Topology, **Jocelyn Bell**, Hobart and William Smith Colleges, **Eleanor Ollhoff**, University of Tennessee, **Candice Price**, University of San Diego, and **Arunima Ray**, Brandeis University.

AMS Sessions for Contributed Papers

There will be sessions of ten-minute contributed talks. Although an individual may present only one contributed paper at a meeting, any combination of joint authorship may be accepted, provided no individual speaks more than once on the program. Contributed papers will be grouped together by related subject classifications into sessions.

Submission of Abstracts for AMS Sessions

Authors must submit abstracts of talks through `joint mathematicsmeetings.org/meetings/abstracts/abstract.pl?type=jmm`. Indicate the number of authors for the paper, click on the "New Abstract" button, and you will be taken to the submission form. Simply follow the step-by-step instructions (read them carefully) until you receive your unique abstract receipt number. No submission is complete until you are given this number. **The deadline for all submissions is September 20, 2016**. Late papers cannot be accommodated. Please e-mail `abscoord@ams.org` if you have questions. If you make an inquiry about your specific abstract, please include your abstract receipt number.

Other AMS Sessions

AMS Committee on the Profession Panel Discussion: Diversity and Inclusion in the Mathematical Sciences, organizers are **Pamela Gorkin,** Bucknell University; **Monica Jackson,** American University and **John McCleary,** Vassar College; Wednesday, 4:30–6:00 pm. Representation, recruitment and retention of a diverse set of students continue to be critical in higher education and in the workplace. To involve the best talent possible in the enterprise of mathematics, departments will need to bring the widest possible base of students to the field, nurturing students from marginalized communities and providing support for underrepresented students who choose to pursue a career in mathematics. From the panel we hope to hear how the speakers' experiences and expertise can help us shape new approaches to the challenge of increasing diversity in the mathematical community. Moderator for this panel will be **Helen G. Grundman**, AMS. Panelists will include **Carlos Castillo-Chavez,** Arizona State University; **Kristin Lauter,** Microsoft Corporation and **Talithia Williams,** Harvey Mudd College.

Conversation on Nonacademic Employment, Thursday, 10:30 am–noon. This session will concentrate on how to find nonacademic positions, types of jobs, the interview process, work environments, and advancement opportunities. The discussion will be led by a panel of mathematical scientists working in government and industry.

MAA-AMS Joint Panel Session on Design (or improve) Preparation of Your Graduate Students to Teach: Using MAA's CoMInDS Resource Suite, organized by **Jessica Deshler,** West Virginia University; Thursday, 10:35–11:55 am. CoMInDS is a MAA project, funded by the NSF, to support teaching-related professional development (PD) for beginning college mathematics instructors (CMIs),

e.g., graduate student teaching assistants. CoMInDS aims to provide resources and support networks for those: (1) who deliver the PD in their departments (2) who create PD materials for CMIs and (3) who conduct research on CMI PD. One component of the project is an online collection of instructional materials and research-related resources for use in CMI PD. In this session, we will illustrate how to use the resource suite to design PD programs for CMIs. We will provide an overview of the contents of the suite and then we will illustrate how to identify specific resources. In particular, we will provide a guided tour of how items from the resources suite can be used to create a pre-semester orientation session for new CMIs. We will also illustrate how to locate and use research-based resources from the suite, such as research articles, to use as readings and research reports that can be used to support the need for such programs. At the close of the session we will present opportunities for participants to get involved in the project and to contribute their own materials to the resources suite.

This panel is being organized and offered in conjunction with a complementary AMS Special Session on Saturday morning and afternoon, *Teaching Assistant Development Programs: Why and How? (see AMS sessions).*

Panelists are **Jack Bookman,** Duke University; **Natasha Speer**, University of Maine; **Jessica Deshler**, West Virginia University; and **Sarah Schott,** Duke University. This panel is sponsored by the MAA Committee on Professional Development and AMS-MAA Joint Committee on TAs and Part-Time Instructors.

AMS and SIAM Committees on Education Joint Panel Discussion: Broadening Research Experiences for Doctoral Students in the Mathematical Sciences, organized by **Loek Helminck**, NC State University; **Rachel Levy**, Harvey Mudd College; **Douglas Mupasiri,** University of Northern Iowa and **Suzanne L. Weekes,** Worcester Polytechnic Institute; Thursday, 1:00–2:30 pm. AMS survey data demonstrate that a substantial portion of doctoral recipients are taking positions outside of academia. In this panel, we will hear about efforts to improve the training of mathematical sciences doctoral students by involving them in research activities outside of their main dissertation research in order to better them for a broader range of careers.

Programs have been designed to encourage connections between mathematical sciences and other academic departments, and between academia and business, industry, government and non-profits. The goal is to produce students who are able to recognize opportunities for the development of mathematics and statistics in problems originating in a variety of settings, and who can apply advance mathematics and statistics to help solve such problems. Panelists are **Peter Constantin**, Princeton University; **Susan Minkoff**, University of Texas at Dallas; **Stephen Pankavich,** Colorado School of Mines; and **Carlos Tolmasky**, Institute for Mathematics and its Applications, University of Minnesota.

Grad School Fair, Friday, 8:30–10:30 am. Here is the opportunity for undergrads to meet representatives from mathematical sciences graduate programs from universities all over the country. January is a great time for juniors to learn more, and college seniors may still be able to refine their search. This is your chance for one-stop shopping in the graduate school market. At last year's meeting about 300 students met with representatives from 60 graduate programs. If your school has a graduate program and you are interested in participating, for US$80 a table will be provided for your posters and printed materials (**registration for this event must be made by a person already registered for the JMM**), and you are welcome to personally speak to interested students. Complimentary coffee will be served. Co-sponsored by the AMS and MAA.

Who Wants to Be a Mathematician / National Contest, organized by **Michael A. Breen,** AMS, and **William T. Butterworth**, DePaul University; Saturday, 1:00 pm–2:45 pm. Show your support for ten of the nation's best high school students as they compete for a US$5,000 first prize for themselves and US$5,000 for their school's math department. Semifinals are at 1:00 pm and finals are at 2:00 pm. Come and match wits with the contestants.

Current Events Bulletin, organized by **David Eisenbud**, Mathematical Sciences Research Institute; Friday, 1:00 pm–5:00 pm. Speakers in this session follow the model of the Bourbaki Seminars in that mathematicians with strong expository skills speak on work not their own. Written versions of the talks will be distributed at the meeting and will also be available online at `www.ams.org/ams/current-events-bulletin.html` after the conclusion of the meeting.

AMS Committee on Science Policy Panel Discussion*: *Grassroots Advocacy for Mathematics and Science Policy, organized by **Jeffrey Hakim,** American University; Douglas Mupasiri, University of Northern Iowa and **Scott Wolpert**, University of Maryland; Friday, 2:30–4:00 pm.

Congressional Fellowship Session, Friday, 4:30–6:30 pm. This fellowship provides a public policy learning experience, demonstrates the value of science-government interaction and brings a technical background and external perspective to the decision-making process in Congress. Learn more about this program and speak with current and former AMS Fellows. Application deadline for the 2017–18 AMS Congressional Fellowship is **February 15, 2017.**

Other AMS Events

Council, Tuesday, 2:30 pm.

Business Meeting, Saturday, 11:45 am. The secretary notes the following resolution of the Council: Each person who attends a business meeting of the Society shall be willing and able to identify himself as a member of the Society. In further explanation, it is noted that each person who is to vote at a meeting is thereby identifying himself as and claiming to be a member of the American Mathematical Society. The Society has a Committee on the Agenda for Business Meetings. The purpose is to make business meetings orderly and effective. The committee does not have legal or administrative power. It is intended that the committee consider what may be called "quasipolitical" motions. The committee has several possible courses of action on a proposed motion, including but not restricted to:

(a) doing nothing,

(b) conferring with supporters and opponents to arrive at a mutually accepted amended version to be circulated in advance of the meeting,

(c) recommending and planning a format for debate to suggest to a business meeting,

(d) recommending referral to a committee, and

(e) recommending debate followed by referral to a committee.

There is no mechanism that requires automatic submission of a motion to the committee. However, if a motion has not been submitted through the committee, it may be thought reasonable by a business meeting to refer it rather than to act on it without benefit of the advice of the committee.

In order that a motion for this business meeting receive the service offered by the committee in the most effective manner, it should be in the hands of the AMS Secretary by **December 13, 2016**.

AMS Short Course on Random Growth Models

This two-day course will take place on Monday and Tuesday before the meeting actually begins. It is co-organized by **Michael Damron**, Georgia Institute of Technology; **Firas Rassoul-Agha**, University of Utah; and **Timo Seppäläinen**, University of Wisconsin-Madison. Michael Damron will give an *Introduction to Random Growth Models* in two lectures, followed by **Jack Hanson,** The City College of New York, *Infinite Geodesics, Asymptotic Directions, and Buseman Functions*; **Philippe Sosoe**, Harvard University, *Concentration in First-Passage Percolation*; **Firas Rassoul-Agha**, University of Utah, *Busemann Functions, Geodesics, and the Competition Interface for Directed Percolation*; **Timo Seppäläinen**, University of Wisconsin-Madison, *Stationary Versions and Fluctuation Exponents for Exactly Solvable Models*; and **Ivan Corwin**, Columbia University, *KPZ Fluctuations in Exactly Solvable Models*.

There are separate registration fees to participate in this course. Advance registration **(before December 20, 2016)**: Member, US$112; Non-member, US$170; Student, unemployed, or emeritus, US$60. On-site registration: Member, US$146; Nonmember, US$200; Student, unemployed, or emeritus, US$81. Please see the complete Short Course article on page 1087 of this issue or go to www.ams.org/meetings/short-courses/short-course-general.

NSF-EHR Grant Proposal Writing Workshop

Developing a Competitive Proposal for NSF-EHR, Monday (two days before the first day of the JMM), 3:00 pm–6:00 pm. Workshop goals are to familiarize participants with current direction/priorities in EHR, familiarize participants with key EHR education research and development programs, consider common issues of competitive proposals, and prepare participants to write a competitive proposal. There is no registration fee for this workshop, but participants must register separately in advance. Please contact the AMS Washington Office at 401-455-4116 or amsdc@ams.org for further information.

Department Chairs Workshop

This annual one-day workshop for department chairs and leaders is held on Tuesday, 8:00 am–6:30 pm, the day before the JMM actually begins, and is designed to stimulate discussion on a wide range of issues facing departments today, including personnel issues (staff and faculty), long-range planning, hiring, promotion and tenure, budget management, assessments, outreach, stewardship, junior faculty development, communication, and departmental leadership. There is a separate registration and fee to participate. Interested participants should also consider attending the NSF-EHR Grant Proposal Writing Workshop to be held on Monday, January 2. For further information, please contact the AMS Washington Office at 401-455-4116 or amsdc@ams.org.

100th Meeting of the MAA

MAA Invited Addresses

Jason Cantarella, University of Georgia, *Random polygons, grassmannians, and a problem of Lewis Carroll;* Wednesday, 3:20 pm.

Ingrid Daubechies, Duke University, *Mathematics for art investigation;* Saturday, 3:00 pm (MAA-AMS-SIAM Gerald and Judith Porter Public Lecture).

Susan Holmes, Stanford University, *Finding meaningful patterns: the decoding of the human microbiome;* Saturday, 10:05 am.

Lillian Pierce, Duke University, *From Gauss to today: class numbers and p-torsion in class groups of number fields;* Thursday, 9:00 am.

Matthew Richey, St. Olaf College, *Take what you have gathered from coincidence: understanding and using randomness*; Friday, 1:00 pm (Lecture for Students).

Francis Su, Harvey Mudd College, *Mathematics for human flourishing,* Friday, 9:00 am (Retiring Presidential Address).

Laura Taalman, James Madison University**,** *Math by design: 3D printing for the Working Mathematician;* Wednesday, 2:15 pm.

Presentations by MAA Teaching Award Recipients

Friday, 2:30–3:50 pm, organized by MAA Secretary **Barbara Faires**, Westminster College, and MAA President **Francis Su**, Harvey Mudd College. Winners of the Deborah and Franklin Tepper Haimo Awards for Distinguished College or University Teaching will give presentations on the secrets of their success.

MAA Invited Paper Sessions

Current Trends in Mathematical and Computational Biology, organized by **Raina Robeva,** Sweet Briar College; **Erin Bodine,** Rhodes College**; and Brian Walton,** James Madison University; Saturday, 8:00–11:50 am. Mathematical and computational biology encompasses a diverse range of biological phenomena and quantitative methods for exploring those phenomena. The pace of research at this junction continues to accelerate and substantial advancements in problems from gene regulation, genomics, phylogenetics, RNA folding, evolution,

infectious disease dynamics, neuroscience, growth and control of populations, ecological networks, drug resistance modeling, and medical breakthroughs related to cancer therapies have increasingly ensued from utilizing mathematical and computational approaches. Our session on current trends will sample from this diversity of important questions from biology and medicine and their mathematical treatments, with a goal of maximizing the range of topics and research methods presented at the session. Mathematical approaches will include deterministic and stochastic continuous dynamical models, as well as finite dynamical systems and combinatorial and algebraic methods. This session is sponsored by BIO SIGMAA.

L-functions and Other Animals, organized by **Caroline Turnage-Butterbaugh,** Duke University**, and Maria Nastasescu,** Duke University; Part A: Friday, 8:00–10:50 am and Part B: Friday, 1:00 – 2:50 pm. The Riemann zeta function famously encodes the properties of the prime numbers, and generalizations of the zeta function, called *L*-functions, are ubiquitous in number theory. Yet like the Riemann zeta function, many properties of *L*-functions remain unproved. This session will highlight a variety of approaches to studying *L*-functions and to applying properties of *L*-functions to other problems in number theory. This session complements the MAA Invited Address by Lillian B. Pierce.

Role of Modeling in Understanding Environmental Risks, organized by **Ben Fusaro,** Florida State University; Wednesday afternoon. Systems and structures can collapse unexpectedly. The challenge is to quantitatively and qualitatively analyze such events and perhaps be in a better position to prevent or mitigate damage–dam collapse (Mariana, Brazil; Mosul, Iraq), mining & resource extraction (fracking, subsidence, ecosystem impact, occupational & public health), spread of disease (Ebola, TB, Zika, TB), nuclear power (Fukushima), etc. This session is sponsored by SIGMAA EM and and the SIAM Activity Group on the Mathematics of Planet Earth (SIAG/MPE).

New Directions in Quantitative Literacy for General Education, in honor of Lynn Steen organized by **Catherine Crockett,** Point Loma Nazarene University**; Gary Franchy,** Southwestern Michigan College**;** and **Andy Miller,** Belmont University; Saturday, 8:30–10:50 am. In a number of influential books, articles, and collaborations at the turn of the twenty-first century, Lynn A. Steen (1941–2015) laid the foundation for contemporary quantitative literacy education. In Mathematics and Democracy (2001), he wrote, "Quantitatively literate citizens…need a predisposition to look at the world through mathematical eyes ….Quantitative literacy empowers people by giving them the tools to think for themselves, to ask intelligent questions of experts, and to confront authority confidently."

Over the last two decades, a number of mathematicians have answered Steen's and his colleagues' calls to advance quantitative literacy education for college students, most commonly through universities' general education programs. A number of mathematicians and educators have written new textbooks, designed new courses, founded or revived journals, connected quantitative literacy to new social contexts, and used quantitative literacy to reframe developmental mathematics. In this session, we will hear from some of these innovators and consider the future of quantitative literacy in general education programs. This session is sponsored by SIGMAA QL.

Office Hours with a Geometric Group Theorist, organized by **Dan Margalit,** Georgia Tech, and **Matthew Clay,** University of Arkansas; Part A: Wednesday, 9:00 – 10:50 am and Part B: Wednesday, 2:15–4:35 pm. Each talk will be a broadly accessible introduction to some topic within the exciting world of geometric group theory. The speakers are all contributing authors of the forthcoming introductory textbook Office Hours with a Geometric Group Theorist.

Random Polygons and Knots, organized by **Jason Cantarella,** University of Georgia; Thursday morning. Random knotting occupies an interesting corner of the intersection of mathematics, physics, and biology, as it provides a foundational model for knotted polymers like DNA. Recently, it has been proposed as a potentially powerful method for constructing examples in knot theory as well. The field has seen a lot of progress in recent years as new techniques are imported from other areas of mathematics and old problems solved. One of the appealing features of the area is that many of the techniques and arguments are fairly understandable for a general mathematical audience. In this session, a cross-section of speakers will deliver accessible talks from a variety of perspectives on the subject. This MAA Invited Paper Session accompanies **Jason Cantarella**'s invited address on the same topic.

Research in Improving Undergraduate Mathematical Sciences Education: Examples Supported by the National Science Foundation's IUSE: EHR Program, organized by **Ron Buckmire, John Haddock, Teri (TJ) Murphy, Sandra Richardson, and Lee Zia,** National Science Foundation; Directorate for Education and Human Resources; Division of Undergraduate Education; Friday, January 6, 8:00–10:50 am. In this Invited Paper Session, research and findings will be presented from projects funded by the National Science Foundation Division of Undergraduate Education's Improving Undergraduate STEM Education (IUSE) Program. The purpose of this session is to provide a venue for the mathematical sciences community to share recent research from innovations related to undergraduate mathematical sciences.

The session will highlight research from ongoing IUSE-funded projects, with a focus on the study of the teaching and learning of undergraduate mathematical sciences. Session topics will include research findings from one or more of the following themes related to undergraduate mathematical sciences education: (1) Systemic structures to support effective teaching and broadening participation; (2) Curricular and pedagogical innovations to strengthen student experiences in mathematical sciences learning; and (3) Effective use of digital tools and other sources as teaching and learning resources. Because some projects

are in early stages of project development and analysis, research findings may be preliminary.

Technical Tools for Mathematical 3D Printing, organized by **Elizabeth Denne,** Washington & Lee University, and **Laura Taalman,** James Madison University; Thursday, 1:00–4:15 pm. Speakers will go through the nitty-gritty technical details involved in designing mathematical models for 3D printing, including the strengths and quirks of using software such as Rhino, Grasshopper, Cinema4D, and OpenSCAD. Session participants will learn multiple ways to produce models that reflect and illustrate their own mathematical research.

MAA Minicourses

MAA Minicourses are open only to persons who register for the Joint Meetings and pay the Joint Meetings registration fee in addition to the appropriate minicourse fee. The MAA reserves the right to cancel any minicourse that is undersubscribed. Participants should read the descriptions of each minicourse thoroughly as some require participants to bring their own laptops and special software; laptops will not be provided in any minicourse. The enrollment in each minicourse is limited to 50; the cost is US$100.

Minicourse #1. ***Complex Analysis and Geometry/Topology as Introductions to Proofs Courses***, presented by **Neelesh Tiruviluamala**, University of Southern California; **David Crombecque**, University of Southern California; Part A, Wednesday, 4:45–6:45 pm, and Part B, Friday, 3:30–5:30 pm. An "Introduction to Proofs" course is valuable for young math majors who are transitioning to more rigorous areas in the curriculum. Several departments lack the resources to implement such a course. Furthermore, students often do not have the time or the necessary units to incorporate such a course into their four-year plan. Complex Analysis and Geometry/Topology courses are natural substitutes because the material involved is inspiring, accessible, and not always intuitive. As such, students discover for themselves that they cannot always rely on their intuition and this organically leads to several tractable and elucidating proofs. Furthermore, Complex analysis and Geometry/Topology incorporate concepts and proof techniques from a wide range of mathematical subjects. This minicourse will provide instructors with the specific tools necessary to extend their Complex analysis and Geometry/Topology courses to function dually as introduction to proofs courses.

Minicourse #2. ***Directing Undergraduate Research,*** presented by **Aparna Higgins,** University of Dayton; Part A, Wednesday, 2:15–4:15 pm, and Part B, Friday, 1:00–3:00 pm. This minicourse is designed as a guide for faculty who are interested in directing undergraduate research at their own institutions during the academic year, and who are new to directing undergraduate research. The minicourse will cover many aspects of facilitating research by undergraduates, such as getting students involved in research, finding appropriate problems, deciding how much help to provide, and presenting and publishing the results. Ideas for short projects will be provided. Certain questions, that can be used to generalize research in any area will be discussed. Although the examples used will be primarily in the area of discrete mathematics, the strategies discussed can be applied to any area of mathematics.

Minicourse #3. ***Flipping your Linear Algebra Course using Open Educational Resources***, presented by **Sarah Eichhorn,** University of California, Irvine**; David Farmer,** American Institute of Mathematics; **Jim Fowler,** The Ohio State University; **and Petra Bonfert-Taylor,** Dartmouth College; Part A, Wednesday, 2:15–4:15 pm, and Part B, Friday, 1:00–3:00 pm. The flipped classroom is an instructional strategy in which instructional content is delivered outside of class (often online) and classroom time is utilized for activities traditionally done as homework. Open educational resources (OERs) are openly licensed, online course materials that can be freely used by instructors and students. Participants in this minicourse will learn to design a flipped mathematics course using OERs. We will specifically focus building a flipped linear algebra course using a particular set of OER materials, however the instructional strategies learned in this workshop would apply equally well to other mathematical subject areas. Upon completion of this minicourse, participants will be able to apply best practices in flipped classroom design, identify appropriate OER materials for their mathematics courses, design assessments to check for knowledge of pre-class content, facilitate an active, problem-solving based classroom session, and utilize a particular set of linear algebra OER materials and provide meaningful feedback for the continuous improvement of these community resources.

Minicourse #4. ***Incorporating Randomization Methods into Introductory Statistics***, presented by **Patti Frazer Lock,** St. Lawrence University; **Robin H. Lock,** St. Lawrence University; **Allan Rossman,** Cal Poly–San Luis Obispo; **Beth Chance,** Cal Poly–San Luis Obispo; **Soma Roy,** Cal Poly–San Luis Obispo; Part A, Wednesday, 9:00B–11:00 am, and Part B, Friday, 9:00–11:00 am. The goal of this minicourse is to help participants see how to use simulation-based methods to introduce students to concepts of statistical inference in an introductory statistics course. The Common Core State Standards in Mathematics recommend these methods, so instructors teaching pre-service teachers are particularly welcomed. Through easy to use free online tools and class activities, participants will see how to engage students and make these methods readily accessible. We illustrate how to use these methods to build conceptual understanding and how to integrate them into an existing introductory statistics course without requiring a major overhaul. This course is sponsored by the SIGMAA on Statistics Education.

Minicourse #5. ***Introductory Proposal Writing for Grant Applications to the National Science Foundation EHR Division of Undergraduate Education***, presented by **Ron Buckmire, John Haddock, Teri Jo Murphy, Sandra Richardson, and Lee Zia,** Division of Undergraduate Education, National Science Foundation; Part A, Wednesday, 2:15–4:15 pm, and Part B, Thursday, 9:00–11:00 am. Presenters will describe the general NSF grant proposal process and consider particular details relevant to programs in the Division of Undergraduate Education. This short course is geared towards those who have not

submitted a proposal to NSF and are unfamiliar with the organization. If you believe you have an idea, project or program worthy of Federal support that will positively impact undergraduate education in mathematics you should attend this session. This two-part short course will provide information on the specific components of a NSF proposal, demonstrate the NSF peer review process, provide access to previously funded proposals and explicate the NSF merit review criteria by which proposals are reviewed. Participants should leave this short course with a draft of a project summary.

Minicourse #6. ***Linear Algebra in Computer Graphics and Data Mining***, presented by **Tim Chartier,** Davidson College; Part A, Wednesday, 4:45–6:45 pm, and Part B, Friday, 3:30–5:30 pm. This minicourse is designed to help participants who wish to integrate linear algebra applications into classes. Application topics will range from those that require little mathematical background (such as submatrices, matrix arithmetics) which would be suitable in a first year seminar or general education course), to more sophisticated topics (eigenanalysis, singular value) that can supplement a linear algebra course or elective course for mathematics majors or minors. Examples will come from computer graphics and data mining. Participants will find many of the issues covered are discussed in the MAA published book When Life is Linear: From Computer Graphics to Bracketology by Tim Chartier and on the free edX MOOC Applications of Linear Algebra Parts 1 and 2 created through a partnership through Davidson College and edX. This course is sponsored by the MAA Subcommittee on Mathematics Across the Disciplines (MAD)

Minicourse #7. ***Mathematical Modeling Contest Papers: Insights for Instructors and Students***, presented by **Gregory Rhoads,** Appalachian State University; **William Bauldry,** Appalachian State University; Part A, Thursday, 1:00–3:00 pm, and Part B, Saturday, 1:00–3:00 pm. Mathematical modeling has been identified as an important connection between classroom mathematical content and the types of problems that could be encountered in future employment. Modeling contests gives students an experience solving "real-world" type problems and participation in these contests has been steadily increasing in the past decade. This minicourse will give the participants insight into what constitutes a good paper for these contests. Participants will read a stratified set of papers from an actual contest and analyze them for strengths and weaknesses, which will then be compared to comments from actual contest graders. The course will include discussions about the modeling process and how this process is reflected in the submissions, ideas for creating and assessing modeling problems used as classroom assignments, and how to prepare a team for a contest. This minicourse is intended for both students and faculty. A limited number of scholarships are available for undergraduate students interested in attending this minicourse. Please contact Gregory Rhoads at rhoadsgs@appstate.edu for more information.

Minicourse #8. ***(Re)Designing Your Own Mathematics Course using Backwards Course Design***, presented by **Joel Kilty,** Centre College and **Alex M. McAllister, Centre College**; Part A, Wednesday, 9:00–11:00 am, and Part B, Friday, 9:00–11:00 am. As mathematics faculty, we are often tasked with designing, or redesigning, courses to meet the specific needs of the students at our institutions. However, our educational background is typically in mathematics and we have little formal training in or experience with educational theory. This minicourse introduces "backwards" course design theory and provides participants with a workshop type atmosphere to begin the process of designing or redesigning a course of their choice through a process of articulating (1) the goals for their course, (2) acceptable evidence of goal attainment, and (3) learning experiences as specific approaches to achieving these goals.

Minicourse #9. ***Statistical Education of Teachers***; presented by **Anna E. Bargagliotti,** Loyola Marymount University; **Christine Franklin,** University of Georgia; **Denise Spangler,** University of Georgia; Part A, Thursday, 9:00–11:00 am and Part B, Saturday, 9:00–11:00 am. The Common Core State Standards for Mathematics place a large emphasis on statistics, especially in the middle- and high-school grades. Although statistics has been included as an important branch of K–12 mathematics education, there is a great need for preparing and supporting teachers trying to integrate statistics learning into the classroom. The American Statistical Association commissioned the Statistical Education of Teachers (SET) report to clarify the statistics teachers must know to effectively address current K–12 needs. At many institutions preservice and inservice teachers, particularly pre-K–8 teachers, learn their statistics content in mathematics courses. Thus, it is imperative that mathematicians and mathematics educators be well-versed in issues of statistics education so that they can orchestrate conversations with statisticians and those who teach mathematics content courses about the statistical preparation of teachers. This minicourse will present the recommendations of the SET report. Participants will work through grade-band specific examples, examine teacher work, and discuss difficulties and potential "roadblocks" that could emerge. This course is sponsored by the SIGMAA on Statistics Education.

Minicourse #10. ***Teaching an Applied Topology Course,*** presented by **Colin Adams,** Williams College and **Robert Franzosa,** University of Maine; Part A, Thursday, 9:00–11:00 am, and Part B, Saturday, 9:00–11:00 am. Applications of topology have proliferated in recent years. It is now possible to teach a course in topology, still covering much of the same material that would appear in a traditional topology course, but motivated entirely by applications. Typically, offering an "applied" topology course immediately doubles the enrollments. Applications include areas such as geographic information systems, robotics, chaos, fixed point theory in economics, knots in DNA and synthetic chemistry, and the topology of the spatial universe. Through the applications, students become engaged with the material. In this minicourse, we will introduce the various applications, and provide participants with the background necessary to design and teach their own applied topology course.

Minicourse #11. ***Teaching an Introduction to the Mathematics of Computer Graphics***, presented by **Nathan C. Carter,** Bentley University; Part A, Thursday, 9:00–11:00 am, and Part B, Saturday, 9:00–11:00 am. This minicourse introduces a project-based, general-population elective on the mathematics of computer graphics. Participants will see some new mathematics and receive a course outline and syllabus, and more importantly, a hands-on introduction to the free software used in the course projects. The minicourse also covers how to extend the course for more advanced audiences, such as mathematics majors or computer science majors. The free software POV-Ray has been around for decades, but is still updated and released today. It creates realistic 3D images and animations from mathematical descriptions of the objects in a scene. This requires students to master the mathematical content in pursuit of their creative goals, but also gives them immediate and enjoyable practical applications of that content. Students no longer ask, "What is this good for?" They immediately see the purpose of the mathematics in their own creative projects, and in the computer graphics industry. Participants receive a list of suggested student projects with grading rubrics, interactive online tools, references for further reading, and more. Prerequisites for this general-population course are algebra and polynomial differentiation; linear algebra and/or computer programming are not required.

Minicourse #12. ***Teaching Introductory Statistics, GAISE 2016***, presented by **Carolyn K. Cuff,** Westminster College; Part A, Wednesday, 9:00–11:00 am, and Part B, Friday, 9:00–11:00 am. This minicourse, intended for instructors new to teaching statistics, exposes participants to the big ideas of statistics and the 2016 Guidelines for Assessment and Instruction in Statistics Education (GAISE) recommendations. It considers ways to engage students in statistical thinking, and emphasizes the contrast between conceptual and procedural understanding in the first statistics course. Participants will engage in many of the classic activities that all statistics instructors should know. A set of approximately 6–8 hands-on classroom-ready activities will be given to participants. Parts of each activity will be done by the participants, other parts will be summarized by the presenter and the main statistical ideas of the activity will be explained to the participants. The activities have been chosen so that they require minimal adaptation for a wide variety of classrooms, use freely available applets and other software and are easy to implement. Each activity includes goals, key ideas, prerequisite skills and concepts, connection to other statistical concepts, objectives, known student difficulties and assessment questions. Internet sources of real data, activities, and best practices articles will be examined. An annotated list of additional resources will be discussed. This course is sponsored by the SIGMAA on Statistics Education and theMAA-ASA Joint Committee on Undergraduate Statistics.

Minicourse #13. ***Teaching Modeling-First Differential Equations–Technology and Complete End Game Efforts***, presented by **Brian Winkel,** SIMIODE**; Rosemary Farley,** Manhattan College; **Jon Paynter,** US Military Academy; **Therese Shelton,** Southwestern College; and **Patrice Tiffany,** Manhattan College**;** Part A, Thursday, 1:00–3:00 pm, and Part B, Saturday, 1:00–3:00 pm. We offer experiences for building and teaching mathematical models with differential equations: epidemic model of school infirmary, Torricelli's Law, fishery management effort, post-operative retinal fluid dissipation, fair stadium design, sublimation of carbon dioxide, chemical kinetics, ant tunnel building, spread of oil slick, pursuit efforts, pharmacokinetics of LSD and paracetamol, shuttlecock fall, and lake algae. We discuss the role technology plays in the end game modeling efforts of parameter estimation, non-linear regression analysis, and model comparison. Through hands-on small group learning, faculty will experience the use of modeling and technology to teach differential equations. We use SIMIODE–Systemic Initiative for Modeling Investigations and Opportunities with Differential Equations, an online (www.simiode.org) community of teachers.

Minicourse #14. ***Teaching Quantitative Reasoning with Common Sense and Common Knowledge***, presented by **Ethan D. Bolker,** UMass Boston; **Maura B. Mast,** Fordham University; Part A, Wednesday, 2:15–4:15 pm, and Part B, Friday 1:00–3:00 pm. Ten years from now, what do you want or expect your Quantitative Reasoning students to remember? Our answers to this question profoundly shaped our approach to teaching Quantitative Reasoning. We realized that in ten years, what matters will be how students approach a problem using the tools they carry with them – common sense and common knowledge – not the particular mathematics we chose for the curriculum. That changed how and what we teach. In this interactive minicourse we will provide hands-on experience with class activities using our approach, discuss issues in teaching and learning quantitative reasoning, and practice creating examples and exercises from current news. New and experienced instructors will learn how to craft classes and problems that will help their students come to grips with numbers in the news while learning the necessary mathematics. This course is sponsored by SIGMAA QL.

Minicourse #15. ***Unraveling Four Interesting Ciphers***, presented by **Chris Christensen,** Northern Kentucky University; and **Jeffrey Ehme,** Spelman College; Part A, Thursday, 1:00–3:00 pm, and Part B, Saturday, 1:00–3:00 pm. This minicourse will explore four cryptologically, historically, and mathematically interesting ciphers: the running key cipher, rotor machine ciphers, the Playfair cipher, and the ADFGX and ADFGVX ciphers. Running key ciphers were used by spies; the Playfair and ADFGX and ADFGVX ciphers were used during World War I; and machine ciphers, like the German Enigma, dominated cryptography from the 1920s until the 1970s. For each cipher, the method of enciphering will be explained and a method of attack will be discussed.

Minicourse #16. *Using and Making Integrated Online Textbooks with MathBook XML*, presented by **Karl-Dieter Crisman,** Gordon College; Part A, Wednesday, 4:45–6:45 pm, and Part B, Friday, 3:30–5:30 pm. In this minicourse participants will learn how to effectively use online textbooks authored with the AIM-sponsored MathBook XML (MBX, `mathbook.pugetsound.edu/`), as well as to begin creating their own course supplements with this

tool. First, we will explore the power of having online (and print) texts in subjects from Abstract Algebra to Calculus with embedded online WeBWorK problems and Sage computational cells. In the second session, participants will try their hands at creating a small supplement to one of their own classes using MBX, experiencing the "write once, read anywhere" philosophy that creates output in print, pdf, webpages, and computational notebooks. In both cases, the presenter's own free Number Theory text will be used as a case study of how to create a project like this. No previous experience with Sage or WeBWorK necessary; you should be ready to try a few necessary command line tools. You will need to bring a wireless-enabled laptop, and will receive instructions regarding software in pre-workshop correspondence. This course is sponsored by the MAA Committee on Technology in Mathematics Education (CTiME).

MAA Contributed Papers

The MAA Committee on Contributed Paper Sessions solicits papers pertinent to the sessions listed below. Contributed Paper Session presentations are limited to fifteen minutes, except in the general session where they are limited to ten minutes. Each session room is equipped with a computer projector and a screen. Please note that the days and times scheduled for these sessions remain tentative. Several of these sessions have specific suggestions for the appropriateness of submissions. Potential submitters are advised to read the full descriptions of these sessions at `jointmathematicsmeetings.org/meeting/national/jmm2017/2180_maacall`.

The deadline for submission of abstracts is Tuesday, September 20, 2016.

MAA Contributed Paper Sessions with Themes

The Advancement of Open Educational Resources, organized by **Benjamin Atchison**, Framingham State University; and **Jeremy Russell**, The College of New Jersey; Saturday morning.

Assessment in Distance Learning Environments, organized by **Miriam Harris-Botzum,** Lehigh Carbon Community College*;* **William O. Martin,** North Dakota State University; **Sarah Cook,** Washburn University; and **Semra Kilic-Bahi,** Colby-Sawyer College; Wednesday afternoon. Sponsored by the MAA Assessment Committee.

The Creation and Implementation of Effective Homework Assignments, organized by **Sarah Greenwald,** Appalachian State University; and **Judy Holdener**, Kenyon College; Saturday morning. Sponsored by Problems, Resources, and Issues in Undergraduate Mathematics Studies (PRIMUS).

Cryptology for Undergraduates, organized by **Robert Lewand**, Goucher College; **Joshua Holden**, Rose-Hulman Institute of Technology; and **Chris Christensen**, Northern Kentucky University; Wednesday morning.

Discrete Mathematics in the Undergraduate Curriculum - Ideas and Innovations for Teaching, Organized by **John S. Caughman**, Portland State University; **Elise Lockwood**, Oregon State University; and **Art Duval**, University of Texas El Paso; Saturday afternoon.

Do Mathematicians Really Need Philosophy?, organized by **Bonnie Gold**, Monmouth University; and **Carl Behrens,** Alexandria VA; Saturday afternoon. Sponsored by POM SIGMAA.

Humanistic Mathematics, organized by **Eric S. Marland,** Appalachian State University; and **Gizem Karaali,** Pomona College; Thursday afternoon. Sponsored by the MAA Committee on Curriculum Renewal Across the First Two Years (CRAFTY) and the Journal of Humanistic Mathematics.

Humor and Mathematics, Organized by **Debra K. Borkovitz**, Wheelock College; **Gizem Karaali,** Pomona College; **Semra Kilic-Bahi,** Colby-Sawyer College; and **Cesar Martínez-Garza**, Penn State Berks; Friday morning.

Incorporating Big Data Ideas in the Mathematics and Statistics Classroom, organized by **Sue Schou**, Idaho State University; **Stacey Hancock**, University of California, Irvine; and **Patti Frazer Lock**, St. Lawrence University; Thursday afternoon. Sponsored by the SIGMAA on Statistics Education.

Innovative and Effective Ways to Teach Linear Algebra, organized by **Megan Wawro**, Virginia Tech; **Gil Strang**, MIT; and **David Strong**, Pepperdine University; Friday morning.

Innovative Strategies to Inspire & Prepare Potential STEM Majors Who Are Not Yet Ready for Calculus, organized by **Rebecca Hartzler**, Seattle Central College; **Suzanne I. Doree**, Augsburg College; **Frank Savina**, University of Texas at Austin; and **Michael Oehrtman**, Oklahoma State University; Thursday afternoon. Sponsored by the MAA Committee on Curriculum Renewal Across the First Two Years (CRAFTY).

Innovative Teaching through Recreational Mathematics, organized by **Matthew Jura**, Manhattan College; **Tyler Markkanen**, Springfield College; and **Oscar Levin,** University of Northern Colorado; Wednesday morning.

Inquiry-Based Teaching and Learning, Organized by **Brian P. Katz,** Augustana College; **Judith Covington,** Louisiana State University in Shreveport; **Theron Hitchman**, University of Northern Iowa; **Angie Hodge**, University of Nebraska Omaha; **Alison Marr**, Southwestern University; and **Victor Piercey**, Ferris State University; Friday afternoon. Sponsored by the SIGMAA IBL.

Integrating Research into the Undergraduate Classroom, organized by **Timothy B. Flowers**, Indiana University of Pennsylvania; and **Shannon R. Lockard**, Bridgewater State University; Thursday morning.

Intertwining Mathematics with Social Justice in the Classroom, organized by **Joanna Wares**, University of

Richmond; **Carl Yerger**, Davidson College; **Zeynep Teymuroglu**, Rollins College; and **Catherine Buell**, Fitchburg State University; Saturday morning. Sponsored by Problems, Resources, and Issues in Undergraduate Mathematics Studies (PRIMUS).

Mathematical Technology in the Calculus Classroom, organized by **Joel Kilty** and **Alex M. McAllister**, Centre College; Thursday morning.

Mathematics and the Arts, organized by **Douglas Norton,** Villanova University; Wednesday morning. Sponsored by the SIGMAA on Mathematics and the Arts.

Mathematics and Sports, organized by **Drew Pasteur**, College of Wooster; and **John David**, Virginia Military Institute; Wednesday afternoon.

Mathematics Experiences and Projects in Business, Industry, and Government, organized by **Allen Butler,** Daniel H. Wagner Associates, Inc., Friday morning. Sponsored by the BIG SIGMAA.

Meaningful Modeling in the First Two Years of College, organized by **Stuart Boersma**, Central Washington University; and **Jason Douma**, University of Sioux Falls; Thursday morning. Sponsored by MAA Mathematics Across the Disciplines (MAD) Subcommittee and the MAA Curriculum Renewal Across the First Two Years (CRAFTY) Subcommittee.

Methods of Engaging Math Learners with Physical Impairments, organized by **Rebekah Gilbert** and **Steven Schluchter**, George Mason University; Thursday afternoon.

Modern Data Sets for the Intro Statistics Classroom and Beyond, organized by **Sue Schou**, Idaho State University; **Stacey Hancock**, University of California, Irvine; and **Patti Frazer Lock**, St. Lawrence University; Friday afternoon. Sponsored by the SIGMAA on Statistics Education.

PIC Math and Preparing Students for Nonacademic Careers, organized by **Suzanne Weekes**, Worcester Polytechnic Institute; **Michael Dorff**, Brigham Young University; and **Elly Farnell,** Kenyon College; Saturday morning. Sponsored by the MAA BIG committee, BIG SIGMAA, and SIAM.

Preparing Pre-service and In-service Teachers to Support the Common Core State Standards Assessments, organized by **Bonnie Gold**, Monmouth University; **Karen Morgan**, New Jersey City University; and **Gulden Karakok**, University of Northern Colorado; Friday afternoon.

Preserving and Writing the History of Mathematics Departments, organized by **Toke Knudsen**, SUNY Oneonta; and **Lawrence D'Antonio**, Ramapo College; Friday morning. Sponsored by the HOM SIGMAA.

Proofs and Mathematical Reasoning in the First Two Years of College, organized by **Dean Gooch**, Santa Rosa Junior College; **Chris Oehrlein**, Oklahoma City Community College; and **Joanne Peeples**, El Paso Community College; Thursday morning. Sponsored by the MAA Committee on Two-Year Colleges.

Research in Undergraduate Mathematics Education (RUME), organized by **Karen Keene**, North Carolina State University; and **Megan Wawro**, Virginia Tech; Thursday morning and afternoon. Sponsored by the SIGMAA RUME.

Revitalizing Complex Analysis, organized by **Russell W. Howell**, Westmont College; and **Paul Zorn**, St. Olaf College; Friday morning.

The Scholarship of Teaching and Learning in Collegiate Mathematics, organized by **Jacqueline Dewar,** Loyola Marymount University; **Thomas Banchoff**, Brown University; **Curtis Bennett**, Loyola Marymount University; **Pam Crawford**, Jacksonville University; and **Edwin Herman**, University of Wisconsin-Stevens Point; Wednesday morning and afternoon.

Successful Implementation of Innovative Models for Developmental and General Education Mathematics, organized by **Christopher Oehrlein**, Oklahoma City Community College; **Phil Mahler**, Middlesex Community College; **Tom Hagedorn**, The College of New Jersey; and **Christina H. Lee**, Oxford College of Emory University; Thursday afternoon. Sponsored by the MAA Committee on Two-Year Colleges.

Teaching Abstract Algebra: Topics and Techniques, organized by **Kristi Meyer,** Wisconsin Lutheran College; and **Jessie Lenarz**, St. Catherine University; Wednesday afternoon.

The Teaching and Learning of Undergraduate Ordinary Differential Equations, organized by **Christopher S. Goodrich**, Creighton Preparatory School; and **Beverly H. West**, Cornell University; Saturday afternoon. Sponsored by the Community of Ordinary Differential Equations Educators (CODEE).

Trends in Undergraduate Mathematical Biology Education, organized by **Timothy D. Comar**, Benedictine University; and **Daniel Hrozencik**, Chicago State University; Friday afternoon. Sponsored by the SIGMAA on Mathematical and Computational Biology.

Unexpected Topics for a Math Circle, organized by **Robert M. Klein**, Ohio University, and **Phillip Yasskin**, Texas A&M University; Friday morning. Sponsored by the SIGMAA MCST.

Women in Mathematics, organized by **Semra Kilic-Bahi**, Colby-Sawyer College; **Meghan De Witt**, St. Thomas Aquinas College; and **Kim Roth**, Juniata College; Saturday afternoon.

General Contributed Paper Sessions, organized by **Emelie Kenney**, Siena College; **Kimberly Presser**, Shippensburg University; and **Melvin Royer**, Indiana Wesleyan University; Wednesday, Thursday, Friday, and Saturday, mornings and afternoons. These sessions accept

contributions in all areas of mathematics, curriculum, and pedagogy. When you submit your abstract you will be asked to classify it according to the following scheme: Algebra; Analysis; Applied Mathematics; Assessment; Geometry; Graph Theory; History or Philosophy of Mathematics; Interdisciplinary Topics in Mathematics; Linear Algebra; Logic and Foundations; Mathematics and Technology; Mentoring; Modeling and Applications; Number Theory; Outreach; Probability and Statistics; Teaching and Learning Advanced Mathematics; Teaching and Learning Calculus; Teaching and Learning Developmental Mathematics; Teaching and Learning Introductory Mathematics; Topology; or Other.

An Electronic Poster Session

Me and My Gadgets–Teaching with Technology, organized by **Karl R. B. Schmitt, V**alparaiso University; **John Travis,** Mississippi College; **Thomas Hagedorn,** The College of New Jersey; and **Michael Scott,** California State University at Monterey Bay; Saturday, 10:00–11:55 am. Constantly changing technology presents an exciting and shifting opportunity to engage students and improve learning. This electronic poster session will consist of live, interactive demonstrations of applets, widgets or other technology for teaching mathematics. Rather than preparing a traditional printed poster, presenters will showcase how students engage mathematics through their application using some electronic device such as a tablet, smartphone, or laptop. Preference will be given to presenters demonstrating their own or new applications or to novel approaches in using existing ones.

In addition to the active displays, all participants will give a 3–5 minute "Lightning Talk" to demonstrate their application, highlighting where it fits into a mathematics curriculum. These will be scheduled in the middle of the session, and included in the program.

Abstracts should include a short description of the application/software (or a web-link to it) and explain the pedagogical use of the application.

Sponsored by the MAA Committee for Technology in Mathematics Education (CTiME) and Web SIGMAA.

Submission Procedures for MAA Contributed Paper Abstracts

Abstracts may be submitted electronically at `jointmathematicsmeetings.org/meetings/abstracts/abstract.pl?type=jmm`. Simply fill in the number of authors, click "New Abstract", and then follow the step-by-step instructions. **The deadline for abstracts submission is Tuesday, September 20, 2016.**

Each participant may make at most one presentation in an MAA Contributed Paper Session, either a presentation in one of the themed sessions or a presentation in one of the general sessions. If your paper cannot be accommodated in the themed session for which it was submitted, it will automatically be considered for the general contributed paper sessions. The organizer(s) of your session will automatically receive a copy of the abstract, so it is not necessary for you to send it directly to the organizer. All accepted abstracts are published in a book that is available to registered participants at the meeting. The session rooms are equipped with computer projectors and screens. Please note that the dates and times scheduled for these sessions remain tentative. Questions concerning the submission of abstracts should be addressed to `abs-coord@ams.org`.

MAA Panels, Posters, Workshops, and Other Sessions

Refocusing Your Career: Making Time and Space, organized by **Brian P. Katz**, Augustana College, and **Rachelle Bouchat**, Indiana University of Pennsylvania; Wednesday, 8:00–9:20 am. The ongoing work of an educator, scholar, colleague, leader, and advisor can and does fill all of the time we, as mathematicians, have to give. And yet, many of us have projects we are passionate about that we struggle to fit into this time, including issues of social justice, community outreach, exploration of novel areas of mathematics, and incorporation of students into our research. Some are struggling to make time rather than to make more time, while others are struggling to define the work of a mathematician so that it includes their passion projects. Panelists will discuss their varied experiences pursuing these kinds of projects and share advice that can help others navigate this career passage. There will be time for questions and discussion about applying these ideas to our own careers. This panel is sponsored by the MAA Project NExT Pine'09 cohort. Many members of this cohort are moving into phases of their careers in which both time pressures and self-determination have grown, making this issue particularly salient. While the needs of this group generated this panel, we intend the discussion to be accessible and useful for all conference attendees.Panelists are: **Colin Adams,** Williams College; **Gizem Karaali,** Pomona College; **Katherine Socha**, Park School of Baltimore; **Michael Starbird,** University of Texas at Austin; **Laura Taalman,** James Madison University; and **Diana White**, University of Colorado Denver. This panel is sponsored by MAA Project NExT.

NSF Funding Opportunities for the Learning and Teaching of the Mathematical Sciences, organizers and panelists are **Ron Buckmire, John Haddock, Teri Jo Murphy, Sandra Richardson,** and **Lee Zia,** Division of Undergraduate Education, NSF; **Karen King**, Division of Research on Learning, NSF; **Tasha Inniss**, Division of Human Resource Development, NSF; **Tara Smith,** Division of Graduate Education, NSF and **Jennifer Slimowitz Pearl**, Division of Mathematical Sciences, NSF. A number of NSF divisions offer a variety of grant programs that support innovations in learning and teaching in the mathematical sciences. These programs will be discussed along with examples of successful projects in two sessions. Anticipated budget highlights and other new initiatives for the next fiscal year, as appropriate, will also be presented. These programs will be discussed in two sessions.

Part I: Undergraduate/Graduate Education, Department of Mathematics Infrastructure, and Human Resource Development (DUE/DGE/DMS/HRD)Wednesday, 8:00–9:15 am, and

Part II: The K–16 Continuum: Learning Science & Research and Pre- and In-Service Teachers (DUE/DRL) Wednesday, 9:30–10:30 am.

What Belongs in a Twenty-First Century Geometry Course?, organized by **Stephen Kennedy**, MAA Press; Wednesday, 9:35–10:55 am. The members of the panel are all well-known authors of successful textbooks for the college geometry course. Panelists will attempt to address all the relevant questions a faculty member teaching that course might face. *What is the proper role of axiomatics? What topics are absolutely essential to include? What is important for future high-school teachers in your class to master? How does the Common Core affect the answer to that question? At what level should technology be used and what are some good options?* Particular attention will be paid to the recommendations contained in the most recent MAA CUPM Guide. Panelists are: **Matthew Harvey**, University of Virginia College at Wise; **Tom Sibley**, St. John's University; and **Gerard Venema**, Calvin College.

What Every Student Should Know about the JMM, organized by **Violeta Vasilevska**, Utah Valley University; Wednesday, 2:15–3:35 pm. Navigating a large conference can be overwhelming, even for those who have previously attended such an event. Panelists Joyati Debnath, Winona State University; Michael Dorff, Brigham Young University; and Matt DeLong, Taylor University, will provide guidance for students attending the Joint Mathematics Meetings, including answers to some common questions: *How do I get the most out of the program? What sessions are especially for students? What other events should I be on the lookout for? Will I understand any of the invited addresses or should I not bother attending them? If I am presenting a poster, where do I go to set it up? How can I get some cool, free math stuff?* Students and their faculty mentors are encouraged to attend. Panelists are: **Joyati Debnath,** Winona State University; **Michael Dorff**, Brigham Young University; and **Matt DeLong**, Taylor University. This panel is sponsored by the MAA Committee for Undergraduate Student Activities and Chapters (CUSAC).

Preparing for the Data Deluge: Mathematics Programs and the Future of Undergraduate Statistics Education organized by **Sue Schou**, Idaho State University; **Stacey Hancock,** University of California, Irvine; and **Patti Frazer Lock,** St. Lawrence University; Wednesday, 2:15–3:35 pm. The McKinsey report states that "by 2018, the United States alone could face a shortage of 140,000 to 190,000 people with deep analytical skills as well as 1.5 million managers and analysts with the know-how to use the analysis of big data to make effective decisions." With terms like "Big Data" and "Analytics" being used in the media and among academics, the question arises as to how to best prepare undergraduates for careers in statistics. Employers value statistics skills and the demand is high, perhaps higher than it has ever been due to the "data deluge." In response, there is a trend in the growth of and creation of statistics undergraduate programs. Programs, especially those housed within mathematics departments, need to determine the best options to train and teach future statisticians. Our panel will host several members of the mathematics and statistics community who have created innovative curriculum and programs to meet the demand for statistics training. These panelists will share their experiences in creating programs in statistics, the advantages and disadvantages of creating separate Mathematics and Statistics majors, and how to incorporate new ASA guidelines for Statistics Programs into new or existing programs. Panelists are: **Robin Lock**, St. Lawrence University; **Nicholas Horton**, Amherst College; and **K. Scott Alberts**, Truman State University. This panel is sponsored by the SIGMAA on Statistics Education.

Professional Development at the Section Level: Section NExT, Opportunities for Graduate Students, & More, organized by **Julie Barnes,** Western Carolina University; **Benjamin V. C. Collins,** University of Wisconsin-Platteville; **Jessica Deshler,** West Virginia University; **Eric Eager,** University of Wisconsin La Crosse; and **David Torain,** Hampton University; Wednesday, 3:50–5:10 pm. MAA sections can provide a great set of faculty-development resources for individuals throughout the entire spectrum of the mathematical community. For example, yearly or bi-yearly section meetings are a great place for faculty to interact and learn from each other without the expense of attending national meetings. Section NExT retreats and panels offer early-career faculty with the opportunity to be mentored, without the time and financial commitment that come with national MAA Project NExT. However, that isn't the only thing that sections can do to provide professional development opportunities. In this panel, mathematicians from three different sections will share ideas from their Section NExT programs; an additional panelist will discuss professional development being offered for graduate students in one section. We will include time at the end not only for questions, but also for people to share ideas about any form of professional development available in their sections. Panelists are: **Brian Birgen,** Wartburg College; **Eric Eager,** University of Wisconsin La Crosse; **Jon Ernstberger**, LaGrange College; and **Sarah Frick,** Furman University. This panel is sponsored by the MAA Committee on Professional Development; MAA Committee on Sections; MAA Committee on Early Career Mathematicians; and MAA Project NExT.

Research Support Networks organized by **Louis Deaett**, Quinnipiac University; Wednesday, 3:50–5:10 pm. Faculty in the early and middle part of their careers may find it challenging to maintain an active program of scholarship that extends beyond their thesis work. A support network of fellow mathematicians with similar expectations of scholarship and background in a common area of mathematics can be vital to success. Diverse programs exist offering faculty opportunities to foster such research support networks. Panelists representing three such programs will share features that make each program unique, while panelists who have participated in one or more of these programs will speak to the benefits of their experiences. Panelists are: **Margaret Cozzens**, Rutgers University; **Ulrica Wilson**, Morehouse College/ICERM; **Joyati Debnath**, Winona State University; and **T. Christine Stevens**, American Mathematical Society. This panel is sponsored by the MAA Committee on Professional Development.

Bylaws for a New Century: Q&A Forum on Proposed Changes in MAA Governance, Thursday, 8:00 – 8:50 am. Come hear about and ask questions about the revised MAA bylaws which will be voted on at the Saturday MAA Business Meeting. Moderators for this forum are **Jim**

Daniel, MAA Treasurer, and **Matt Boelkins**, MAA First Vice President.

Pushing for Change: the MAA and Advocacy, organized by **Karen Saxe,** Macalester College, and **David Manderscheid,** Ohio State University; Thursday, 9:00–10:20 am. This panel will update the community on the policy and advocacy activities of the Mathematical Association of America. After a broad overview of the history of policy and advocacy work of the MAA, we will discuss more recent work of the MAA Science Policy Committee, and future directions for this committee, the MAA, and indeed all professional associations moving forward working with both federal and state governments. Panelists for this session are: **Daniel Goroff,** Alfred P. Sloan Foundation; **David Manderscheid,** Ohio State University; and **Michael Pearson,** MAA.

MAA Session for Chairs: Data, Information, Knowledge using Annual Survey of Math Science & CBMS Survey, organized by **Catherine M. Murphy**, Purdue University Calumet, and **Daniel Maki,** Indiana University; Thursday, 9:00–10:35 am. This will be an interactive session for Chairs to learn how the AMS-ASA-MAA-SIAM Annual Survey of the Mathematical Sciences (ASMS) and the Conference Board of the Mathematical Sciences (CBMS) Survey are conducted and how to effectively use these and other surveys to address issues such as course enrollments, teaching loads, trends in hiring faculty, patterns in compensation, and diversity in the work force and student population. Participants will have the opportunity to work in groups and consult with presenters on questions of their own choosing or from a suggested list. Having a notebook computer with browser and spreadsheet application would be most useful during the consulting process. Panelists are: **Thomas Barr**, American Mathematical Society, and **Ellen Kirkman**, Wake Forest University. This panel is sponsored by the AMS-ASA-MAA-SIAM Joint Data Committee.

Mathematical Outreach Programs, organized by **Elizabeth Yanik**, Emporia State University; Thursday, 10:00 am –12:00 noon. This poster session is designed to highlight special programs which have been developed to encourage students to maintain an interest in and commitment to succeeding in mathematics. These programs might include such activities as after school clubs, weekend activities, one day conferences, mentoring opportunities, summer camps, etc. This poster session encompasses a wide variety of outreach efforts for a variety of age groups. For example, programs might be designed to reach out to underrepresented groups. The projects supported by MAA Tensor and Summa grants will find this an ideal venue in which to share the progress of their funded projects. Another possible type of outreach might involve mathematical enrichment programs. For example, recipients of Dolciani Mathematics Enrichment Grants might wish to highlight their programs. Other examples might include innovative programs to motivate undergraduates to study mathematics. We encourage everyone involved with offering mathematical outreach activities to consider submitting an abstract to the session organizer, Betsy Yanik, eyanik@emporia.edu.

Models for Mathematicians Working with K–12 Mathematics Teachers, organized by **Ben Ford,** Sonoma State University, and **Debbie Gochenaur,** Shippensburg University; Thursday, 10:35–11:55 am. In addition to work preparing teachers before they enter the classroom, many mathematical science departments are integral to professional development efforts for practicing teachers in their regions. Panelists will discuss successful models in which they participate, including statewide networks, masters programs for in-service teachers, math teacher circles, and national programs. Panelists are: **James A. M. Epperson,** The University of Texas at Arlington; **Davida Fischman,** California State University, San Bernardino; and **Robert M. Klein,** Ohio University. This panel is sponsored by the MAA Committee on the Mathematical Education of Teachers (COMET).

MAA-AMS Joint Panel Session on Design (or improve) Preparation of Your Graduate Students to Teach: Using MAA's CoMInDS Resource Suite, organized by **Jessica Deshler,** West Virginia University; Thursday, 10:35–11:55 am. CoMInDS is a MAA project, funded by the NSF, to support teaching-related professional development (PD) for beginning college mathematics instructors (CMIs), e.g., graduate student teaching assistants. CoMInDS aims to provide resources and support networks for those: (1) who deliver the PD in their departments (2) who create PD materials for CMIs and (3) who conduct research on CMI PD. One component of the project is an online collection of instructional materials and research-related resources for use in CMI PD. In this session, we will illustrate how to use the resource suite to design PD programs for CMIs. We will provide an overview of the contents of the suite and then we will illustrate how to identify specific resources. In particular, we will provide a guided tour of how items from the resources suite can be used to create a pre-semester orientation session for new CMIs. We will also illustrate how to locate and use research-based resources from the suite, such as research articles, to use as readings and research reports that can be used to support the need for such programs. At the close of the session we will present opportunities for participants to get involved in the project and to contribute their own materials to the resources suite.

This panel is being organized and offered in conjunction with a complementary AMS Special session on Saturday morning and afternoon, *Teaching Assistant Development Programs: Why and How? (see AMS sessions).*

Panelists are **Jack Bookman,** Duke University; **Natasha Speer**, University of Maine; **Jessica Deshler**, West Virginia University; and **Sarah Schott,** Duke University. This panel is sponsored by the MAA Committee on Professional Development and AMS-MAA Joint Committee on TAs and Part-Time Instructors.

Perspectives on Inquiry Based Learning: Novice, Experienced, and Master, organized by **Theron J. Hitchman,** University of Northern Iowa; **Judith Covington**, Louisiana State University Shreveport; **Angie Hodge**, University of Nebraska Omaha; **Brian Katz,** Augustana College; **Alison Marr**, Southwestern University; and **Victor Piercey**, Ferris State University; Thursday, 1:00 – 2:20 pm. Panelists will share their experiences in getting started

with Inquiry Based Learning (IBL) and perspectives on maintaining these techniques over time. They will share a quick thought on the opportunities and challenges of IBL courses, but a large fraction of the time will be reserved for a questions from the audience. Our panelists include someone new to IBL teaching, someone with enough experience to feel comfortable designing a new course, and an acknowledged master teacher who has mentored others in IBL teaching. Panelists are **Carol Schumacher**, Kenyon College; **Theron Hitchman**, University of Northern Iowa; and **Susan Crook**, Loras College. This panel is sponsored by IBL SIGMAA.

Women and Scholarly Publishing, organized by **Semra Kilic-Bahi,** Colby-Sawyer College; **Kim Roth**, Juniata College; and **Jenna Carpenter**, Campbell University; Thursday, 1:00–2:20 pm. Data on the publications emphasize the gender gap among the authorship of published scholarly work. A further analysis of the data reveals that the number of submissions by women to professional journals is considerably less than men's. There is a wide array of publishing venues and format to present scholarly work to diverse audiences. Panelists will share tips on how to integrate writing to our busy schedules, how to best frame articles for a variety of journals, and how to become successful authors. The exploration of possible reasons on the gender discrepancy in scholarly publishing will be an important theme of the panel. Panelists are **Jackie Jensen-Vallin,** Lamar University; **Susan Colley**, Oberlin College; **Gizem Karaali,** Pomona College; **Marjorie Senechal**, Smith College; **Cathy Kessel**, Illustrative Mathematics; and ***Dorothy Wallace***, Dartmouth College.

Projects Supported by the NSF Division of Undergraduate Education, organized by **Jon Scott**, Montgomery College; Thursday, 2:00–4:00 pm. This session will feature principal investigators (PIs) presenting progress and outcomes from various NSF funded projects in the Division of Undergraduate Education. The poster session format will permit ample opportunity for attendees to engage in small group discussions with the PIs and to network with each other. Information about presenters and their projects will appear in the program.

MAA Panel on the Dolciani Award: Mathematicians in K–16 Education, organized by **David Stone**, Georgia Southern University**; Will Abram**, Hillsdale College; **Judith Grabiner**, Pitzer College; **Bill Hawkins**, University of the District of Columbia**; Betty Mayfield**, Hood College; **Susan Wildstrom,** Walt Whitman HS, Bethesda MD; **and Glenn Stevens**, Boston University; Thursday, 2:35–3:55 pm. The MAA Mary P. Dolciani Award, funded by the Dolciani Halloran Foundation, recognizes a pure or applied mathematician who is making a distinguished contribution to the mathematical education of K–16 students in the United States or Canada. Although it is new and relatively unknown, it is one of the MAA's major awards. Its recipients form an impressive list of mathematicians who are widely recognized as having contributed to mathematics education:

2015 Sybilla Beckmann, University of Georgia

2014 Alan Schoenfeld, University of California at Berkeley

2013 Hyman Bass, University of Michigan

2012 William G. McCallum, University of Arizona.

The panel will feature recipients of the award and other mathematicians who have been involved in mathematics education. The panelists will address why they believe it is important that research mathematicians become involved in K–16 mathematics education, can provide examples of positive engagement and provide a road map for others who wish to follow their lead. They will highlight the key issues, the roadblocks and rewards in such endeavors. In an address at a previous JMM, Hy Bass said "There are three issues in which every mathematician should be engaged: research, applications and education." This session is an opportunity to hear from mathematicians who have been leaders in all of these arenas. The panel will conclude with an interactive Q&A session. Panelists are: **Hyman Bass,** University of Michigan; **Sybilla Beckman,** University of Georgia; and **Bill McCallum,** University of Arizona.

MAA-AMS-SIAM Panel on Multiple Paths to Mathematics Careers in Business, Industry and Government(BIG),organized by **Rachel Levy,** Harvey Mudd College; **Allen Butler,** Daniel H Wagner Associates; and **Douglas Mupasiri**, University of Northern Iowa Thursday, 2:35–3:55 pm. Career opportunities in Business, Industry and Government (BIG) are growing as tenure track academic job opportunities are shrinking. Yet many Mathematics PhD programs do not include preparation for BIG career options as part of the standard curriculum. At this panel you will have the opportunity to hear about multiple career paths to BIG. Panelists will share (a) what they wish they had known and done as graduate students/postdocs and (b) what you can do at your career stage if you are interested in making connections with business, industry or government. Panelists are: Natalie Durgan, Spiceworks; Mary Morley, State of New Jersey; Frank Cullen, Emeritus Principal with Blackstone & Cullen, Inc.; Dan Sanders, Columbia University; and Prasad Tetali, Georgia Tech. Sponsors for this panel are AMS, BIG SIGMAA, MAA, and SIAM.

Poetry + Math, organized by **Gizem Karaali**, Pomona College; **Lawrence M. Lesser**, University of Texas at El Paso; and **Douglas Norton**, Villanova University; Thursday, 5:30–7:00 pm. In the last few years, JMM attendees have enjoyed eclectic poetry readings. This year's poetry reading continues the tradition. All who are interested in mathematical poetry and/or mathematical art are invited. Come to share your poetry or simply enjoy the evening's offerings! Though we do not discourage last-minute decisions to participate, we invite and encourage poets to submit poetry (no more than three poems, no longer than five minutes) and a bio in advance—and, as a result, be listed on our printed program. Inquiries and submissions (by December 1, 2016) may be made to Gizem Karaali (gizem.karaali@pomona.edu) Sponsors for this event are the Journal of Humanistic Mathematics and SIGMAA ARTS.

Developing the MAA Instructional Practices Guide, organized by **Martha Abell**, Georgia Southern University, and **Linda Braddy**, Tarrant County Community College; Friday, 9:35–10:55 am. In the process of revising the Curriculum Guide, the MAA Committee on the Undergraduate Program in Mathematics (CUPM) encountered questions related to "how we teach" as well as "what we teach." As a result,

the MAA Committee on the Teaching of Undergraduate Mathematics (CTUM) was charged with developing an Instructional Practices (IP) Guide to help faculty become more aware of research-based pedagogical approaches, course design, and assessment of student learning. Panelists are lead writers or project PIs who will discuss various aspects of the Guide, including structure, content, and review process. This panel discussion provides an opportunity for members of the mathematics community to learn more about the Guide and to provide feedback as it is being developed. Panelists are: **Ben Braun**, University of Kentucky; **Julie Phelps**, Valencia College; **Lew Ludwig**, Denison University; and **Hortensia Soto, University of Northern Colorado.** Sponsored by the MAA Committee on the Teaching of Undergraduate Mathematics (CTUM).

Insights from MAA studies of College Algebra, Precalculus, and Calculus, organized by **David Bressoud,** Macalester College, and **Marilyn Carlson,** Arizona State University; Friday, 9:35–10:55 am. The MAA has been running two large NSF-sponsored studies of introductory undergraduate mathematics: Using Research to Shape Instruction and Placement in Algebra and Precalculus (URSIP) and Progress through Calculus (PtC). The latter builds on the findings of Characteristics of Successful Programs in College Calculus to provide tools for departments to improve the precalculus through calculus sequence. It also is studying the obstacles and affordances to the implementation of beneficial changes. This panel will consist of researchers from these two projects summarizing their most significant findings and seeking feedback from the audience for future directions. Panelists are: **Jess Ellis,** Colorado State University; **Bernie Madison**, University of Arkansas; **Chris Rasmussen**, San Diego State University; and **Michael Tallman,** Oklahoma State University.

Presentations by MAA Teaching Award Recipients, organized by **Barbara Faires,** Westminster College, and **Francis Su,** Harvey Mudd College.; Friday, 2:30–3:50 pm. Winners of the Deborah and Franklin Tepper Haimo Awards for Distinguished College or University Teaching will give presentations on the secrets of their success.

Highlighting Contributions to Mathematics Education from Members of Departments of Mathematical Sciences, organized by **Beth Burroughs,** Montana State University; **Jacqueline Dewar**, Loyola Marymount; and **Pao-sheng Hsu**; 2:35–3:55 pm. There are a variety of ways in which members of departments of mathematical sciences contribute to work in mathematics education. This panel is designed to illustrate the breadth and range of these activities and to provide a forum for discussion of particular issues that might arise from such work. It will highlight examples and include the perspectives of mathematicians and mathematics education researchers who contribute in areas such as: teacher education (pre- and in-service); instructional materials development in K–16 mathematics; equity issues in mathematics; and mathematics education research. Panelists will discuss their work in mathematics education and may reflect on how their work is received in their departments. Panelists will update the community on the project. The moderator for this panel is **Robert Klein**, Ohio University. Panelists are: **Viveka Borum**, Spelman College; **LouAnn Lovin**, James Madison University; **Megan Wawro**, Virginia Polytechnic and State University; and **Nina White**, University of Michigan. This panel is co-sponsored by the MAA Committee on the Mathematical Education of Teachers (COMET) and AWM Committee on Education.

MAA Student Poster Session, organized by **Chasen Smith,** Georgia Southern University, **and Eric Ruggieri,** College of the Holy Cross; Friday, 4:30–6:00 pm. This session features research done by undergraduate students. First-year graduate students are eligible to present if their research was completed while they were still undergraduates. Research by high school students can be accepted if the research was conducted under the supervision of a faculty member at a post-secondary institution.

Appropriate content for a poster includes, but is not limited to, a new result, a new proof of a known result, a new mathematical model, an innovative solution to a Putnam problem, or a method of solution to an applied problem. Purely expository material is not appropriate for this session.

Participants should submit an abstract describing their research in 250 words or less by midnight, Friday, October 7, 2016. Notification of acceptance or rejection will be sent by November 1, 2016. See `www.maa.org/programs/students/undergraduate-research/jmm-student-poster-session` for further information on what should be included in the abstract and a link to the abstract submission form.

Posters will be judged during the session and award certificates will be mailed to presenters with the highest scores. Trifold, self-standing 48" by 36" tabletop poster boards will be provided. Additional materials and equipment are the responsibility of the presenters. Participants must set up posters between 2:30 and 3:30 pm and must be available at their posters from 3:30 to 6:00 pm. Judging will begin at 3:30 pm, and general viewing will begin at 4:30 pm. Judges results will be available at the MAA Pavilion in the Exhibit Hall the following day until the exhibits close.

Questions regarding this session should be directed to Chasen Smith `csmith@georgiasouthern.edu` and `Eric Ruggieri eruggier@holycross.edu`. This session is sponsored by the MAA Committee on Undergraduate Student Activities and Chapters.

Actuarial Science at the JMM: 25 Years and Counting, organized by **Patrick Brewer**, Lebanon Valley College; **Robert Buck**, Slippery Rock University; **Bettye Case**, Florida State University; **Kevin Charlwood**, Washburn University; **Michelle Guan**, Indiana University Northwest; **Steve Paris**, Florida State University; and **Sue Staples**, Texas Christian University; Friday, 5:00–7:00 pm. In 1992, James Daniel, University of Texas, began organizing actuarial science sessions to keep faculty members informed of ever-evolving actuarial curriculum changes and career information. Commemorating the 25th anniversary celebration of that first session, Jim will be the opening speaker. He will offer some historical perspective of the past 25 years and a view of the future challenges and rewards for actuarial science faculty. Dwayne Husbands and Jonathan Applewhite, representing the International

Association of Black Actuaries will discuss a new initiative involving a pilot program at Florida State University. The next panel section, "From the Field," will feature working actuaries from the Atlanta area; this popular tradition of the sessions generates lively questions from the audience. Because exam content and credentialing requirements change much faster than the usual academic pace, annual updates from the major credentialing organizations are essential: Rick Gorvett represents the Casualty Actuarial Society and Stuart Klugman represents the Society of Actuaries—there are big changes in the exams structure and content which are anticipated very soon. Panelists are: **James Daniel, University of Texas; Stuart Klugman,** Society of Actuaries; **Rick Gorvett,** Casualty Actuarial Society; **Dwayne Husbands** and **Jonathan Applewhite,** Ernst and Young, representing the International Association of Black Actuaries; two Atlanta area practicing actuaries.

Mathematically Bent Theater, featuring **Colin Adams** and the **Mobiusbandaid Players**; Friday, 6:00–7:00 pm. *Which Greek letter has more cachet, epsilon, delta or sigma? How many mathematicians does it take to change a light bulb?* Who walked off with my copy of "Green's Kernels and Meso-Scale Approximations in Perforated Domains" at the Project NExT Reception at the Seattle Joint Meetings? These are just a few of the questions we will not answer in this theatrical presentation of several short mathematically inclined humorous pieces.

Backgammon! organized by **Arthur Benjamin**, Harvey Mudd College; Friday, 8:00–10:00 pm. Learn to play backgammon from expert players. It's a fun and exciting game where players with a good mathematics background have a decisive advantage. Boards and free lessons will be provided by members of the US Backgammon Federation. Stop by anytime!

Roadblocks for Implementing Active Learning Strategies in Calculus Courses, organized by **Debbie Gochenaur,** Shippensburg University, and **Larissa Schroeder,** University of Hartford; Saturday, 9:00–10:20 am. Faculty members who would like to begin implementing active learning strategies in their Calculus course(s) may become overwhelmed by apparent roadblocks, often quitting before getting very far. Panelists will discuss roadblocks they have encountered through their own journey towards integrating active learning in calculus courses, as well as successful models for implementation. Ample time will be given for questions from the audience. Panelists are: **Angie Hodge,** University of Nebraska Omaha**; Matthew Boelkins,** Grand Valley State University; and **Darryl Yong,** Harvey Mudd College.

Outside the Equation - Exploring Alternative Forms of Mathematical Communication, organized by **Samuel Hansen,** ACMEScience; Saturday, 9:00–10:20 am. Talks, classes, articles, and books. We all know the basics about how mathematics is typically communicated, but there is no reason to limit ourselves to such a narrow set of communication tools. The more ways mathematics is communicated the more people will develop a meaningful connection to mathematics and the more people with a deep connection to our beloved subject the more positive the public perception of mathematics, which is something we can all would be a boon. There are many cases of different types of mathematical communication in the world from videos to art to audio shows to live performances to music. This panel will feature talks from the people on the front lines of this work discussing how they transform mathematics from the classroom and the page into something engaging and new to be enjoyed by many types of different audiences. The panel is made up of people who communicate mathematics through music, mime, art, and podcasts. Panelists are: **Anna Haensch,** Dusquense Univeristy; **Robert Schneider**, Emory University; **Edmund Harriss**, University of Arkansas; and **Tim Chartier,** Davidson College.

Weird Ways to Multiply (and Isn't the Spelling of "Weird" Weird?), organized by **Deanna Haunsperger**, Carleton College; Saturday,10:00–10:50 am. Presenter, **James Tanton**, MAA, will share a whole slew of strange and wild techniques for performing multiplication. Will you be able to figure out why these crazy techniques work? This interactive lecture welcomes students of all ages, and teachers, parents, mathematicians, and math enthusiasts of all ages. Sponsored by the MAA Council on Outreach.

Me and My Gadgets—Teaching with Technology, organized by **Karl R. B. Schmitt, V**alparaiso University; **John Travis,** Mississippi College; **Thomas Hagedorn,** The College of New Jersey; and **Michael Scott,** California State University at Monterey Bay; Saturday, 10:00–11:55 am. Constantly changing technology presents an exciting and shifting opportunity to engage students and improve learning. This electronic poster session will consist of live, interactive demonstrations of applets, widgets or other technology for teaching mathematics. Rather than preparing a traditional printed poster, presenters will showcase how students engage mathematics through their application using some electronic device such as a tablet, smartphone, or laptop. Preference will be given to presenters demonstrating their own or new applications or to novel approaches in using existing ones.

In addition to the active displays, all participants will give a 3–5 minute "Lightning Talk" to demonstrate their application, highlighting where it fits into a mathematics curriculum. These will be scheduled in the middle of the session, and included in the program.

Abstracts should include a short description of the application/software (or a web-link to it) and explain the pedagogical use of the application.

Sponsored by the MAA Committee for Technology in Mathematics Education (CTiME) and Web SIGMAA.

The Impact of High School Calculus on the Transition to College Mathematics, organized by **David Bressoud,** Macalester College, and **Brendan Murphy**, John Bapst High School; Saturday, 10:35–11:55 am. Three-quarters of the students who begin calculus each year do so in high school. Roughly half of all students who matriculate as full-time undergraduates in a four-year program have completed a calculus course before leaving high school. The MAA, NCTM, and College Board are all concerned about differences between students who have and those who have not had access to calculus in high school, particularly the effects on both students' interest in taking and the success experienced in college mathematics courses. This panel will report on what we know about the effects

of this "rush to calculus" and discuss what we might need to know and how such information can be gathered. Panelists are: **Vilma Mesa**, University of Michigan; **Dixie Ross**, Pflugerville High School; **Philip Sadler**, Harvard University; and **Bill Trapp**, The College Board. This panel is sponsored by the College Board/MAA Joint Committee on Mutual Concerns.

What We Talk About When We Talk About Mathematics, organized by **Samuel Hansen**, ACMEScience; Saturday, 10:35–11:55 am. Mathematics is not always the easiest thing to talk or write about, especially when the audience is not other mathematicians. This panel of journalists, authors, and online mathematical communicators will discuss how they take high level mathematics and present them to a general audience in such a way that the audience can not only understand but enjoy the mathematics. The panel will be moderated by Samuel Hansen, the host of the mathematics podcast Relatively Prime. Panelists are: **Beth Malmskog**, Villanova University; **Evelyn Lamb**, Scientific American Blog Network and Freelance Journalist; and **Colin Adams,** Williams College and Author

Math Circle Demonstration, organized by **Gabriella Pinter,** University of Wisconsin Milwaukee; **Tatiana Shubin**, San Jose State University; and **Bob Klein**, Ohio University; Saturday, 11:00–11:55 am. A math circle is an enrichment experience that brings mathematics professionals in direct contact with pre-college students and/or their teachers. Circles foster passion and excitement for deep mathematics. This demonstration session offers the opportunity for conference attendees to observe and then discuss a math circle experience designed for local students. While students are engaged in a mathematical investigation, mathematicians will have a discussion focused on appreciating and better understanding the organic and creative process of learning that circles offer, and on the logistics and dynamics of running an effective circle. The sponsor for this demonstration is SIGMAA MCST.

Introductory Statistics: Where Are We and Where Do We Need to Go? organized by **Gail Burrill**, Michigan State University; Saturday, 2:35–3:35 pm. The content and focus of current introductory statistics courses vary considerably across institutions. In this session, the panelists will discuss the changing audience for the course, new approaches to structuring a course to meet the needs of more students, the changing landscape for the role of statistics and how it is taught, the overarching concepts that should be part of any course, and what the statistics education community should be doing to prepare teachers at all levels for these changes. Questions for the audience will include what they see as barriers to rethinking current courses, what might be done to overcome these barriers, and suggestions for other concerns and considerations in promoting better student learning. Panelists are **Roxy Peck**, Cal Poly, San Luis Obispo; **Uri Triesman**, University of Texas at Austin; **Rob Gould**, University of California Los Angeles; and **Nathan Tintle**, Dordt College. This panel is sponsored by MAA/College Board Mutual Concerns Committee.

SAT Test Development Committee Reflections, organized by **Bill Trapp**, College Board; Saturday, 1:00–2:20 pm. The College Board administered a fully redesigned SAT in March 2016. Some of the changes to the SAT included a narrower content focus, separate calculator portion and no-calculator portion, and no penalty for guessing. Subject matter experts in mathematics began reviewing new questions in 2013 and continue to review hundreds of new questions yearly. This panel will share their experiences and their impressions which have been gathered during their participation as SAT question reviewers for the College Board. Panelists are: **Rinav Mehta,** Central Piedmont Community College; **Gloria Barrett,** North Carolina School of Mathematics and Science; **Luke Wilcox**, East Kentwood High School; and **Katrina Piatek-Jimenez**, Central Michigan University. This panel is sponsored by the College Board/MAA Committee on Mutual Concerns.

Math Wrangle, organized by **Mark Saul**, MAA; **Ed Keppelmann**, University of Nevada Reno and **Paul Zeitz**, University of San Francisco Saturday, 1:00–2:30 pm. Math Wrangle will pit teams of students against each other, the clock, and a slate of great math problems. The format of a Math Wrangle is designed to engage students in mathematical problem solving, promote effective teamwork, provide a venue for oral presentations, and develop critical listening skills. A Math Wrangle incorporates elements of team sports and debate, with a dose of strategy tossed in for good measure. The intention of the Math Wrangle demonstration at the Joint Math Meetings is to show how teachers, schools, circles, and clubs can get students started in this exciting combination of mathematical problem solving with careful argumentation via public speaking, strategy and rebuttal. Sponsors for this event is SIGMAA-MCST.

Special Interest Groups of the MAA (SIGMAAs)

SIGMAAs will be hosting a number of activities, sessions, and guest lectures. There are currently twelve such focus groups in the MAA offering members opportunities to interact, not only at meetings, but throughout the year, via newsletters and email-based communications. For more information visit `www.maa.org/community/sigmaas`.

SIGMAA Officers Meeting, Thursday, 10:30 am to noon; chaired by **Andrew Miller,** Belmont University.

SIGMAA on Mathematics and the Arts (SIGMAA ARTS)

Mathematics and the Arts, Wednesday morning (see MAA Contributed Paper Sessions).

Poetry+Math, Thursday, 5:30–7:00 pm.

SIGMAA on Business, Industry, and Government (BIG SIGMAA)

MAA-AMS-SIAM Joint Panel on Multiple Paths to Mathematics Careers in Business, Industry and Government (BIG), Thursday, 2:35–3:55 pm (see MAA Panels).

Mathematics Experiences and Projects in Business, Industry, and Government, Friday morning (see MAA Contributed Paper Sessions).

PIC Math and Preparing Students for Nonacademic Careers, Saturday morning (see MAA Contributed Paper Sessions).

Guest Lecture, Friday, 5:30–6:20 pm.

Business Meeting and Reception, Friday 6:20–7:30 pm.

SIGMAA on Mathematical and Computational Biology (BIO SIGMAA)

Business Meeting and Reception, Thursday, 6:00–7:00 pm.

Guest Lecture, Thursday, 7:00–7:50 pm, **Martin Meltzer**, Centers for Disease Control.

Trends in Undergraduate Mathematical Biology Education, *Friday afternoon* (see MAA Contributed Papers Sessions).

Current Trends in Mathematical and Computational Biology, Saturday morning (see MAA Invited Paper Sessions).

SIGMAA on Environmental Mathematics (SIGMAA EM)

Modeling and Understanding Environmental Risks, Wednesday (see MAA Invited Paper Sessions).

SIGMAA on the History of Mathematics (HOM SIGMAA)

Business Meeting, Wednesday, 6:00–6:30 pm.

Reception, Wednesday, 6:30–7:00 pm.

Guest Lecture, Wednesday, 7:00–7:50 pm, **Glen Van Brummelen.**

Preserving and Writing the History of Mathematics Departments, Friday morning (see MAA Contributed Paper Sessions).

SIGMAA on Inquiry Based Learning (SIGMAA IBL)

Perspectives on Inquiry Based Learning: Novice, Experienced, and Master, Thursday, 1:00–2:20 pm (see MAA Panels).

Inquiry-Based Teaching and Learning, Friday afternoon (see MAA Invited Paper Sessions).

SIGMAA on Math Circles for Students and Teachers (SIGMAA MCST)

Unexpected Topics for a Math Circle, Friday morning (see MAA Contributed Paper Sessions).

Math Wrangle, Saturday, 1:00–2:30 pm.

SIGMAA on the Philosophy of Mathematics (POM SIGMAA)

Do Mathematicians Really Need Philosophy?, Saturday afternoon (see MAA Contributed Paper Sessions).

SIGMAA on Quantitative Literacy (SIGMAA QL)

New Directions in Quantitative Literacy for General Education, in honor of Lynn Steen, Saturday morning (see MAA Invited Paper Sessions).

SIGMAA on Research in Undergraduate Mathematics Education (SIGMAA RUME)

Research in Undergraduate Mathematics Education, Thursday morning and afternoon (see MAA Contributed Paper Sessions).

SIGMAA on Statistics Education (SIGMAA Stat Ed)

Preparing for the Data Deluge: Mathematics Programs and the Future of Undergraduate Statistics Education,Wednesday, 2:15–3:35 pm (see MAA Panels).

MAA Minicourse: Incorporating Randomization Methods into Introductory Statistics, Part A: Wednesday 9:00–11:00 am and Part B: Friday 9:00–11:00 am (see MAA Minicourses).

MAA Minicourse: Statistical Education of Teachers, Part A: Thursday 9:00–11:00 am and Part B: Saturday 9:00 –11:00 am (see MAA Minicourses).

Incorporating Big Data Ideas in the Mathematics and Statistics Classroom, Thursday afternoon (see MAA Contributed Paper Sessions).

Reception, Thursday, 5:30–6:00 pm.

Business Meeting, Thursday, 6:00–6:45 pm.

Guest Lecture, Thursday, 6:50–7:40 pm, **Brian Gurbaxani**, Centers for Disease Control and Prevention, *Applied Mathematics and Statistics at the CDC–2017 and Beyond*

Modern Data Sets for the Intro Statistics Classroom and Beyond, Friday afternoon (see MAA Contributed Paper Sessions).

SIGMAA on the Teaching of Advanced High School Mathematics (SIGMAA TAHSM)

SIGMAA on Undergraduate Research (UR SIGMAA)

SIGMAA on Mathematics Instruction Using the Web (WEB SIGMAA)

Reception, Friday, 5:30–6:00 pm.

Guest Lecture, Friday, 6:00–6:50 pm, **Rob Beezer**, University of Puget Sound, *Textbooks for the Web from MathBook XML.*

Poster Session: *Me and My Gadgets–Teaching with Technology,* Saturday, 10:00–11:55 am.

MAA Sessions for Students

Radical Dash! organized by ***Stacey Muir***, University of Scranton, and **Janine Janoski**, Kings College; **Radical Dash Kickoff Meeting:** Wednesday, 10:00–10:45 a.m and **Radical Dash Prize Session:** Friday, 10:00–10:45 am. The Radical Dash is a multi-day scavenger hunt for teams of undergraduates filled with math challenges and creative activities. Clues will be released periodically via Instagram (follow us now `@MAARadicalDash`) tasking teams with doing things such as solving math problems, finding mathematical objects in everyday life, and hunting down locations throughout the conference. Team posts will be judged based on completion of tasks as well as creativity. Join us for the Radical Dash Kickoff on Wednesday, January 4, 10:00–10:45 am where team sign ups take place and more details will be provided. Individuals are welcome and encouraged to participate; they will be formed into teams on-site at our kickoff. Winners and prizes will be announced at the Radical Dash Prize Session on Friday, January 6, 10:00–10:45 am. Questions? E-mail us at `MAARadicalDash@gmail.com`. The Radical Dash! is sponsored by MAA Committee on Undergraduate Student Activities and Sections (CUSAC).

What Every Student Should Know about the JMM, organized by **Violeta Vasilevska**, Utah Valley University;

Wednesday, 2:15 –3:35 pm. Navigating a large conference can be overwhelming, even for those who have previously attended such an event. Panelists Joyati Debnath, Winona State University; Michael Dorff, Brigham Young University; and Matt DeLong, Taylor University, will provide guidance for students attending the Joint Mathematics Meetings, including answers to some common questions: How do I get the most out of the program? What sessions are especially for students? What other events should I be on the lookout for? Will I understand any of the invited addresses or should I not bother attending them? If I am presenting a poster, where do I go to set it up? How can I get some cool, free math stuff? Students and their faculty mentors are encouraged to attend. Panelists are: **JJoyati Debnath,** Winona State University; **Michael Dorff**, Brigham Young University; and **Matt DeLong**, Taylor University. This panel is sponsored by the MAA Committee for Undergraduate Student Activities and Chapters (CUSAC).

Grad School Fair, Friday, 8:30–10:30 am. Here is the opportunity for undergrads to meet representatives from mathematical sciences graduate programs from universities all over the country. January is a great time for juniors to learn more, and college seniors may still be able to refine their search. This is your chance for one-stop shopping in the graduate school market. At last year's meeting about 300 students met with representatives from 60 graduate programs. If your school has a graduate program and you are interested in participating, a table will be provided for your posters and printed materials for US$80 (registration for this event must be made by a person already registered for the JMM), and you are welcome to personally speak to interested students. Complimentary coffee will be served. Co-sponsored by the AMS and MAA.

MAA Lecture for Students, Friday, 1:00–1:50 pm, will be given by **Matthew Richey**, St. Olaf College, on *Take What You Have Gathered from Coincidence: Understanding and Using Randomness.*

MAA Student Poster Session, organized by **Chasen Smith,** Georgia Southern University, **and Eric Ruggieri,** College of the Holy Cross; Friday, 4:30–6:00 pm. This session features research done by undergraduate students. First-year graduate students are eligible to present if their research was completed while they were still undergraduates. Research by high school students can be accepted if the research was conducted under the supervision of a faculty member at a post-secondary institution.

Appropriate content for a poster includes, but is not limited to, a new result, a new proof of a known result, a new mathematical model, an innovative solution to a Putnam problem, or a method of solution to an applied problem. Purely expository material is not appropriate for this session.

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Weird Ways to Multiply (and Isn't the Spelling of "Weird" Weird?), organized by **Deanna Haunsperger**, Carleton College; Saturday, 10:00–10:50 am. Presenter, **James Tanton**, MAA, will share a whole slew of strange and wild techniques for performing multiplication. Will you be able to figure out why these crazy techniques work? This interactive lecture welcomes students of all ages, and teachers, parents, mathematicians, and math enthusiasts of all ages. Sponsored by the MAA Council on Outreach.

Project NExT

Project NExT Workshop, Wednesday–Saturday, 8:00–6:00 pm.

Project NExT Lecture on Teaching, Thursday, 11:10 –12 noon, will be given by **Daniel Goroff,** Sloan Foundation on *Behavioral and Bayesian Approaches to Classroom Decision Making.*

See details about the reception on Friday in Social Events.

Other MAA Events

Board of Governors, Tuesday, 9:00 am–5:00 pm.

Department Liaisons Meeting, Wednesday, 9:30–11:00 am.

MAA Section Officers Meeting, Wednesday, 4:00–5:00 pm, chaired by **Betty Mayfield**, Hood College. Section officers will meet with members of the Committee on Sections and MAA staff to share information and discuss current initiatives.

SIGMAA Officers Meeting, Thursday, 10:30–12:00 noon, chaired by **Andrew Miller,** Belmont University.

MAA Business Meeting, Saturday, 11:10–11:40 am, chaired by MAA President **Francis Su**, Harvey Mudd College, and organized by MAA Secretary **Barbara Faires**, Westminster College.

MAA Workshops

Implementing and Orchestrating Active Learning Strategies in Calculus, organized by **Larissa B. Schroeder**, University of Hartford, and **Debbie Gochenaur,** Shippensburg University; Thursday, 1:00–2:20 pm. In this workshop,

participants will engage in pedagogical discussions focused on developing practical strategies for incorporating active learning strategies (e.g., student presentation, inquiry-based learning activities, writing to learn, etc.) into their Calculus courses. The emphasis will be on using existing curricular materials (e.g., activities from Active Calculus (Boelkins, Austin, & Schlicker, 2015), classroom voting questions, concept tests, etc.) to support active learning. Active learning strategies are those that engage students in activities that promote analysis, synthesis and evaluation of course content. This workshop, intended for the novice user, will include small group discussions and interactive discussions with the organizers and will focus on helping participants move beyond the initial difficulties associated with first-time implementation of active learning strategies.

Course Design with Active Learning, organized by **Victor Piercey,** Ferris State University, and **Luke Tunstall**, Michigan State University; Thursday, 2:35–3:55 pm. Faculty are often called upon to create new courses and redesign existing courses. Participants in this workshop will outline the design for a sample learning module using "backwards design." Backwards design is a technique for course design which begins with what students should be able to do or demonstrate at the end of the course, followed by how this will be assessed, and concludes with preparing learning activities. We will identify learning outcomes appropriate for active learning, discuss assessment techniques, and conclude by outlining supporting learning activities. Regardless of whether you are addressing general education reform or redesigning advanced courses for graduate students, if you are working on a designing a new course then this workshop will be for you.

Using Interactive Dynamic Technology in Teaching Introductory Statistics: Simulation-Based Inference, organized by **Gail Burrill,** Michigan State University; presenters for this workshop are **Darren Starnes,** The Lawrenceville School; **Chris Franklin,** American Statistics Association; and **Beth Chance,** California Polytechnic State University, San Luis Obispo; Saturday, 9:00–10:20 am. The use of software packages to analyze data is considered a core part of introductory statistics courses. But technology can also be used to introduce fundamental concepts of statistical inference using simulation-based methods. This shift from methods based on the normal distribution can provide new insights into statistical reasoning. Participants will engage in activities using interactive dynamic technology to explore the underlying logic of confidence intervals and significance tests with real data.

Activities of Other Organizations

This section includes scientific sessions. Several organizations or special groups are having receptions or other social events. Please see the "Social Events" section of this announcement for those details.

Association for Symbolic Logic (ASL)

This two-day program on Friday and Saturday will include sessions of contributed papers as well as Invited Addresses by **Matthew Foreman**, University of California Irvine; **Clinton Conley,** Carnegie Mellon University; **Alfred Dolich**, Kingsborough Community College; **Rahim Moosa,** University of Waterloo; **Linda Brown Westrick,** University of Connecticut; **Alexandra Shlapentokh**, East Carolina University; and **Henry Towsner**, University of Pennsylvania.

Association for Women in Mathematics (AWM)

Thirty-Eighth Annual Noether Lecture, Thursday, 10:05 am, will be given by **Lisa Jeffrey,** University of Toronto, *Cohomology of Symplectic Quotients.*

Also see the sessions on *Symplectic Geometry, Moment Maps and Morse Theory,* jointly sponsored by the AWM, in the "AMS Special Sessions" listings.

Association for Women in Mathematics Panel: "Mentoring Women in Mathematics." organized by **Michelle Manes**, University of Hawaii at Manoa; Wednesday, 2:15–3:40 pm. Mentors play many roles: They may give specific advice about mathematics, schools, and career; or they may convey informal "common wisdom" about the life of a mathematician and how to live it. They may be a role model, an embodiment of what might be possible down the line. They may be the person a student turns to for guidance when she faces a difficult situation either personally or professionally. Relationships with mentors might be official or unofficial, and they may be short-lived or decades long. Mentors might be teachers, advisors, collaborators, colleagues, or friends. Women in mathematics face all the same challenges as their male colleagues: the challenge of doing a very difficult job well, imposter syndrome, fear of failure, the job search, two-body problems, and work-life balance questions. But they are more likely than their male colleagues to face sexism, discrimination, and even harassment. Effective mentors offer guidance through difficult times, know about opportunities, and help with goal setting. Hear from panelists with extensive and varied experiences mentoring women at all stages of their mathematics studies and careers. This session is open to all JMM attendees. Panelists include **Helen Grundman**, Bryn Mawr College; **Ruth Hass,** Smith College; **Deanna Haunsperger,** Carleton College; **Kristin Lauter**, Microsoft Research, and other panelists to be announced. `https://sites.google.com/site/awmpanel2017/`

Business Meeting, Wednesday, 3:45–4:15 pm. Chair, **Kristen Lauter,** AWM President

Workshop Poster Presentations and Reception, Friday, 6:00–7:15 pm. AWM will conduct its workshop poster presentations by women graduate students. AWM seeks volunteers to serve as mentors for workshop participants. If you are interested, please contact the AWM office at awm@awm-math.org. This session is open to all JMM attendees. Organizers for these presentations are **Rosa Orellana,** Dartmouth College and **Anne Shepler**, University of North Texas. The Poster Judging Coordinator is **Sylvia Wiegand,** University of Nebraska at Lincoln..

AWM Workshop: Special Session on Number Theory, Saturday, 8:00–5:00 pm, AWM will conduct its workshop with presentations by senior and junior women researchers. Updated information about the workshop is available at `www.awm-math.org/workshops.html`. All JMM attendees are invited to attend the program. Organizers for this

workshop are **Alina Bucur,** University of California, San Diego and **Ellen Eischen**, University of Oregon.

Reception, Wednesday, 9:30–11:00 pm. See the listing in the "Social Events," section of the announcement.

See also the sessions cosponsored by the AWM on *Symplectic Geometry, Moment Maps and Morse Theory* on Friday in the "AMS Special Sessions" listings. Organizers for these sessions are **Lisa Jeffery**, University of Toronto, and **Tara Holm,** Cornell University.

National Association of Mathematicians (NAM)

Granville-Brown-Hayes Session of Presentations by Recent Doctoral Recipients in the Mathematical Sciences, Friday, 1:00–4:00 pm. Organizer: Talitha Washington, Howard University/NAM.

Cox-Talbot Address, to be given Friday after the banquet by **Garikai Campbell**, Provost, Morehouse College, title to be announced. See details about the banquet on Friday in the "Social Events" section.

Panel Discussion; ***Transforming Post-Secondary Education (TPSE) Mathematics: Implications for the Preparation of African American Undergraduates and Institutions,*** Saturday, 9:00–9:50 am, Moderator: **Duane Cooper**, Morehouse; Panelists to be announced.

Claytor-Woodward Lecture, Saturday, 1:00 pm, **Wilfrid Gangbo**, Georgia Institute of Technology, ***Paths of minimal lengths on the set of exact differential k-forms.***

See also the special session on Thursday co-sponsored by NAM in the "AMS Special Sessions" listings: ***The Mathematics of the Atlanta University Center,*** organized by **Talitha M. Washington**, Howard University, **Monica Jackson**, American University, and **Colm Mulcahy**, Spelman College.

Business Meeting, Saturday, 10:00–10:50 am.

National Science Foundation (NSF)

The NSF will be represented at a booth in the exhibit area. NSF staff members will be available to provide counsel and information on NSF programs of interest to mathematicians. The booth is open the same days as the exhibits. Times that staff will be available will be posted at the booth.

Pi Mu Epsilon (PME)

Council Meeting, Thursday, 8:00–11:00 am.

Rocky Mountain Consortium Board Meeting,

Friday, 2:15–4:00 pm

Society for Industrial and Applied Mathematics (SIAM)

This program consists of an Invited Address, ***The dynamics of systems interacting across statistical scales,*** at 11:10 am on Thursday given by **Irene M. Gamba**, University of Texas at Austin, and a series of Minisymposia to include ***Recent Advances in Linear Algebra,*** **James Nagy**, Emory University; ***Applications of Algebra, Geometry, and Topology***, **Frank Sottile**, Texas A&M University; ***The GAIMME Report on Mathematical Modeling in K-16***, **Kathleen Fowler**, Clarkson University; ***Topics in Analysis and Numerical Methods for Collisional Kinetic Equations,*** **Ricardo Alonso**, Pontifical Catholic University of Rio de Janeiro, **Irene M. Gamba,** University of Texas at Austin, and **Robert Strain**, University of Pennsylvania; ***Recent Advances in Uncertainty Quantification,*** **Noemi Petra,** University of California Merced**,** and **Juan C. Meza,** University of California Merced; ***Recent Developments in Computational Inverse Problems and Imaging,*** **Kui Ren**, University of Texas, Austin, **Fernando Guevara Vasquez**, University of Utah**,** and **Alexander V. Mamonov,** University of Houston; ***Mathematics of Planet Earth***, **Hans Kaper,** Georgetown University; and ***PDEs in Biology and Materials Science,*** **Yuliya Gorb,** University of Houston, and **Sunčica Čančić,** University of Houston.

The Program also includes the following co-sponsored panel discussions:, ***AMS-SIAM Committees on Education***, ***Panel on Broadening Research Experiences for Doctoral Students in the Mathematical Sciences,*** Thursday, 1:00 – 2:30 pm **(**see AMS Panels); and the ***MAA-AMS-SIAM Panel on Multiple Paths to Mathematics Careers in Business, Industry and Government (BIG),*** Thursday, 2:35–3:55 pm. (See AMS and MAA Panels).

In this panel, we will hear about efforts to improve the training of mathematical sciences doctoral students by involving them in research activities outside of their main dissertation research topic in order to better prepare them for a broader range of careers.

Programs have been designed to encourage connections between mathematical sciences and other academic departments, and between academia and business, industry, government, and non-profit organizations.

The aim is to produce students who are able to recognize opportunities for the development of mathematics and statistics in problems originating in a variety of settings, and who can apply advanced mathematics and statistics to help solve such problems.

See also the AMS-MAA-SIAM Special Session on *Research in Mathematics by Undergraduates and Students in Post-Baccalaureate Programs* in the "AMS Special Session" listings. The organizers for this session are **Darren A. Narayan**, Rochester Institute of Technology, **Tamas Forgacs**, California State University, Fresno, and **Ugur Abdulla**, Florida Institute of Technology

Others

Hrabowski-Gates-Tapia-McBay Session, organized by **Ricardo Cortez,** Tulane University; Wednesday, 9:00–9:50 am. The Hrabowski-Gates-Tapia-McBay Session is named after four influential scientists of color: (1) Freeman Hrabowski, President of the University of Maryland at Baltimore County; (2) James S. Gates, University of Maryland, College Park; (3) Richard Tapia, Rice University; and (4) Shirley McBay, President of Quality Education for Minorities (QEM). Through multiple mechanisms, these Sessions expect to facilitate and accelerate the participation of scientists in the building of sustainable communities of mathematicians and mathematical scientists. In particular, the intention is to systematically recruit, welcome, encourage, mentor, and support individuals from underrepresented groups in the USA. This year the 2017 session will consist of a lecture will be given by **Mariel Vazquez**, University of California Davis.

From Calculus to a Bachelor's Degree: Encouraging and Developing Undergraduate Mathematics Majors, organized by **Jenna P. Carpenter**, Campbell University; Thursday, 1:00–2:30 pm. This panel will address how to identify, encourage, and develop undergraduate mathematics majors. This is of particular relevance to women, since recent studies show that only half as many women as men who start in first semester Calculus continue on to the second semester. The panel will cover steps that faculty members and departments can take to identify and develop majors, educate students about careers, and create exciting and relevant courses and opportunities. It will also be of particular interest to undergraduate students. Panelists are **Alison Henrich**, Seattle University; **Sylvia Bozeman,** Spelman, Infinite Possibilities; **Federico Ardila,** San Francisco State University; and **Christine Kelley**, University of Nebraska-Lincoln. Sponsored by the Joint Committee on Women in the Mathematical Sciences.

Mathematical Art Exhibition, organized by **Robert Fathauer**, Tessellations Company; **Anne Burns**, Long Island University C. W. Post Campus, **Nathan Selikoff**, Digital Awakening Studios, and **Elizabeth Whiteley**, studio artist, Washington, D.C. A popular feature at the Joint Mathematics Meetings, this exhibition provides a break in your day. On display are works in various media by artists who are inspired by mathematics and by mathematicians who use visual art to express their findings. Topology, fractals, polyhedra, and tiling are some of the ideas at play here. Don't miss this unique opportunity for a different perspective on mathematics. The exhibition will be located inside the Joint Mathematics Exhibits and open during the same exhibit hours.

Summer Program for Women in Mathematics (SPWM) Reunion, organized by **Murli M. Gupta,** George Washington University; Thursday, 1:00–3:00 pm. This is a reunion of the summer program participants from all 19 years (1995–2013) who are in various states of their mathematical careers: some are students and, others are in various jobs, both in academia as well as government and industry. The participants will describe their experiences relating to all aspects of their careers. There will also be a discussion on the increasing participation of women in mathematics over the past two decades and the national impact of SPWM and similar programs. See `www.gwu.edu/~spwm`.

Social Events

All events listed are open to all registered participants. It is strongly recommended that for any event requiring a ticket, tickets should be purchased through advance registration. Only a very limited number of tickets, if any, will be available for sale on site. If you must cancel your participation in a ticketed event, you may request a 50% refund by returning your tickets to the Mathematics Meetings Service Bureau (MMSB) by **December 29, 2016.** After that date no refunds can be made. Special meals are available at banquets upon advance request, but this must be indicated on the Advanced Registration/Housing Form.

2017 AMS Dinner, Join your colleagues on this special occasion of celebration in the mathematical community. The AMS will recognize long-term members as well as honor the recipients of Programs That Make a Difference Awards and the Exemplary Programs Award. Enjoy delicious meals from gourmet food stations, special entertainment, and enter to win fun prizes at the raffle table! This evening of celebration will be held on Saturday, January 7th with a reception at 6:30 pm and doors opening at 7:30 pm. Tickets are US$69 including tax and gratuity. The student ticket price is US$30.

Association of Christians in the Mathematical Sciences (ACMS) Reception and Lecture, Thursday, 5:30–7:30 pm. The reception will take place between 5:30 and 6:30 pm, followed by a short program and 20 minute talk at 6:30 pm. The talk will be given by Satyan Devadoss from the University of San Diego. Students are encouraged to attend. Opportunity will be provided afterwards for delegates to go to dinner at local restaurants.

Association of Lesbian, Gay, Bisexual, and Transgendered Mathematicians Reception, Thursday, 6:00–8:00 pm. Annual reception for lesbian, gay, bisexual, and transgender mathematicians. We are affiliated with NOGLSTP, the National Organization of Gay and Lesbian Scientists and Technical Professionals, Inc. `www.lgbtmath.org`.

Association for Women in Mathematics Reception and Awards Presentation, the AWM Reception which is open to all JMM attendees will be held on Wednesday at 9:30 pm after the AMS Gibbs Lecture. The AWM President at 10:00 pm will recognize all of the honorees of the AWM Alice T. Schafer Prize for Excellence in Mathematics by an Undergraduate Woman, the recipients of the AWM Dissertation Prize and the AWM Service Awards.

Backgammon! organized by **Arthur Benjamin**, Harvey Mudd College; Friday, 8:00–10:00 pm. Learn to play backgammon from expert players. It's a fun and exciting game where players with a good mathematics background have a decisive advantage. Boards and free lessons will be provided by members of the US Backgammon Federation. Stop by anytime on Friday evening.

Budapest Semesters in Mathematics Annual Alumni Reunion, Thursday, 5:30 pm.

Budapest Semesters in Mathematics Education Informational Session, Friday, 12:00–1:00 pm. BSME is a semester-long program in Budapest, Hungary, designed for American and Canadian undergraduates (and recent graduates) interested in teaching middle school or high school mathematics. Participants will study the *Hungarian approach* to learning and teaching, in which a strong and explicit emphasis is placed on problem solving, mathematical creativity, and communication. Come learn more about this exciting new program.

George Washington University Math Alumni Reception, Thursday, 7:00 - 8:00 pm. The George Washington University Department of Mathematics invites all of our graduates attending the Joint Mathematics Meetings in Atlanta. Please come and meet the math faculty and other alumni; refreshments will be served.

Reception for Graduate Students and First-Time Participants, Wednesday, 5:30–6:30 pm. The AMS and MAA cosponsor this social hour. Graduate students and first-timers are especially encouraged to come and meet

some old-timers to pick up a few tips on how to survive the environment of a large meeting. Light refreshments will be served.

University of Illinois at Urbana-Champaign, Friday, 5:30–7:30pm. Department of Mathematics, Math Reception. Everyone ever connected with the Department is encouraged to get together for conversation and to hear about mathematics at the University of Illinois.

Joint Prize Reception, Thursday 5:30–6:30 pm.

Knitting Circle, Thursday, 8:00–9:30 pm. Bring your needlework and come knit (crochet, cross-stitch, etc.) with us while talking about math or other relaxing subjects. Catch up with your friends and meet new ones during this fun social event.

MAA/Project NExT Reception, Friday, 8:00–10:00 pm, organized by **Julia Barnes**, Western Carolina University; **Alissa Crans**, Loyola Marymount University; **Matt DeLong,** Taylor University; and **Dave Kung**, St. Mary's College of Maryland. All Project NExT Fellows, consultants, and other friends of Project NExT are invited.

MAA Two-Year College Reception, Wednesday, 5:45–7:00 pm, is open to all meeting participants, particularly two-year faculty members. This is a great opportunity to meet old friends and make some new ones. There will be hot and cold refreshments and a cash bar.

Mathematical Reviews Reception, Friday, 6:00–7:00 pm. All friends of the Mathematical Reviews (MathSciNet) are invited to join reviewers and MR editors and staff (past and present) for a reception in honor of all of the efforts that go into the creation and publication of the Mathematical Reviews database. Refreshments will be served.

Mathematical Institutes Open House, Wednesday, 5:30–8:00 pm. Members of the AMS and MAA who are attending the Joint Mathematics Meetings are warmly invited to come to the Mathematical Institutes Open House reception, co-sponsored by several of the mathematical sciences institutes in North America. This reception precedes the Gibbs Lecture. We hope to see you there! `https://icerm.brown.edu/events/mioh/2017`

MSRI Reception for Current and Future Donors, Thursday, 6:30–8:00pm. MSRI invites current and prospective donors to an informal reception with appetizers and drinks. Directors David Eisenbud and Helene Barcelo will speak about present and upcoming events and programs, as well as the impact of private support on the Institute.

MSRI thanks and acknowledges mathematicians who support MSRI's programs and workshops through membership in the Archimedes Society or the Gauss Society. Archimedes Society members support MSRI with annual gifts. Gauss Society members support MSRI with a planned gift through arrangements in their wills and estates.

For more information about the event and how to join the Archimedes or Gauss Societies, please contact, Heike Friedman, Director of Development, `hfriedman@msri.org`; 510.643-6056. `www.msri.org`

National Association of Mathematicians Banquet, Friday, 6:00–8:40 pm. A cash bar reception will be held at 6:00 pm, and dinner will be served at 6:30 pm. Tickets are US$65 each, including tax and gratuity. The Cox-Talbot Invited Address will be given after the dinner.

NSA Women in Mathematics Society Networking Session, Thursday, 6:00–8:00 pm.

PROMYS and Ross Reception for Alumni and Friends, Thursday, 6:30–8:30 pm. There will be hors d'oeuvres, a cash bar, old friends, new friends, and good conversation!

Texas A&M University Mathematics Department Reception for Alumni, Students, and Faculty, Friday, 5:30–7:30 pm. All alumni, current students, faculty, and current and former post-docs are invited to join us for this reception.

Reception for Undergraduates, Wednesday, 4:30–5:30 pm.

University of Waterloo Alumni and Friends Reception, Thursday, 6:00–8:00 pm. Dean Stephen M. Watt would like to invite all UW Math Alumni and Friends attending the JMM to join him in celebrating the 50th Anniversary of the Faculty of Mathematics at the University of Waterloo.

YP17 HCSSiM Reunion Breakfast, Friday, 7:34 am.

Welcoming Environment Policy

The AMS and MAA strive to ensure that participants in the Joint Mathematics Meetings (JMM) enjoy a welcoming environment. In all JMM activities, the two organizations seek to foster an atmosphere that encourages the free expression and exchange of ideas. The AMS and MAA support equality of opportunity and treatment for all participants, regardless of gender, gender identity or expression, race, color, national or ethnic origin, religion or religious belief, age, marital status, sexual orientation, disabilities, or veteran status.

Harassment is a form of misconduct that undermines the integrity of JMM activities as well as the AMS and MAA missions. The AMS and MAA will make every effort to maintain an environment that is free of harassment, even though they do not control the behavior of third parties. A commitment to a welcoming environment is expected of all attendees at JMM activities, including mathematicians, students, guests, staff, contractors and exhibitors, and participants in scientific sessions and social events. To this end, the AMS and MAA will include a statement concerning their expectations toward maintaining a welcoming environment in registration materials, and have put in place a mechanism for reporting violations. Violations may be reported confidentially and anonymously to 855-282-5703 or at `www.mathsociety.ethicspoint.com`. The reporting mechanism ensures the respect of privacy while alerting the AMS and MAA to the situation.

Registering in Advance

The importance of registering for the meeting cannot be overemphasized. Advanced registration fees are considerably lower than on-site registration fees. The AMS and the MAA encourage all participants to register for the meeting. When a participant pays a registration fee, he or she is helping to support a wide range of activities associated with planning, organizing, and executing the meetings.

All participants who wish to attend sessions are expected to register and should be prepared to show their badges if so requested. Badges are required to enter the

Joint Mathematics Meetings (JMM) Exhibits, the Employment Center, to obtain discounts at the AMS and MAA Book Sales, and to cash a check with the Joint Meetings cashier.

All JMM registrations are processed by the Mathematics Meetings Service Bureau (MMSB). Participants who register by **November 22, 2016,** may receive their badges, programs, and tickets (where applicable) in advance by US mail approximately three weeks before the meetings. Those who do not want their materials mailed should check the appropriate box on the Registration and Housing Form. Materials cannot be mailed to Canada, Mexico, or other countries outside of the US. Participants from these countries must pick up their materials at the Joint Meetings Registration Desk, which will be located on the Lower Level 2 of the Hyatt Regency Atlanta. Please note that a replacement fee of US$5 will be charged for programs and badges that were mailed but not brought to the meeting.

Online Registration: To register and reserve a hotel room online, visit www.jointmathematicsmeetings.org/meetreg?meetnum=2180. VISA, MasterCard, Discover, and American Express are the only methods of payment accepted for online registrations, and charges to credit cards will be made in US funds. Registration acknowledgments will be sent by e-mail to the e-mail address provided.

Paper Form Registration: Download and print the paper form that can be found at the following website: www.jointmathematicsmeetings.org/meetings/national/jmm2017/jmm17_regform.pdf. If you are using the paper form to register for the meeting and do not have a credit card, please contact the MMSB at mmsb@ams.org for further instructions. If you are using a check to reserve your hotel room, your reservation and check must be received by the MMSB no later than **December 1, 2016.**

Forms must be mailed or faxed to the MMSB at MMSB, P.O. Box 6887, Providence, RI 02940 or 401-455-4004. For security reasons, credit card numbers by e-mail or fax cannot be accepted. If a participant is registering by paper form and would like to pay for his or her registration via credit card, he or she should indicate this on the form. Someone from the MMSB will then call that person.

Badges: All registered participants (including guests) for the meeting will receive a badge. Each badge of a registered mathematician will include an embedded vCard (electronic business card) in the form of a QR Code; placed on the back of the badge. This code will include name, postal address, phone number, e-mail address, and subject classification code (if given). It will enable exhibitors to retrieve the same information they would receive from a business card with one quick scan. Allowing an exhibitor to scan the code on a badge will be strictly voluntary by each participant and any participant may choose to cover his or her code.

Participant Lists and Mailing Lists: If a participant would like to opt-out of any mailing lists or participant lists that are generated for the meeting, he or she should check the appropriate box on the Registration and Housing Form. All participants who do not opt-out will be included in all mailing lists and participant lists that are generated and distributed for the meeting.

Cancellation Policy: Participants who cancel their registrations for the meetings, minicourses, Short Course, or banquet tickets by December 29, 2016, will be eligible to receive a 50 percent refund of fees paid. No refunds will be issued after this date.

Joint Mathematics Meetings Registration Fees

	Advanced (by Dec. 20)	**At Meeting**
Member of AMS, ASL, CMS, MAA, SIAM	US$316	US$416
Non-member	502	640
Graduate Student Member of AMS, ASL, CMS, MAA, SIAM	71	83
Graduate Student Non-member	113	125
Undergraduate Student Member of AMS, ASL, CMS, MAA, PME, KME, SIAM	71	83
Undergraduate Student Non-member	113	125
Temporarily Employed	258	295
Emeritus Member of AMS, MAA; Unemployed; High School Teacher; Developing Countries; Librarian	71	83
High School Student	7	13
One-Day Member of AMS, ASL, CMS, MAA, SIAM	N/A	226
One-Day Non-member	N/A	353
Non-mathematician Guest	20	20
Commercial Exhibitor	0	0
MAA Minicourses	100	100
Grad School Fair Table	80	80
AMS Short Course:		
Member of AMS	112	146
Non-member	170	200
Student/Unemployed/Emeritus	60	81

Registration Category Definitions

Full-Time Students: Any person who is currently working toward a degree or diploma is eligible for this category. Students are asked to determine whether their status can be described as a graduate (working toward a degree beyond the bachelor's), an undergraduate (working toward a bachelor's degree), or high school (working toward a high school diploma) and to mark the Registration and Housing Form accordingly. See membership distinctions below.

Graduate Student Member: Any graduate student who is a member of the AMS, ASL, CMS, MAA, or SIAM is eligible for this category. Students should check with their department administrator to verify their membership status.

Undergraduate Student Member: Any undergraduate student who is a member of the AMS, ASL, CMS, MAA, SIAM, PME, or KME is eligible for this category. Students should check with their department administrator to verify their membership status.

Emeritus: Any person who has been a member of the AMS for 20 years or more and who retired because of age

or a long-term disability from his or her latest position is eligible for this category. Any person who has been a member of the MAA for 25 years or more and who is 70+ years of age is eligible for this category.

Librarian: Any librarian who is not a professional mathematician is eligible.

Unemployed: Any person who is currently unemployed, actively seeking employment, and is not a student is eligible. This category is not intended to include any person who has voluntarily resigned or retired from his or her latest position.

Developing Country Participant: Any person employed in developing countries where salary levels are radically not commensurate with those in the US is eligible.

Temporarily Employed: Any person currently employed but who will become unemployed by June 1, 2017, and who is actively seeking employment is eligible.

Non-mathematician Guest: Any family member or friend, who is not a mathematician, and who is accompanied by a participant in the meetings is eligible for this category. Guests will receive a badge and may accompany a mathematician to a session or talk. Guests may also enter the exhibit area.

Commercial Exhibitor: Any person exhibiting in the Joint Mathematics Meetings Exhibits and in the Mathematical Art Exhibition is eligible for this category. This does not include anyone participating in any poster sessions. Any exhibitor who is a mathematician and wants to attend sessions, talks, etc. is expected to register separately for the meeting.

Registration Deadlines

There are two separate registration deadlines, each with its own benefits:

ORDINARY meeting registration (hotel reservations, registration materials mailed)—**November 22**

FINAL meeting registration (advanced registration, short course, minicourses)**—December 20**

Ordinary Registration: Participants who register by November 22 can still receive their materials by mail, if they choose. Participants may reserve rooms through the MMSB until **December 12.**

Final Registration: Participants who register after **November 22** and by **December 20** must pick up their badges, programs, and any tickets for social events at the meeting. Registration materials may be picked up at the Meetings Registration Desk, located on the Lower Level 2 of the Hyatt Regency Atlanta.

Hotel Accommodations

The importance of reserving a hotel room at one of the official Joint Mathematics Meetings (JMM) hotels cannot be stressed enough. The AMS and the MAA make every effort to keep participants expenses at the meeting, registration fees, and hotel rooms for the meeting as low as possible. They work hard to negotiate the best hotel rates and to make the best use of your registration dollars to keep the meetings affordable. The AMS and MAA encourage all participants to register for the meeting. When anyone pays the registration fee and reserves a room with an official JMM hotel, he or she is helping to support not only the JMM in 2017, but also future meetings.

General: Participants are encouraged to register for the JMM in order to reserve hotel rooms at the contracted JMM rates. If a participant needs to reserve a hotel room before they are registered for the JMM, he or she must contact the Mathematics Meetings Services Bureau (MMSB) at mmsb@ams.org or 1-800-321-4267 ext. 4137 or ext. 4144 for further instructions.

Special rates have been negotiated exclusively for this meeting at the following hotels: Hyatt Regency Atlanta, Marriott Marquis Atlanta, and Hilton Atlanta. (See details on these hotels below.)

To receive the JMM rates, reservations for these hotels must be made through the MMSB. The hotels will not be able to accept reservations directly until after **December 14, 2016,** and at that time, rooms and rates will be based on availability. Any rooms reserved directly with the hotels after **December 14, 2016** are subject to rates higher than the JMM rates.

A link to the 2017 JMM housing site will be included in e-mail confirmations of all registrations. If a participant needs to have the link e-mailed again, requests should be sent to mmsb@ams.org. Participants requiring assistance reserving a hotel room should send e-mail to mmsb@ams.org.

Any participant who needs to reserve a hotel room and does not have a credit card should contact the MMSB at mmsb@ams.org for further instructions. If a check is being used to reserve a hotel room, the reservation and check must be received by the MMSB no later than **December 1, 2016.**

ADA Accessibility: We strive to take the appropriate steps required to ensure that no individual with a disability is excluded, denied services, segregated, or otherwise treated differently. If special assistance, auxiliary aids, or other reasonable accommodations to fully participate in this meeting is required, it should be indicated in the appropriate section on the Registration and Housing Form or emailed to the MMSB at mmsb@ams.org. Requests for ADA-accessible rooms should also be clearly indicated when making hotel reservations. All requests for special accommodations under the Americans with Disabilities Act of 1990 (ADA) must be made allowing enough time for evaluation and appropriate action by the AMS and MAA. Any information obtained about any disability will remain confidential.

Cancellation Policies: There is a 48-hour cancellation policy prior to check-in at the Hilton Atlanta.

There is a 72-hour cancellation policy prior to check-in: at both the Hyatt Regency Atlanta and Marriott Marquis Atlanta.

Check-in/Check-out: Check-in at the Hilton Atlanta is 3:00 pm and check-out is at 11:00 am. Check-in at the Hyatt Regency Atlanta is at 3:00 pm and check-out is at noon. Check-in at the Marriott Marquis Atlanta is at 4:00 pm and check-out is at noon.

Confirmations: An e-mail confirmation number will be provided for each hotel reservation made online. This

confirmation number will give participants direct access to edit their reservations up to **December 12, 2016.** Those who did not receive a confirmation number or who have any questions about the reservation process should contact the MMSB at mmsb@ams.org or 1-800-321-4267, ext. 4137 or 4144.

Deadlines: The deadline to make changes or cancellations to hotel reservations through the MMSB is **December 12.**

Environmental Policies: All of the hotels listed have environmental-friendly programs in place.

Internet Access/Wireless: Complimentary wireless internet is available in all public areas, the lobby, and all sleeping rooms at the Hilton Atlanta.

Complimentary wireless internet is available in the lobby and all sleeping rooms at the Hyatt Regency Atlanta.

Complimentary wireless internet is available in all public places and the lobby at the Marriott Marquis Atlanta. There is a daily charge of US$14.95 for wired or wireless internet in the sleeping rooms. Free internet is provided in the guest room of any Marriott Rewards member. To become a Marriott Rewards member, visit https://www.marriott.com/rewards/createAccount/createAccountPage1.mi?segmentId=elite.nonrewards to sign up for a free membership if you do not already have one.

Location: The Hyatt Regency Atlanta and the Marriott Marquis Atlanta will be co-headquarter hotels for this meeting. The JMM Registration Desk, exhibits, poster sessions, and AMS Employment Center will be located in the Hyatt Regency Atlanta. Sessions, committee meetings, and other meetings will be held in both the Hyatt Regency Atlanta and the Marriott Marquis Atlanta. All three hotels will be connected by sky bridges and will together occupy approximately 3 city blocks.

Hyatt Regency Atlanta (co-headquarter); 265 Peachtree Street NE, Atlanta, GA, 30303. Room rates are US$175 for a single/double and US$140 for a single/double student rate room. This property is a smoke-free hotel. Restaurants on-site include *Sway, Polaris, Twenty-Two Storys Lobby Bar*, and *the Marketplace*. Amenities at this property include a fitness center, outdoor pool and a 24-hour business center available to registered guests. Full amenities are available in guest rooms including laptop-sized safes and some rooms with windows that open. Children under 16 are free in a room with an adult and cribs are available upon request at no additional charge. Rollaways are available for use in king-bedded rooms only. No pets allowed. Valet parking is available for a charge of US$35 per day and includes in/out privileges. Parking rates are subject to change. This hotel does not offer an airport shuttle. Confirmations will be sent by e-mail only.

Marriott Marquis Atlanta (co-headquarter), 265 Peachtree Center Avenue, Atlanta, GA, 30303. Room rates are US$175 for a single/double and US$140 for a single/double student rate room. This property is a smoke-free hotel. Restaurants on-site include *Sear, High Velocity, Pulse, and Starbucks*. Amenities at this property include a fitness center, outdoor pool and a 24-hour business center available to registered guests. Full amenities are available in guest rooms including laptop-sized safes. Windows in guest rooms do not open. Children under 17 are free in a room with an adult and cribs are available upon request at no additional charge. Rollaways are available for use in king-bedded rooms only. No pets allowed. Valet parking is available for a charge of US$35 per day and includes in/out privileges. Parking rates are subject to change. This hotel does not offer an airport shuttle. Confirmations will be sent by e-mail only.

Hilton Atlanta, 255 Courtland Street NE, Atlanta, GA, 30303. First tier room rates are US$139 for a single/double and second tier rates are US$149 for a single/double room. First Tier rates will be applicable while rooms in that category are available. Second Tier rates will only be available when the inventory of First Tier rates is entirely reserved. Participants who want First Tier rates are advised to reserve their rooms early. This property is a smoke-free hotel. Restaurants on site include *Trader Vic's, Marketplace, Nikolai's Roof,* and *Southern Elements*. Amenities at this property include a fitness center, outdoor pool and a 24-hour business center available to registered guests. Full amenities are available in guest rooms including laptop-sized safes. Windows in guest rooms do not open. Children under 17 are free in room with an adult and cribs are available upon request at no additional charge. Rollaways are available for use in king-bedded rooms only. Pets under 75 pounds are allowed in guest rooms. Valet parking is available for a charge of US$36 per day and includes in/out privileges. Parking rates are subject to change. This hotel does not offer an airport shuttle. Confirmations will be sent by email only.

Parking: Please see the *parking* section under *Travel* for parking options. Parking information for each hotel has been listed above in the description of each property.

Rates: All rates are subject to applicable local and state taxes in effect at the time of check-in; currently the tax rate is 16% (8% State Sales Tax plus 8% Hotel Occupancy Tax), plus an additional State of Georgia Hotel/Motel fee of US$5 per day.

Roommates: Looking for a Roommate? An interactive search board will be available for participants looking for a roommate. See jointmathematicsmeetings.org/jmm for more details

Miscellaneous

Audio-Visual Equipment: A projection screen is included as standard equipment in all Session rooms. Invited 50-minute speakers are automatically provided with an ELMO visual presenter (document camera/projector), and a laptop projector; AMS Special Sessions and Contributed Papers, and MAA Invited and Contributed Paper Sessions, are provided with a screen and a laptop projector. Blackboards and white boards are not available, nor are Internet connections in session rooms. Any request for additional equipment should be sent to meet@ams.org and received by November 1.

Equipment requests made at the meetings most likely

will not be granted because of budgetary restrictions. Unfortunately no audio-visual equipment can be provided for committee meetings or other meetings or gatherings not on the scientific program.

Child Care: The AMS and the MAA will provide reimbursement grants of US$250 per family to help with the cost of child care for a number of registered participants at JMM 2017. The funds may be used for child care that frees a parent to participate more fully in JMM.

Information about child care grants and deadlines for requesting support will be available prior to the opening of advance registration in September; watch the website at jointmathematicsmeetings.org/meetings/national/jmm2017/2180_childcare.

E-mail Services: Limited e-mail access for all Joint Meetings participants will be available in an e-mail center located in Hanover Hall, on the exhibit level in the Hyatt Regency. The hours of operation will be published in the program. Participants should be aware that **complimentary internet access** will also be available in that space.

Information Distribution: Tables are set up in the exhibit area for dissemination of general information of possible interest to the members and for the dissemination of information of a mathematical nature not promoting a product or program for sale. Information must be approved by the AMS Director of Meetings and Conferences prior to being placed on these tables.

If a person or group wishes to display information of a mathematical nature promoting a product or program for sale, they may do so in the exhibit area at the Joint Books, Journals, and Promotional Materials exhibit for a fee of US$50 (posters are slightly higher) per item. Please contact the exhibits coordinator, MMSB, P.O. Box 6887, Providence, RI 02940, or by email at cpd@ams.org for further details.

The administration of these tables is in the hands of the AMS-MAA Joint Meetings Committee, as are all arrangements for Joint Mathematics Meetings.

Local Information: For information about the city, see Atlanta.net

Photograph and Video Policy: The videotaping of any AMS or joint sponsored events, talks, and sessions is strictly forbidden without the explicit written permission of the AMS Director of Meetings and Conferences. The policy for videotaping of any MAA events, talks, and sessions is posted at www.maa.org/about-maa/policies-and-procedures/recording-or-broadcasting-of-maa-events. Photographs and videos of meeting interactions will be taken by professional photographers hired by the Joint Mathematics Meetings or by AMS and MAA staff. These photographs and videos may occasionally be used for publicity purposes. By participating in the Joint Mathematics Meetings, attendees acknowledge that their photograph or a video that includes them may be published in material produced by the Joint Meetings, AMS or MAA. AMS and MAA are not responsible for unauthorized photographs or other images not taken by professional photographers hired by the Joint Mathematics Meetings or AMS and MAA staff.

Telephone Messages: It will be possible to leave a message for any registered participant at the meetings registration desk from January 4 through 7 during the hours that the desk is open. These messages will be posted on the Mathematics Meetings Message Board in the networking center; however, staff at the desk will try to locate a participant in the event of a bona fide emergency. The telephone number will be published in the program and daily newsletter.

Travel/Transportation

The 2017 Joint Mathematics Meetings will be held in Atlanta, GA, at the Hyatt Regency Atlanta and the Marriott Marquis Atlanta. The Hyatt Regency is located at 265 Peachtree Street NE Atlanta, GA 30303, and the Marriott is located at 265 Peachtree Center Avenue, Atlanta, GA 30303. Both hotels are connected by a skywalk. Atlanta is on Eastern Standard Time.

Air Transportation

The principal airport in Atlanta is Hartsfield-Jackson Atlanta International Airport (ATL), which is served by most major airlines. See www.atlanta-airport.com. Hartsfield-Jackson is located 20 minutes south of downtown Atlanta. The address of the main terminal at Hartsfield-Jackson is 6000 North Terminal Parkway, Atlanta, GA 30320. The international terminal has a separate entrance at 2600 Maynard H. Jackson, Jr. Blvd, Atlanta, GA 20254. Terminal maps can be found at www.atlanta-airport.com/Passenger/Terminal/.

The official airline for this meeting is **Delta**. Participants are encouraged to book their flights for the meeting, if possible, with Delta and receive special pricing (in most cases, a 5 percent discount) on scheduled service to Atlanta. Discounts are applicable to US and Canada originating passengers. This discount is not valid with other discounts, certificates, coupons, or promotional offers.

To make a reservation, go to www.delta.com, and click on the box that says "Book a Trip". At the bottom of the drop-down, click on "Advanced Search". On the reservation screen, please enter the Meeting Event Code **NMNJC.** It is located to the right of "Number of Passengers." Reservations can also be made by calling Delta Meeting Network Reservations at 1-800-328-1111 and citing the meeting event code. A direct ticketing charge will apply for booking by phone.

Ground Transportation

Car Rental: All major rental car companies have offices at Hartsfield-Jackson. There is a separate rental car facility. From the north or south baggage claim areas, follow the overhead signs to the rental car center. Leave the west end of the terminal under the covered walkway, take the escalator up the station, and board the ATL SkyTrain for a five-minute ride to the rental car center. For more information and a map, please see www.atlanta-airport.com/Airport/Construction/RentalCarCenter/Access.aspx.

Hertz is the official car rental company for this meeting. A brochure with the information for this meeting is located at jointmathematicsmeetings.org/Hertz-info-Atlanta.pdf. To access the special meeting rates for the JMM at www.hertz.com, enter the standard information (pickup location, dates, etc.) and then click the box that says "Enter a discount or promo code" and enter **04N30007** as the convention number (CV#). Reservations can also be made by calling Hertz directly at 800-654-2240 (US and Canada) or 405-749-4434.

Meeting rates include unlimited mileage and are subject to availability. Advance reservations are recommended and blackout dates may apply. Government surcharges, taxes, tax reimbursement, airport-related fees, vehicle licensing fees and optional items are extra. Standard rental conditions and qualifications apply. Vehicles must be returned to the renting location. Minimum rental age is 20 (age differential charge for 20–24 applies).

Weekend rentals are available in the continental US and Canada for pickup between noon Thursday and noon Sunday and must be returned no later than Monday at 11:59 pm. Thursday pick-up requires a minimum three-day keep. Friday pick-up requires a minimum two-day keep, and Saturday and Sunday pick-up require a one-day keep. Weekly rentals are from five to seven days. Extra day rate for weekly rentals will be one-fifth the Weekly Rate.

Shuttles: SuperShuttle provides transportation to the downtown Atlanta hotels. For reservations, book them online at www.supershuttle.com/Locations/Atlanta-ATL or call 1-800-BLUE-VAN. There is also a SuperShuttle ticket counter located in the domestic terminal's south side baggage claim area. It is staffed during the day, starting at 6:00 am. Shuttles that leave for downtown are approximately every 15 minutes. Currently, a one-way trip in a shared van to the meeting hotels is US$16.50.

Taxi: Taxi service is located at the Yellow Bus Aisle. It is located on the west end of the terminal as you leave the baggage claim area. Taxi fare to the downtown hotels is approximately US$32 one way.

Public Transportation: Atlanta's public transportation system is operated by the Metropolitan Atlanta Rapid Transit Authority (MARTA). It is a convenient and an easy way to travel around Atlanta. For general information about MARTA, there is a Ride Guide located at www.itsmarta.com/uploadedFiles/Using_Marta/How_to_ride_MARTA/MARTA-Ride-Guide.pdf. The main website is www.itsmarta.com.

The MARTA Airport Station is located near the baggage claim area of the domestic terminal, and information about the Airport Station is at www.itsmarta.com/ne-air-overview.aspx. Please check the schedules here for the latest information. To get to the meeting hotels, take the northbound train (Either the Red or the Gold Line) to the Peachtree Center Station stop, one stop north of the Five Points transfer station. When you leave the train, take the escalator up towards Peachtree Center Mall. There is a covered walkway from the Mall to the Hyatt Regency. Currently, the fare is US$2.50.

Driving Directions from the airport to the meeting hotels:

Hyatt and Marriott - Take 75/85 North, and take the right-hand exit 248-C to International Boulevard. Turn left onto International Boulevard, and turn right at the third traffic light onto Peachtree Center Avenue. The entrance to the Hyatt Regency Atlanta's Motor Lobby is one block down on the left. The entrance to the Atlanta Marriott Marquis is two blocks down on the right.

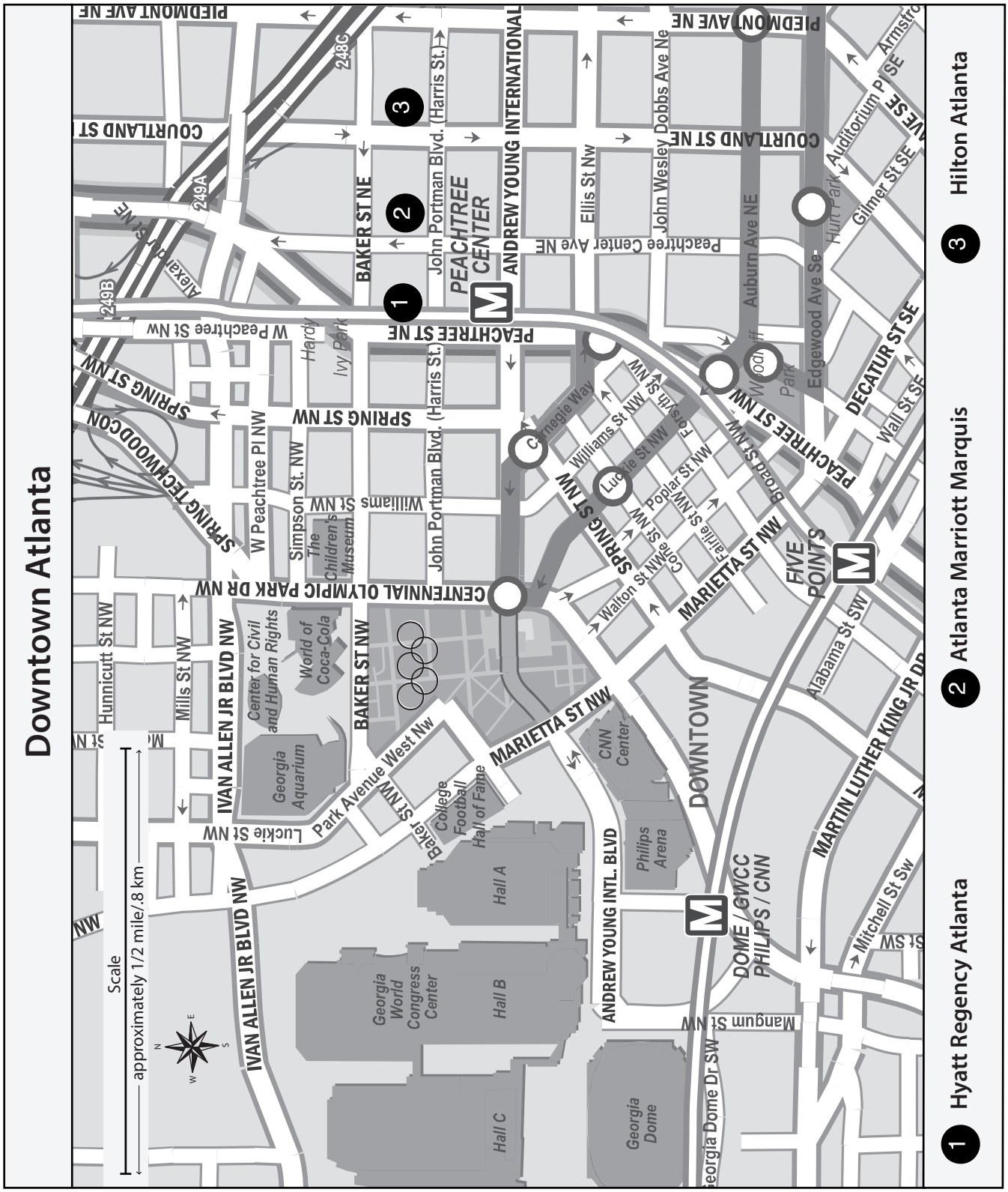
Hilton – Take 75/85 North, and take exit 249B to Peachtree Street. At the first light, turn right onto Peachtree Street. At the next light, turn left onto Ralph McGill Boulevard. At the next light, take a right onto Courtland Street. The entrance to the hotel is one block down on your left.

Parking: All three meeting hotels have parking garages. Please see the hotel section for more information. In addition, there are several parking garages nearby. See an interactive map at www.atlantadowntown.com/guide/getting-around/parking/garage. The following is a listing of some of the nearby garages. Please note that rates are subject to change.

Peachtree Center Parking Garage
221 Peachtree Center Avenue NE
Atlanta, GA 30303
www.atlantadowntown.com/go/221-peachtree-center-avenue
Current rates: US$2 for 20 Minutes; US$12 for two hours; daily maximum is US$18; US$5 after 4:00 pm.

227 Courtland St. NE
Atlanta, GA 30303
404-572-2900
www.atlantadowntown.com/go/227-courtland-street
Current rates: US$2 for 20 Minutes; US$12 for two hours; daily maximum is US$20, US$5 after 4:00 pm. If you arrive between 5:00 am and 9:00 am and leave between 2:00 pm and 7:00 pm, the early bird rate applies which is US$6 per day. Weekend rate is US$6 per day.

Peachtree Center Garage
161 Peachtree Center Ave NE
Atlanta, GA 30303
404-572-2900
www.atlantadowntown.com/go/161-peachtree-center-ave
Current rates: US$2 for 15 minutes, US$2 each additional 15 minutes; daily maximum is US$20; US$5 after 4:00 pm. If you arrive between 5:00 am and 9:00 am and leave between 2:00 pm and 7:00 pm, the early bird rate applies which is US$6 per day. Weekend rate is US$6 per day.


Downtown Atlanta
1 Hyatt Regency Atlanta
2 Atlanta Marriott Marquis
3 Hilton Atlanta
Scale
approximately 1/2 mile/.8 km
PEACHTREE CENTER
FIVE POINTS
DOWNTOWN
DOME / GWCC / PHILIPS / CNN
PEACHTREE ST NE
ANDREW YOUNG INTERNATIONAL
BAKER ST NE
SPRING ST NW
MARIETTA ST NW
CENTENNIAL OLYMPIC PARK DR NW
IVAN ALLEN JR BLVD NW
ANDREW YOUNG INTL. BLVD
MARTIN LUTHER KING JR DR
PEACHTREE ST NW
DECATUR ST SE
COURTLAND ST
PIEDMONT AVE NE
John Portman Blvd. (Harris St.)
Peachtree Center Ave NE
Ellis St Nw
John Wesley Dobbs Ave Ne
Auburn Ave NE
Edgewood Ave Se
Auditorium Pl SE
Gilmer St SE
Wall St SE
Armstrong
Hunt Park
Woodruff Park
W Peachtree St NW
Hardy Ivy Park
W Peachtree Pl NW
Simpson St. NW
Williams St NW
The Children's Museum
Carnegie Way
Williams St NW
Forsyth St NW
Broad St NW
Poplar St NW
Walton St NW
Coca-Cola Pl NW
Fairlie St NW
Lucile St NW
Hunnicutt St NW
Mills St NW
Center for Civil and Human Rights
World of Coca-Cola
Georgia Aquarium
Park Avenue West Nw
Baker St NW
College Football Hall of Fame
CNN Center
Philips Arena
Hall A
Hall B
Hall C
Georgia World Congress Center
Georgia Dome
Georgia Dome Dr SW
Alabama St SW
Mitchell St Sw
Mangum St NW
Alexander St NE
249A
249B
248C

Charleston, South Carolina

College of Charleston

March 10–12, 2017

Friday – Sunday

Meeting #1126

Southeastern Section
Associate secretary: Brian D. Boe
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: Expired
For abstracts: January 17, 2017
The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Pramod N. Achar, Louisiana State University, *Title to be announced.*

Hubert Bray, Duke University, *Title to be announced.*

Alina Chertock, North Carolina State University, *Title to be announced.*

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at www.ams.org/cgi-bin/abstracts/abstract.pl.

Active Learning in Undergraduate Mathematics (Code: SS 21A), **Draga Vidakovic**, Georgia State University, **Harrison Stalvey**, University of Colorado, Boulder, and **Darryl Chamberlain,Jr.**, **Aubrey Kemp**, and **Leslie Meadows**, Georgia State University.

Advances in Long-term Behavior of Nonlinear Dispersive Equations (Code: SS 27A), **Brian Pigott**, Wofford College, and **Sarah Raynor**, Wake Forest University.

Advances in Nonlinear Waves: Theory and Applications (Code: SS 23A), **Constance M. Schober**, University of Central Florida, and **Andrei Ludu**, Embry Riddle University.

Algebras, Lattices, Varieties (Code: SS 19A), **George F. McNulty**, University of South Carolina, and **Kate S. Owens**, College of Charleston.

Analysis and Control of Fluid-Structure Interactions and Fluid-Solid Mixtures (Code: SS 6A), **Justin T. Webster**, College of Charleston, and **Daniel Toundykov**, University of Nebraska-Lincoln.

Analysis, Control and Stabilization of PDE's (Code: SS 13A), **George Avalos**, University of Nebraska-Lincoln, and **Scott Hansen**, Iowa State University.

Bicycle Track Mathematics (Code: SS 25A), **Ron Perline**, Drexel University.

Coding Theory, Cryptography, and Number Theory (Code: SS 17A), **Jim Brown**, **Shuhong Gao**, **Kevin James**, **Felice Manganiello**, and **Gretchen Matthews**, Clemson University.

Commutative Algebra (Code: SS 1A), **Bethany Kubik**, University of Minnesota Duluth, **Saeed Nasseh**, Georgia Southern University, and **Sean Sather-Wagstaff**, Clemson University.

Computability in Algebra and Number Theory (Code: SS 8A), **Valentina Harizanov**, The George Washington University, **Russell Miller**, Queens College and Graduate Center - City University of New York, and **Alexandra Shlapentokh**, East Carolina University.

Data Analytics and Applications (Code: SS 2A), **Scott C. Batson**, **Lucas A. Overbuy**, and **Bryan Williams**, Space and Naval Warfare Systems Center Atlantic.

Factorization and Multiplicative Ideal Theory (Code: SS 16A), **Jim Coykendall**, Clemson University, and **Evan Houston** and **Thomas G. Lucas**, University of North Carolina, Charlotte.

Fluid-Boundary Interactions (Code: SS 26A), **M. Nick Moore**, Florida State University.

Frame Theory (Code: SS 22A), **Dustin Mixon**, Air Force Institute of Technology, **John Jasper**, University of Cincinnati, and **James Solazzo**, Coastal Carolina University.

Free-boundary Fluid Models and Related Problems (Code: SS 7A), **Marcelo Disconzi**, Vanderbilt University, and **Lorena Bociu**, North Carolina State University.

Geometric Analysis and General Relativity (Code: SS 20A), **Hubert L. Bray**, Duke University.

Geometric Methods in Representation Theory (Code: SS 15A), **Pramod N. Achar**, Louisiana State University, and **Amber Russell**, Butler University.

Geometry and Symmetry in Integrable Systems (Code: SS 10A), **Annalisa Calini**, **Alex Kasman**, and **Thomas Ivey**, College of Charleston.

Graph Theory (Code: SS 5A), **Colton Magnant**, Georgia Southern University, and **Zixia Song**, University of Central Florida.

Knot Theory and its Applications (Code: SS 3A), **Elizabeth Denne**, Washington & Lee University, and **Jason Parsley**, Wake Forest University.

Nonlinear Waves: Analysis and Numerics (Code: SS 18A), **Anna Ghazaryan**, Miami University, **Sté phane Lafortune**, College of Charleston, and **Vahagn Manukian**, Miami University.

Numerical Methods for Coupled Problems in Computational Fluid Dynamics (Code: SS 11A), **Vincent J. Ervin** and **Hyesuk Lee**, Clemson University.

Oscillator Chain and Lattice Models in Optics, the Power Grid, Biology, and Polymer Science (Code: SS 14A), **Alejandro Aceves**, Southern Methodist University, and **Brenton LeMesurier**, College of Charleston.

Recent Trends in Finite Element Methods (Code: SS 9A), **Michael Neilan**, University of Pittsburgh, and **Leo Rebholz**, Clemson University.

Representation Theory and Algebraic Mathematical Physics (Code: SS 12A), **Iana I. Anguelova**, **Ben Cox**, and **Elizabeth Jurisich**, College of Charleston.

Riemann-Hilbert Problem Approach to Asymptotic Problems in Integrable Systems, Orthogonal Polynomials and Other Areas (Code: SS 24A), **Alexander Tovbis**, University of Central Florida, and **Robert Jenkins**, University of Arizona.

Rigidity Theory and Inversive Distance Circle Packings (Code: SS 4A), **John C. Bowers**, James Madison University, and **Philip L. Bowers**, The Florida State University.

Bloomington, Indiana

Indiana University

April 1–2, 2017

Saturday – Sunday

Meeting #1127

Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: February 2017
Program first available on AMS website: February 23, 2017
Issue of *Abstracts*: Volume 38, Issue 2

Deadlines

For organizers: Expired
For abstracts: February 7, 2017

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Ciprian Demeter, Indiana University, *Title to be announced.*

Sarah Koch, University of Michigan, title to be announced.

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at www.ams.org/cgi-bin/abstracts/abstract.pl.

Algebraic and Enumerative Combinatorics with Applications (Code: SS 6A), **Saúl A. Blanco**, Indiana University, and **Kyle Peterson**, DePaul University.

Analysis of Variational Problems and Nonlinear Partial Di fferential Equations (Code: SS 11A), **Nam Q. Le** and **Peter Sternberg**, Indiana University.

Automorphic Forms and Algebraic Number Theory (Code: SS 2A), **Patrick B. Allen**, University of Illinois at Urbana-Champaign, and **Matthias Strauch**, Indiana University Bloomington.

Computability and Inductive Definability over Structures (Code: SS 3A), **Siddharth Bhaskar**, **Lawrence Valby**, and **Alex Kruckman**, Indiana University.

Dependence in Probability and Statistics (Code: SS 7A), **Richard C. Bradley** and **Lanh T. Tran**, Indiana University.

Discrete Structures in Conformal Dynamics and Geometry (Code: SS 5A), **Sarah Koch**, University of Michigan, and **Kevin Pilgrim** and **Dylan Thurston**, Indiana University.

Harmonic Analysis and Partial Differential Equations (Code: SS 9A), **Lucas Chaffee**, Western Washington University, **William Green**, Rose-Hulman Institute of Technology, and **Jarod Hart**, University of Kansas.

Network Theory (Code: SS 8A), **Jeremy Alm** and **Keenan M.L. Mack**, Illinois College.

Randomness in Complex Geometry (Code: SS 1A), **Turgay Bayraktar**, Syracuse University, and **Norman Levenberg**, Indiana University.

Self-similarity and Long-range Dependence in Stochastic Processes (Code: SS 10A), **Takashi Owada**, Purdue University, **Yi Shen**, University of Waterloo, and **Yizao Wang**, University of Cincinnati.

Spectrum of the Laplacian on Domains and Manifolds (Code: SS 4A), **Chris Judge** and **Sugata Mondal**, Indiana University.

Pullman, Washington

Washington State University

April 22–23, 2017

Saturday – Sunday

Meeting #1128

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: February 2017
Program first available on AMS website: March 9, 2017
Issue of *Abstracts*: Volume 38, Issue 2

Deadlines

For organizers: September 22, 2016
For abstracts: February 28, 2017

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at www.ams.org/cgi-bin/abstracts/abstract.pl.

Combinatorial and Algebraic Structures in Knot Theory (Code: SS 5A), **Sam Nelson**, McKenna College, and **Allison Henrich**, Seattle University.

Commutative Algebra (Code: SS 3A), **Jason Lutz** and **Katharine Shultis**, Gonzaga University.

Fixed Point Methods in Differential and Integral Equations (Code: SS 1A), **Theodore A. Burton**, Southern Illinois University in Carbondale.

Inverse Problems (Code: SS 2A), **Hanna Makaruk**, Los Alamos National Laboratory (LANL), and **Robert Owczarek**, University of New Mexico, Albuquerque & Los Alamos.

Special Session on Analytic Number Theory and Automorphic Forms (Code: SS 6A), **Steven J. Miller**, Williams College, and **Sheng-Chi Liu**, Washington State University.

Theory and Applications of Linear Algebra (Code: SS 4A), **Judi McDonald** and **Michael Tsatsomeros**, Washington State University.

New York, New York

Hunter College, City University of New York

May 6–7, 2017

Saturday – Sunday

Meeting #1129

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: March 2017
Program first available on AMS website: March 22, 2017
Issue of *Abstracts*: Volume 38, Issue 2

Deadlines

For organizers: October 6, 2016
For abstracts: March 14, 2017

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Jeremy Kahn, City University of New York, *Title to be announced.*

Fernando Coda Marques, Princeton University, *Title to be announced.*

James Maynard, Magdalen College, University of Oxford, *Title to be announced* (Erdős Memorial Lecture).

Kavita Ramanan, Brown University, *Title to be announced.*

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at `www.ams.org/cgi-bin/abstracts/abstract.pl`.

Banach Space Theory and Metric Embeddings (Code: SS 10A), **Mikhail Ostrovskii**, St Johnś University, and **Beata Randrianantoanina**, Miami University of Ohio.

Cluster Algebras in Representation Theory and Combinatorics (Code: SS 6A), **Alexander Garver**, Université du Québec á Montreal and Sherbrooke, and **Khrystyna Serhiyenko**, University of California at Berkeley.

Commutative Algebra (Code: SS 1A), **Laura Ghezzi**, New York City College of Technology-CUNY, and **Jooyoun Hong**, Southern Connecticut State University.

Computability Theory: Pushing the Boundaries (Code: SS 9A), **Johanna Franklin**, Hofstra University, and **Russell Miller**, Queens College and Graduate Center, City University of New York.

Computational and Algorithmic Group Theory (Code: SS 7A), **Denis Serbin** and **Alexander Ushakov**, Stevens Institute of Technology.

Cryptography (Code: SS 3A), **Xiaowen Zhang**, College of Staten Island and Graduate Center-CUNY.

Current Trends in Function Spaces and Nonlinear Analysis (Code: SS 2A), **David Cruz-Uribe**, University of Alabama, **Jan Lang**, The Ohio State University, and **Osvaldo Mendez**, University of Texas at El Paso.

Differential and Difference Algebra: Recent Developments, Applications, and Interactions (Code: SS 12A), **Omár León-Sanchez**, McMaster University, and **Alexander Levin**, The Catholic University of America.

Geometry and Topology of Ball Quotients and Related Topics (Code: SS 5A), **Luca F. Di Cerbo**, Max Planck Institute, Bonn, and **Matthew Stover**, Temple University.

Infinite Permutation Groups, Totally Disconnected Locally Compact Groups, and Geometric Group Theory (Code: SS 4A), **Delaram Kahrobaei**, New York City College of Technology and Graduate Center-CUNY, and **Simon Smith**, New York City College of Technology-CUNY.

Special Session on Hydrodynamic and Wave Turbulence (Code: SS 11A), **Tristan Buckmaster**, Courant Institute of Mathematical Sciences, New York University, and **Vlad Vicol**, Princeton University.

Special Session on Nonlinear and Stochastic Partial Differential Equations: Theory and Applications in Turbulence and Geophysical Flows (Code: SS 8A), **Nathan Glatt-Holtz**, Tulane University, **Geordie Richards**, Utah State University, and **Xiaoming Wang**, Florida State University.

Montréal, Quebec Canada

McGill University

July 24–28, 2017

Monday – Friday

Meeting #1130

The second Mathematical Congress of the Americas (MCA 2017) is being hosted by the Canadian Mathematical Society (CMS) in collaboration with the Pacific Institute for the Mathematical Sciences (PIMS), the Fields Institute (FIELDS), Le Centre de Recherches Mathématiques (CRM), and the Atlantic Association for Research in the Mathematical Sciences (AARMS).

Associate secretary: Brian D. Boe
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: Expired
For abstracts: To be announced

Denton, Texas

University of North Texas

September 9–10, 2017

Saturday – Sunday

Meeting #1131

Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: June 2017
Program first available on AMS website: July 27, 2017
Issue of *Abstracts*: Volume 38, Issue 3

Deadlines

For organizers: February 2, 2017
For abstracts: July 18, 2017
The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Mirela Çiperiani, University of Texas at Austin, *Title to be announced.*

Adrianna Gillman, Rice University, *Title to be announced.*

Kevin Pilgrim, Indiana University, *Title to be announced.*

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at www.ams.org/cgi-bin/abstracts/abstract.pl.

Dynamics, Geometry and Number Theory (Code: SS 1A), **Lior Fishman** and **Mariusz Urbanski**, University of North Texas.

Real-Analytic Automorphic Forms (Code: SS 2A), **Olav K Richter**, University of North Texas, and **Martin Westerholt-Raum**, Chalmers University of Technology.

Buffalo, New York

State University of New York at Buffalo

September 16–17, 2017

Saturday – Sunday

Meeting #1132

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: June 2017
Program first available on AMS website: August 3, 2017
Issue of *Abstracts*: Volume 38, Issue 3

Deadlines

For organizers: February 16, 2017
For abstracts: July 25, 2017
The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Inwon Kim, University of California at Los Angeles, *Title to be announced.*

Govind Menon, Brown University, *Title to be announced.*

Bruce Sagan, Michigan State University, *Title to be announced.*

Orlando, Florida

University of Central Florida, Orlando

September 23–24, 2017

Saturday – Sunday

Meeting #1133

Southeastern Section
Associate secretary: Brian D. Boe
Announcement issue of *Notices*: June 2017
Program first available on AMS website: August 10, 2017
Issue of *Abstracts*: Volume 38, Issue 4

Deadlines

For organizers: February 23, 2017
For abstracts: August 1, 2017

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Christine Heitsch, Georgia Institute of Technology, *Title to be announced.*

Jonathan Kujawa, University of Oklahoma, *Title to be announced.*

Christopher D Sogge, Johns Hopkins University, *Title to be announced.*

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at www.ams.org/cgi-bin/abstracts/abstract.pl.

Commutative Algebra: Interactions with Algebraic Geometry and Algebraic Topology (Code: SS 1A), **Joseph Brennan**, University of Central Florida, and **Alina Iacob** and **Saeed Nasseh**, Georgia Southern University.

Riverside, California

University of California, Riverside

November 4–5, 2017

Saturday – Sunday

Meeting #1134

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: September 2017
Program first available on AMS website: September 21, 2017
Issue of *Abstracts*: Volume 38, Issue 4

Deadlines

For organizers: April 14, 2017
For abstracts: September 12, 2017

Invited Addresses

Paul Balmer, University of California, Los Angeles, *Title to be announced.*

Pavel Etingof, Massachusetts Institute of Technology, *Title to be announced.*

Monica Vazirani, University of California, Davis, *Title to be announced.*

San Diego, California

San Diego Convention Center and San Diego Marriott Hotel and Marina

January 10–13, 2018

Wednesday – Saturday

Meeting #1135

Joint Mathematics Meetings, including the 124th Annual Meeting of the AMS, 101st Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association of Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).

Associate secretary: Georgia Benkart
Announcement issue of *Notices*: October 2017
Program first available on AMS website: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 1, 2017
For abstracts: To be announced

Columbus, Ohio

Ohio State University

March 24–25, 2018

Saturday – Sunday
Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For abstracts: To be announced

Portland, Oregon

Portland State University

April 14–15, 2018

Saturday – Sunday
Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: 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

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at `www.ams.org/cgi-bin/abstracts/abstract.pl`.

Invited Addresses

Sandor Kovács, University of Washington State, *Title to be announced.*

Elena Mantovan, California Institute of Technology, *Title to be announced.*

Dmitri Shlyakhtenko, University of California, Los Angeles, *Title to be announced.*

Inverse Problems (Code: SS 2A), **Hanna Makaruk**, Los Alamos National Laboratory (LANL), and **Robert Owczarek**, University of New Mexico, Albuquerque & Los Alamos.

Pattern Formation in Crowds, Flocks, and Traffic (Code: SS 1A), **J. J. P. Veerman**, Portland State University, **Alethea**

Barbaro, Case Western Reserve University, and **Bassam Bamieh**, UC Santa Barbara.

Nashville, Tennessee

Vanderbilt University

April 14–15, 2018

Saturday – Sunday
Southeastern Section
Associate secretary: Brian D. Boe
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For abstracts: To be announced

Boston, Massachusetts

Northeastern University

April 21–22, 2018

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
Issue of *Abstracts*: To be announced

Deadlines

For organizers: September 21, 2017
For abstracts: March 6, 2018

People's Republic of China

Fudan University

June 11–14, 2018

Monday – Thursday
Associate secretary: Carla D. Savage
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For abstracts: To be announced

Baltimore, Maryland

Baltimore Convention Center, Hilton Baltimore, and Baltimore Marriott Inner Harbor Hotel

January 16–19, 2019

Wednesday – Saturday
Joint Mathematics Meetings, including the 125th Annual Meeting of the AMS, 102nd Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM)and the National Association of Mathematicians (NAM), and the winter meeting of the Association of 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 2018
Program first available on AMS website: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 2, 2018
For abstracts: To be announced

Honolulu, Hawaii

University of Hawaii at Manoa

March 29–31, 2019

Friday – Sunday
Central Section
Associate secretaries: Georgia Benkart and Michel L. Lapidus
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For abstracts: To be announced

Denver, Colorado

Colorado Convention Center

January 15–18, 2020

Wednesday – Saturday
Joint Mathematics Meetings, including the 126th Annual Meeting of the AMS, 103rd Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association of Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM)
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: To be announced
Program first available on AMS website: November 1, 2019
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 1, 2019
For abstracts: To be announced

Washington, District of Columbia

Walter E. Washington Convention Center

January 6–9, 2021

Wednesday – Saturday
Joint Mathematics Meetings, including the 127th Annual Meeting of the AMS, 104th Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association of Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Brian D. Boe
Announcement issue of *Notices*: October 2020
Program first available on AMS website: November 1, 2020
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 1, 2020
For abstracts: To be announced

Program at a Glance

This document provides a thumbnail sketch of all scientific and social events so you can better plan your time. ***For the most up-to-date scheduling information, see*** http://jointmathematicsmeetings.org/meetings/national/jmm2017/2180_timetable.html.

JOINT MATHEMATICS MEETINGS
ATLANTA • JAN 4-7, 2017
AMERICAN MATHEMATICAL SOCIETY
MATHEMATICAL ASSOCIATION OF AMERICA

Monday, January 02

9:00 am–3:15 pm	**AMS SHORT COURSE ON RANDOM GROWTH MODELS, PART I**
3:00 pm–6:00 pm	**NSF-EHR GRANT PROPOSAL WRITING WORKSHOP**

Tuesday, January 03

8:00 am–2:20 pm	**AMS SHORT COURSE ON RANDOM GROWTH MODELS, PART II**
8:00 am–6:30 pm	**AMS DEPARTMENT CHAIRS WORKSHOP**
9:00 am–5:00 pm	**MAA BOARD OF GOVERNORS**
2:30 pm–10:00 pm	**AMS COUNCIL**
3:00 pm–8:00 pm	**JOINT MEETINGS REGISTRATION**
3:00 pm–8:00 pm	**E-MAIL CENTER**

Wednesday, January 04

7:00 am–8:45 am	**MAA MINORITY CHAIRS MEETING**
7:30 am–6:00 pm	**JOINT MEETINGS REGISTRATION**
7:30 am–10:00 pm	**E-MAIL CENTER**
8:00 am–9:15 am	**MAA PANEL DISCUSSION ON NSF FUNDING OPPORTUNITIES FOR THE LEARNING AND TEACHING OF THE MATHEMATICAL SCIENCES, PART I** *Undergraduate/Graduate Education, Department of Mathematics Infrastructure, and Human Resource Development (DUE/DGE/DMS/HRD)*
8:00 am–9:20 am	**MAA PANEL** *Refocusing Your Career: Making Time and Space*
	AMS SPECIAL SESSIONS
8:00 am–10:50 am	*Research in Mathematics by Undergraduates and Students in Post-Baccalaureate Programs, I (AMS-MAA-SIAM)*
8:00 am–10:50 am	*Nonlinear Systems and Applications, I*
8:00 am–10:50 am	*Control and Long Time Behavior of Evolutionary PDEs, I*
8:00 am–10:50 am	*Topology, Representation Theory, and Operator Algebras (A Tribute to Paul Baum), I*
8:00 am–10:50 am	*Analytical and Computational Studies in Mathematical Biology, I*
8:00 am–10:50 am	*Bases in Function Spaces: Sampling, Interpolation, Expansions and Approximations, I*
8:00 am–10:50 am	*Gaussian Graphical Models and Combinatorial Algebraic Geometry, I*
8:00 am–10:50 am	*Arithmetic Properties of Sequences from Number Theory and Combinatorics, I*
8:00 am–10:50 am	*Problems in Partial Differential Equations, I*
8:00 am–10:50 am	*Hopf Algebras and their Actions, I*
8:00 am–10:50 am	*Group Representations and Cohomology, I*
8:00 am–10:50 am	*Coding Theory for Modern Applications, I*
8:00 am–10:50 am	*Harmonic Analysis (In Honor of Gestur Olafsson's 65th Birthday), I*
8:00 am–10:50 am	*Stochastic Matrices and Their Applications, I*
8:00 am–10:50 am	*Recent Advances in Mathematical Biology, I*
8:00 am–10:50 am	*Sheaves in Topological Data Analysis, I*
8:00 am–10:50 am	*Analysis of Fractional, Stochastic, and Hybrid Dynamic Systems and their Applications, I*
8:00 am–10:50 am	*Statistical Methods in Computational Topology and Applications, I*
8:00 am–10:50 am	*History of Mathematics, I (AMS-MAA-ICHM)*

8:00 am–10:55 am **AMS CONTRIBUTED PAPER SESSIONS**

MAA CONTRIBUTED PAPER SESSIONS

8:00 am–10:55 am *Cryptology for Undergraduates*
8:00 am–10:55 am *Innovative Teaching through Recreational Mathematics*
8:00 am–10:55 am *Mathematics and the Arts*
8:00 am–10:55 am *The Scholarship of Teaching and Learning in Collegiate Mathematics*

8:00 am–10:55 am **MAA GENERAL CONTRIBUTED PAPER SESSIONS**

8:00 am–10:55 am **SIAM MINISYMPOSIUM ON RECENT ADVANCES IN LINEAR ALGEBRA**

8:00 am–11:50 am *Random Matrices, Random Percolation and Random Sequence Alignments, I*

8:00 am– 5:30 pm **EMPLOYMENT CENTER**

MAA INVITED PAPER SESSIONS

9:00 am–10:50 am *Office Hours with a Geometric Group Theorist, I*

9:00 am–11:00 am **MAA MINICOURSE #12: PART A** *Teaching Introductory Statistics, GAISE 2016*

9:00 am–11:00 am **MAA MINICOURSE #4: PART A** *Incorporating Randomization Methods into Introductory Statistics*

9:00 am–11:00 am **MAA MINICOURSE #8: PART A** *(Re)Designing Your Own Mathematics Course using Backwards Course Design*

9:00 am– 9:50 am **HRABOWSKI-GATES-TAPIA-MCBAY SESSION**

9:30 am–11:00 am **MAA DEPARTMENT LIAISONS MEETING**

9:30 am–10:30 am **MAA PANEL DISCUSSION ON NSF FUNDING OPPORTUNITIES FOR THE LEARNING AND TEACHING OF THE MATHEMATICAL SCIENCES, PART II** *The K-16 Continuum Learning Science and Research and Pre- and In-Service Teachers (DUE/DRL)*

9:35 am–10:55 am **MAA PANEL** *What Belongs in a Twenty-First Century Geometry Course?*

10:00 am–10:45 am **RADICAL DASH KICKOFF MEETING** *A daily scavenger hunt filled with math challenges and creativity for teams of undergraduates. Individuals are welcome and encouraged to participate; they will be formed into teams.*

10:05 am–10:55 am **AMS INVITED ADDRESS** *Spectral Theory Sum Rules, Meromorphic Herglotz Functions and Large Deviations.* **Barry Simon**

11:10 am–12:00 pm **AMS-MAA INVITED ADDRESS** *Through the Cryptographer's Looking-Glass, and what Alice found there.* **Alice Silverberg**

1:00 pm– 2:00 pm **AMS COLLOQUIUM LECTURES: LECTURE I** *Overview: The focusing energy critical wave equation.* **Carlos E. Kenig**

2:15 pm– 3:05 pm **MAA INVITED ADDRESS** *Math by design: 3D printing for the working mathematician.* **Laura Taalman**

2:15 pm– 3:35 pm **MAA PANEL** *Preparing for the Data Deluge: Mathematics Programs and the Future of Undergraduate Statistics Education*

2:15 pm– 3:35 pm **MAA PANEL** *What Every Student Should Know about the JMM*

2:15 pm– 3:40 pm **ASSOCIATION FOR WOMEN IN MATHEMATICS PANEL DISCUSSION** *Mentoring Women in Mathematics*

2:15 pm– 4:15 pm **MAA MINICOURSE #14: PART A** *Teaching Quantitative Reasoning with Common Sense and Common Knowledge*

2:15 pm– 4:15 pm **MAA MINICOURSE #2: PART A** *Directing Undergraduate Research*

2:15 pm– 4:15 pm **MAA MINICOURSE #3: PART A** *Flipping your Linear Algebra Course using Open Educational Resources*

2:15 pm– 4:15 pm **MAA MINICOURSE #5: PART A** *Introductory Proposal Writing for Grant Applications to the National Science Foundation EHR Division of Undergraduate Education*

MAA INVITED PAPER SESSIONS

2:15 pm– 4:35 pm *Office Hours with a Geometric Group Theorist, II*
2:15 pm– 5:35 pm *Modeling and Understanding Environmental Risks*

2:15 pm– 5:55 pm **AMS CONTRIBUTED PAPER SESSIONS**

2:15 pm– 5:55 pm **MAA GENERAL CONTRIBUTED PAPER SESSIONS**

MAA CONTRIBUTED PAPER SESSIONS

2:15 pm– 6:00 pm *Assessment in Distance Learning Environments*
2:15 pm– 6:00 pm *Teaching Abstract Algebra: Topics and Techniques*
2:15 pm– 6:00 pm *Mathematics and Sports*

2:15 pm–6:00 pm **SIAM MINISYMPOSIUM ON RECENT DEVELOPMENTS IN COMPUTATIONAL INVERSE PROBLEMS AND IMAGING**

AMS SPECIAL SESSIONS

2:15 pm–6:05 pm *Orthogonal Polynomials, I*
2:15 pm–6:05 pm *Random Matrices, Random Percolation and Random Sequence Alignments, II*
2:15 pm–6:05 pm *Nonlinear Systems and Applications, II*
2:15 pm–6:05 pm *Control and Long Time Behavior of Evolutionary PDEs, II*
2:15 pm–6:05 pm *Topology, Representation Theory, and Operator Algebras (A Tribute to Paul Baum), II*
2:15 pm–6:05 pm *Bases in Function Spaces: Sampling, Interpolation, Expansions and Approximations, II*
2:15 pm–6:05 pm *Gaussian Graphical Models and Combinatorial Algebraic Geometry, II*
2:15 pm–6:05 pm *Arithmetic Properties of Sequences from Number Theory and Combinatorics, II*
2:15 pm–6:05 pm *Problems in Partial Differential Equations, II*
2:15 pm–6:05 pm *Hopf Algebras and their Actions, II*
2:15 pm–6:05 pm *Group Representations and Cohomology, II*
2:15 pm–6:05 pm *Coding Theory for Modern Applications, II*
2:15 pm–6:05 pm *Harmonic Analysis (In Honor of Gestur Olafsson's 65th Birthday), II*
2:15 pm–6:05 pm *PDEs for Fluid flow: Analysis and Computation, I*
2:15 pm–6:05 pm *Recent Advances in Mathematical Biology, II*
2:15 pm–6:05 pm *Sheaves in Topological Data Analysis, II*
2:15 pm–6:05 pm *Analysis of Fractional, Stochastic, and Hybrid Dynamic Systems and their Applications, II*
2:15 pm–6:05 pm *Statistical Methods in Computational Topology and Applications, II*

AMS SPECIAL SESSIONS

2:15 pm–6:05 pm *History of Mathematics, II (AMS-MAA-ICHM)*

3:20 pm–4:10 pm **MAA INVITED ADDRESS** *Random polygons, Grassmannians, and a problem of Lewis Carroll.* **Jason Cantarella**

3:45 pm–4:15 pm **AWM BUSINESS MEETING**

3:50 pm–5:10 pm **MAA PANEL DISCUSSION** *Professional Development at the Section Level: Section NExT, Opportunities for Graduate Students, & More*

3:50 pm–5:10 pm **MAA PANEL** *Research Support Networks*

4:00 pm–5:00 pm **MAA SECTION OFFICERS**

4:30 pm–5:30 pm **RECEPTION FOR UNDERGRADUATE STUDENTS**

4:30 pm–6:00 pm **AMS COMMITTEE ON THE PROFESSION PANEL DISCUSSION** *Diversity and Inclusion in the Mathematical Sciences*

4:45 pm–6:45 pm **MAA MINICOURSE #16: PART A** *Using and Making Integrated Online Textbooks with MathBook XML*

4:45 pm–6:45 pm **MAA MINICOURSE #1: PART A** *Complex Analysis and Geometry/Topology as Introductions to Proofs Courses*

4:45 pm–6:45 pm **MAA MINICOURSE #6: PART A** *Linear Algebra in Computer Graphics and Data Mining*

5:30 pm–6:30 pm **RECEPTION FOR GRADUATE STUDENTS AND FIRST-TIME PARTICIPANTS**

5:30 pm–8:00 pm **MATHEMATICAL INSTITUTES OPEN HOUSE**

6:00 pm–6:30 pm **SIGMAA ON THE HISTORY OF MATHEMATICS (HOM SIGMAA) BUSINESS MEETING**

6:30 pm–7:00 pm **SIGMAA ON THE HISTORY OF MATHEMATICS (HOM SIGMAA) RECEPTION**

7:00 pm–7:50 pm **SIGMAA ON THE HISTORY OF MATHEMATICS (HOM SIGMAA) GUEST LECTURE**

8:30 pm–9:30 pm **AMS JOSIAH WILLARD GIBBS LECTURE** *Title to be announced.* **John Preskill**

9:30 pm–11:00 pm **ASSOCIATION FOR WOMEN IN MATHEMATICS RECEPTION AND AWARDS PRESENTATION**

Thursday, January 05

7:30 am–4:00 pm **JOINT MEETINGS REGISTRATION**

7:30 am–10:00 pm **E-MAIL CENTER**

8:00 am– 8:50 am **BYLAWS FOR A NEW CENTURY: Q&A FORUM ON PROPOSED CHANGES IN MAA GOVERNANCE** *Come hear about and ask questions about the revised MAA bylaws which will be voted on at the Saturday MAA Business Meeting.*

AMS SPECIAL SESSIONS

8:00 am–11:50 am **AMS-NAM JOINT SPECIAL SESSION ON THE MATHEMATICS OF THE ATLANTA UNIVERSITY CENTER, I**

AMS SPECIAL SESSIONS

8:00 am–10:50 am *Theory and Applications of Numerical Algebraic Geometry, I*
8:00 am–11:50 am *Mathematics of Cryptography, I (AMS-MAA)*
8:00 am–11:50 am *Recent Progress on Nonlinear Dispersive and Wave Equations, I*
8:00 am–11:50 am *Lie Group Representations, Discretization, and Gelfand Pairs (a Mathematics Research Communities Session), I*
8:00 am–11:50 am *Character Varieties (a Mathematics Research Communities Session), I*
8:00 am–11:50 am *Algebraic Statistics (a Mathematics Research Communities Session), I*
8:00 am–11:50 am *Mathematics in Physiology and Medicine (a Mathematics Research Communities Session), I*
8:00 am–11:50 am *Orthogonal Polynomials, II*
8:00 am–11:50 am *Combinatorial and Cohomological Invariants of Flag Manifolds and Related Varieties, I*
8:00 am–11:50 am *Stochastic Processes and Modelling, I*
8:00 am–11:50 am *Discrete Structures in Number Theory, I*
8:00 am–11:50 am *Spin Glasses and Disordered Media, I*
8:00 am–11:50 am *An Amicable Combination of Algebra and Number Theory (Dedicated to Dr. Helen G. Grundman), I*
8:00 am–11:50 am *Advances in Numerical Analysis for Partial Differential Equations, I*
8:00 am–11:50 am *RE(UF)search on Graphs and Matrices, I*
8:00 am–11:50 am *Dynamical Systems, I*
8:00 am–11:50 am *Fusion Categories and Quantum Symmetries, I*
8:00 am–11:50 am *History of Mathematics, III (AMS-MAA-ICHM)*

8:00 am–11:55 am **AMS CONTRIBUTED PAPER SESSIONS**

8:00 am–11:55 am **MAA GENERAL CONTRIBUTED PAPER SESSIONS**

8:00 am–11:00 am **SIAM MINISYMPOSIUM ON THE GAIMME REPORT ON MATHEMATICAL MODELING IN K-16**

MAA CONTRIBUTED PAPER SESSIONS

8:00 am–11:00 am *Research in Undergraduate Mathematics Education (RUME)*
8:00 am–12:00 pm *Meaningful Modeling in the First Two Years of College*
8:00 am–12:00 pm *Mathematical Technology in the Calculus Classroom*
8:00 am–12:00 pm *Integrating Research into the Undergraduate Classroom*

8:00 am– 5:30 pm **EMPLOYMENT CENTER**

MAA INVITED PAPER SESSIONS

8:30 am–11:50 am *Random Polygons and Knots*

9:00 am– 9:50 am **MAA INVITED ADDRESS** *From Gauss to today: class numbers and p-torsion in class groups of number fields.* **Lillian Pierce**

9:00 am–10:35 am **MAA SESSION FOR CHAIRS** *Data, Information, Knowledge using Annual Survey of Math Science & CBMS Survey*

9:00 am–10:20 am **MAA PANEL** *Pushing for change: the MAA and Advocacy*

9:00 am–11:00 am **MAA MINICOURSE #10: PART A** *Teaching an Applied Topology Course*

9:00 am–11:00 am **MAA MINICOURSE #11: PART A** *Teaching an Introduction to the Mathematics of Computer Graphics*

9:00 am–11:00 am **MAA MINICOURSE #5: PART B** *Introductory Proposal Writing for Grant Applications to the National Science Foundation EHR Division of Undergraduate Education*

9:00 am–11:00 am **MAA MINICOURSE #9: PART A** *Statistical Education of Teachers*

10:00 am–12:00 pm **MAA POSTER SESSION**

10:05 am–10:55 am **AWM-AMS NOETHER LECTURE** *Cohomology of Symplectic Quotients.* **Lisa Jeffrey**

10:30 am–12:00 pm **SIGMAA OFFICERS MEETING**

10:35 am–11:55 am **MAA-AMS JOINT PANEL** *Design (or improve) Preparation of Your Graduate Students to Teach: Using MAA's CoMInDS Resource Suite*

10:35 am–11:55 am **MAA PANEL** *Models for Mathematicians Working with K-12 Mathematics Teachers*

11:10 am–12:00 pm **PROJECT NExT LECTURE ON TEACHING**

11:10 am–12:00 pm **SIAM INVITED ADDRESS** *The dynamics of systems interacting across statistical scales.* **Irene M. Gamba**

1:00 pm– 2:00 pm **AMS COLLOQUIUM LECTURES: LECTURE II** *The focusing energy critical wave equation: the radial case in 3 space dimensions.* **Carlos E. Kenig**

1:00 pm– 2:20 pm **MAA PANEL** *Women and Scholarly Publishing*

1:00 pm–2:20 pm **MAA PANEL** *Perspectives on Inquiry Based Learning: Novice, Experienced, and Master*

1:00 pm–2:20 pm **MAA WORKSHOP** *Implementing and Orchestrating Active Learning Strategies in Calculus*

1:00 pm–2:30 pm **JOINT COMMITTEE ON WOMEN PANEL DISCUSSION** *From Calculus to a Bachelor's Degree: Encouraging and Developing Undergraduate Mathematics Majors*

1:00 pm–2:30 pm **AMS AND SIAM COMMITTEES ON EDUCATION JOINT PANEL DISCUSSION** *Broadening Research Experiences for Doctoral Students in the Mathematical Sciences*

1:00 pm–3:00 pm **MAA MINICOURSE #13: PART A** *Teaching Modeling-First Differential Equations–Technology and Complete End Game Efforts*

1:00 pm–3:00 pm **MAA MINICOURSE #15: PART A** *Unraveling Four Interesting Ciphers*

1:00 pm–3:00 pm **MAA MINICOURSE #7: PART A** *Mathematical Modeling Contest Papers: Insights for Instructors and Students*

AMS SPECIAL SESSIONS

1:00 pm–3:50 pm *Mathematics of Cryptography, II (AMS-MAA)*

1:00 pm–3:50 pm **AMS-NAM JOINT SPECIAL SESSION ON THE MATHEMATICS OF THE ATLANTA UNIVERSITY CENTER, II**

AMS SPECIAL SESSIONS

1:00 pm–3:50 pm *Lie Group Representations, Discretization, and Gelfand Pairs (a Mathematics Research Communities Session), II*

1:00 pm–3:50 pm *Character Varieties (a Mathematics Research Communities Session), II*

1:00 pm–3:50 pm *Algebraic Statistics (a Mathematics Research Communities Session), I*

1:00 pm–3:50 pm *Mathematics in Physiology and Medicine (a Mathematics Research Communities Session), II*

1:00 pm–3:50 pm *Combinatorial and Cohomological Invariants of Flag Manifolds and Related Varieties, II*

1:00 pm–3:50 pm *Stochastic Processes and Modelling, II*

1:00 pm–3:50 pm *Discrete Structures in Number Theory, II*

1:00 pm–3:50 pm *Analytical and Computational Studies in Mathematical Biology, II*

1:00 pm–3:50 pm *Spin Glasses and Disordered Media, II*

1:00 pm–3:50 pm *Spectral Calculus & Quasilinear Partial Differential Equations, I*

1:00 pm–3:50 pm *An Amicable Combination of Algebra and Number Theory (Dedicated to Dr. Helen G. Grundman), II*

1:00 pm–3:50 pm *Advances in Numerical Analysis for Partial Differential Equations, II*

1:00 pm–3:50 pm *RE(UF)search on Graphs and Matrices, II*

1:00 pm–3:50 pm *Dynamical Systems, II*

1:00 pm–3:50 pm *Theory and Applications of Numerical Algebraic Geometry, II*

1:00 pm–3:50 pm *Fusion Categories and Quantum Symmetries, II*

AMS SPECIAL SESSIONS

1:00 pm–3:50 pm *History of Mathematics, IV (AMS-MAA-ICHM)*

1:00 pm–4:10 pm **AMS CONTRIBUTED PAPER SESSIONS**

1:00 pm–4:10 pm **MAA GENERAL CONTRIBUTED PAPER SESSIONS**

MAA CONTRIBUTED PAPER SESSIONS

1:00 pm–4:10 pm *Innovative Strategies to Inspire & Prepare Potential STEM Majors Who Are Not Yet Ready for Calculus*

1:00 pm–4:10 pm *Methods of Engaging Math Learners with Physical Impairments*

1:00 pm–4:10 pm *Proofs and Mathematical Reasoning in the First Two Years of College*

1:00 pm–4:10 pm *Humanistic Mathematics*

1:00 pm–4:10 pm *Successful Implementation of Innovative Models for Developmental and General Education Mathematics*

1:00 pm–4:10 pm *Incorporating Big Data Ideas in the Mathematics and Statistics Classroom*

1:00 pm–4:10 pm **SIAM MINISYMPOSIUM ON TOPICS IN ANALYSIS AND NUMERICAL METHODS FOR COLLISIONAL KINETIC EQUATIONS**

MAA INVITED PAPER SESSIONS

1:00 pm–4:15 pm *Technical Tools for Mathematical 3D Printing*

2:00 pm–4:00 pm **MAA POSTER SESSION ON PROJECTS SUPPORTED BY THE NSF DIVISION OF UNDERGRADUATE EDUCATION**

2:15 pm–3:05 pm **AMS INVITED ADDRESS** *The many faces of dispersive and wave equations.* **Gigliola Staffilani**

2:35 pm–3:55 pm **MAA PANEL** *The Dolciani Award: Mathematicians in K-16 Education*

2:35 pm–3:55 pm **MAA WORKSHOP** *Course Design with Active Learning*

2:35 pm–3:55 pm	**MAA-AMS-SIAM PANEL** *Multiple Paths to Mathematics Careers in Business, Industry and Government (BIG)*
3:20 pm–4:10 pm	**AMS INVITED ADDRESS** *Galois groups and locally symmetric spaces.* **Richard Taylor**
4:25 pm–5:25 pm	**JOINT PRIZE SESSION**
5:30 pm–6:00 pm	**SIGMAA ON STATISTICS EDUCATION RECEPTION**
5:30 pm–6:30 pm	**JOINT PRIZE SESSION RECEPTION**
5:30 pm–7:00 pm	**MAA SPECIAL PRESENTATION: POETRY + MATH.**
5:30 pm–7:30 pm	**ASSOCIATION OF CHRISTIANS IN THE MATHEMATICAL SCIENCES RECEPTION AND LECTURE**
5:30 pm–7:30 pm	**BUDAPEST SEMESTERS IN MATHEMATICS ALUMNI REUNION**
5:45 pm–7:00 pm	**MAA TWO-YEAR COLLEGE RECEPTION**
6:00 pm–6:45 pm	**SIGMAA ON STATISTICS EDUCATION BUSINESS MEETING**
6:00 pm–7:00 pm	**SIGMAA ON MATHEMATICAL AND COMPUTATIONAL BIOLOGY RECEPTION AND BUSINESS MEETING**
6:00 pm–7:00 pm	**WORKSHOP FOR RESEARCHERS "GET YOUR PAPER PUBLISHED"**
6:00 pm–8:00 pm	**ANNUAL RECEPTION FOR LESBIAN, GAY, BISEXUAL, AND TRANSGENDERED MATHEMATICIANS**
6:00 pm–8:00 pm	**UNIVERSITY OF WATERLOO ALUMNI AND FRIENDS RECEPTION**
6:30 pm–8:00 pm	**MSRI RECEPTION FOR NEW AND PROSPECTIVE DONORS**
6:30 pm–8:30 pm	**PROMYS AND ROSS GATHERING FOR ALUMNI AND FRIENDS**
6:50 pm–7:40 pm	**SIGMAA ON STATISTICS EDUCATION GUEST LECTURE**
7:00 pm–7:50 pm	**SIGMAA ON MATHEMATICAL AND COMPUTATIONAL BIOLOGY GUEST LECTURE**
7:00 pm–8:00 pm	**GEORGE WASHINGTON UNIVERSITY MATH ALUMNI RECEPTION**

Friday, January 06

7:30 am–4:00 pm	**JOINT MEETINGS REGISTRATION**
7:30 am–9:00 pm	**E-MAIL CENTER**
7:34 am– 8:00 am	**YP17 HCSSIM REUNION BREAKFAST**
8:00 am– 9:20 am	**MAA PANEL** *Developing the MAA Instructional Practices Guide*
	AMS SPECIAL SESSIONS
8:00 am–10:50 am	*Research in Mathematics by Undergraduates and Students in Post-Baccalaureate Programs, II (AMS-MAA-SIAM)*
8:00 am–10:50 am	*Symplectic Geometry, Moment Maps and Morse Theory, I (AMS-AWM)*
8:00 am–10:50 am	*Recent Progress on Nonlinear Dispersive and Wave Equations, II*
8:00 am–10:50 am	*Mapping Class Groups and their Subgroups, I*
8:00 am–10:50 am	*Ergodic Theory and Dynamical Systems, I*
8:00 am–10:50 am	*Topics in Graph Theory, I*
8:00 am–10:50 am	*Discrete Geometry and Convexity (Dedicated to András Bezdek on the occasion of his 60th birthday), I*
8:00 am–10:50 am	*Spectral Calculus & Quasilinear Partial Differential Equations, II*
8:00 am–10:50 am	*Complex Analysis and Special Functions, I*
8:00 am–10:50 am	*Inverse Problems and Applications, I*
8:00 am–10:50 am	*Advances in Mathematics of Ecology, Epidemiology and Immunology of Infectious Diseases, I*
8:00 am–10:50 am	*Advances in Operator Algebras, I*
8:00 am–10:50 am	*Symmetries, Integrability, and Beyond, I*
8:00 am–10:50 am	*Representations and Related Geometry in Lie Theory, I*
8:00 am–10:50 am	*Quantum Groups, I*
8:00 am–10:50 am	*Partition Theory and Related Topics, I*
8:00 am–10:50 am	*Operator Theory, Function Theory, and Models, I*
8:00 am–10:50 am	*Automorphic Forms and Arithmetic, I*
8:00 am–10:50 am	*Mathematics and Music, I*
	MAA INVITED PAPER SESSIONS
8:00 am–10:50 am	*L-functions and Other Animals, I*

8:00 am–10:50 am	*Research in Improving Undergraduate Mathematical Sciences Education: Examples Supported by the National Science Foundation's IUSE: EHR Program*
8:00 am–10:55 am	**AMS CONTRIBUTED PAPER SESSIONS**
8:00 am–10:55 am	**ASL INVITED ADDRESSES**
	MAA CONTRIBUTED PAPER SESSIONS
8:00 am–10:55 am	*Humor and Mathematics*
8:00 am–10:55 am	*Innovative and Effective Ways to Teach Linear Algebra*
8:00 am–10:55 am	*Revitalizing Complex Analysis*
8:00 am–10:55 am	*Unexpected Topics for a Math Circle*
8:00 am–10:55 am	*Preserving and Writing the History of Mathematics Departments*
8:00 am–10:55 am	**MAA GENERAL CONTRIBUTED PAPER SESSIONS**
8:00 am–10:55 am	**SIAM MINISYMPOSIUM ON RECENT ADVANCES IN UNCERTAINTY QUANTIFICATION**
8:00 am–12:00 pm	*Mathematics Experiences and Projects in Business, Industry, and Government*
8:00 am– 5:30 pm	**EMPLOYMENT CENTER**
8:30 am–10:30 am	**AMS-MAA GRAD SCHOOL FAIR** *Undergrads! Take this opportunity to meet representatives from mathematical science graduate programs.*
9:00 am– 9:50 am	**MAA RETIRING PRESIDENTIAL ADDRESS** *Mathematics for human flourishing.* **Francis Su**
9:00 am–11:00 am	**MAA MINICOURSE #12: PART B** *Teaching Introductory Statistics, GAISE 2016*
9:00 am–11:00 am	**MAA MINICOURSE #4: PART B** *Incorporating Randomization Methods into Introductory Statistics*
9:00 am–11:00 am	**MAA MINICOURSE #8: PART B** *(Re)Designing Your Own Mathematics Course using Backwards Course Design*
9:35 am–10:55 am	**MAA PANEL** *Insights from MAA studies of College Algebra, Precalculus, and Calculus*
10:05 am–10:55 am	**AMS INVITED ADDRESS** *A tale of rigidity and flexibility–discrete subgroups of higher rank Lie groups.* **Anna Wienhard**
10:30 am–11:00 am	**RADICAL DASH PRIZE SESSION**
11:10 am–12:00 pm	**AMS-MAA INVITED ADDRESS** *Distance Correlation Coefficients: A New Tool for Detecting Association and Measuring Correlation Between Data Sets.* **Donald Richards**
12:00 pm– 1:00 pm	**BUDAPEST SEMESTERS IN MATHEMATICS EDUCATION INFORMATIONAL SESSION**
1:00 pm– 2:00 pm	**AMS COLLOQUIUM LECTURES: LECTURE III** *The focusing energy critical wave equation: the non-radial case.* **Carlos E. Kenig**
1:00 pm– 1:50 pm	**MAA LECTURE FOR STUDENTS** *Take What You Have Gathered from Coincidence: Understanding and Using Randomness.* **Matthew Richey**
	MAA INVITED PAPER SESSIONS
1:00 pm– 2:50 pm	*L-functions and Other Animals, II*
1:00 pm– 3:00 pm	**MAA MINICOURSE #14: PART B** *Teaching Quantitative Reasoning with Common Sense and Common Knowledge*
1:00 pm– 3:00 pm	**MAA MINICOURSE #2: PART B** *Directing Undergraduate Research*
1:00 pm– 3:00 pm	**MAA MINICOURSE #3: PART B** *Flipping your Linear Algebra Course using Open Educational Resources*
1:00 pm– 4:00 pm	**NAM GRANVILLE-BROWNE-HAYNES SESSION OF PRESENTATIONS BY RECENT DOCTORAL RECIPIENTS IN THE MATHEMATICAL SCIENCES**
1:00 pm– 4:45 pm	**CURRENT EVENTS BULLETIN**
	AMS SPECIAL SESSIONS
1:00 pm– 5:50 pm	*Symplectic Geometry, Moment Maps and Morse Theory, II (AMS-AWM)*
1:00 pm– 5:50 pm	*Public School Districts and Higher Education Mathematics Partnerships, I*
1:00 pm– 5:50 pm	*Mapping Class Groups and their Subgroups, II*
1:00 pm– 5:50 pm	*Topics in Graph Theory, II*
1:00 pm– 5:50 pm	*Quaternions, I*
1:00 pm– 5:50 pm	*Real Discrete Dynamical Systems with Applications, I*
1:00 pm– 5:50 pm	*Discrete Geometry and Convexity (Dedicated to András Bezdek on the occasion of his 60th birthday), II*
1:00 pm– 5:50 pm	*Women in Topology, I*
1:00 pm– 5:50 pm	*Inverse Problems and Applications, II*

1:00 pm–5:50 pm	*Advances in Operator Algebras, II*
1:00 pm–5:50 pm	*ApREUF: Applied Research Experience for Undergraduate Faculty, I*
1:00 pm–5:50 pm	*Symmetries, Integrability, and Beyond, II*
1:00 pm–5:50 pm	*Dynamics of Fluids and Nonlinear Waves, I*
1:00 pm–5:50 pm	*Representations and Related Geometry in Lie Theory, II*
1:00 pm–5:50 pm	*Quantum Groups, II*
1:00 pm–5:50 pm	*Partition Theory and Related Topics, II*
1:00 pm–5:50 pm	*Operator Theory, Function Theory, and Models, I*
1:00 pm–5:50 pm	*Automorphic Forms and Arithmetic, II*
1:00 pm–5:50 pm	*Commutative Algebra: Research for Undergraduate and Early Graduate Students, I*
1:00 pm–5:55 pm	**AMS CONTRIBUTED PAPER SESSIONS**
1:00 pm–5:55 pm	**MAA GENERAL CONTRIBUTED PAPER SESSIONS**
1:00 pm–6:00 pm	**ASL INVITED ADDRESSES**
	MAA CONTRIBUTED PAPER SESSIONS
1:00 pm–6:00 pm	*Trends in Undergraduate Mathematical Biology Education*
1:00 pm–6:00 pm	*Inquiry-Based Teaching and Learning*
1:00 pm–6:00 pm	*Preparing Pre-service and In-service Teachers to Support the Common Core State Standards Assessments*
1:00 pm–6:00 pm	*Modern Data Sets for the Intro Statistics Classroom and Beyond*
1:00 pm–6:00 pm	**SIAM MINISYMPOSIUM ON APPLICATIONS OF ALGEBRA, GEOMETRY, AND TOPOLOGY**
2:15 pm–4:00 pm	**ROCKY MOUNTAIN MATHEMATICS CONSORTIUM BOARD OF DIRECTORS MEETING**
2:30 pm–3:50 pm	**PRESENTATIONS BY MAA TEACHING AWARD RECIPIENTS**
2:30 pm–4:00 pm	**AMS COMMITTEE ON SCIENCE POLICY PANEL DISCUSSION** *Grassroots Advocacy for Mathematics and Science Policy*
2:35 pm–3:55 pm	**MAA PANEL** *Highlighting Contributions to Mathematics Education from Members of Departments of Mathematical Sciences*
3:30 pm–5:00 pm	**MAA MINICOURSE #16: PART B** *Using and Making Integrated Online Textbooks with MathBook XML*
3:30 pm–5:30 pm	**MAA MINICOURSE #1: PART B** *Complex Analysis and Geometry/Topology as Introductions to Proofs Courses*
3:30 pm–5:30 pm	**MAA MINICOURSE #6: PART B** *Linear Algebra in Computer Graphics and Data Mining*
4:30 pm–6:00 pm	**MAA STUDENT POSTER SESSION**
5:00 pm–7:00 pm	**MAA PANEL DISCUSSION:** *Actuarial Science at the JMM: 25 Years and Counting*
5:30 pm–6:00 pm	**SIGMAA ON MATHEMATICS INSTRUCTION USING THE WEB (WEB SIGMAA) RECEPTION**
5:30 pm–6:20 pm	**SIGMAA ON BUSINESS, INDUSTRY, AND GOVERNMENT (BIG SIGMAA) GUEST LECTURE**
5:30 pm–7:30 pm	**TEXAS A&M UNIVERSITY MATHEMATICS DEPARTMENT ALUMNI, STUDENT, AND FACULTY RECEPTION**
5:30 pm–7:30 pm	**UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN DEPARTMENT OF MATHEMATICS ALUMNI RECEPTION**
6:00 pm–6:50 pm	**SIGMAA ON MATHEMATICS INSTRUCTION USING THE WEB (WEB SIGMAA) GUEST LECTURE**
6:00 pm–7:00 pm	**MATHEMATICALLY BENT THEATER** *Performed by Colin Adams and the Mobiusbandaid Players*
6:00 pm–7:00 pm	**AMS MATHEMATICAL REVIEWS RECEPTION**
6:00 pm–7:15 pm	**AWM WORKSHOP POSTER PRESENTATIONS AND RECEPTION**
6:00 pm–8:40 pm	**NAM RECEPTION AND BANQUET**
6:20 pm–7:00 pm	**SIGMAA ON BUSINESS, INDUSTRY, AND GOVERNMENT (BIG SIGMAA) RECEPTION**
7:00 pm–7:30 pm	**SIGMAA ON BUSINESS, INDUSTRY, AND GOVERNMENT (BIG SIGMAA) BUSINESS MEETING**
7:45 pm–8:35 pm	**NAM COX-TALBOT ADDRESS** *Title to be announced.* **Garikai Campbell**
8:00 pm–10:00 pm	**BACKGAMMON!**
8:00 pm–10:00 pm	**PROJECT NExT RECEPTION** *All Project NExT Fellows, consultants, and other friends of Project NExT are invited.*

Saturday, January 07

7:30 am–2:00 pm **JOINT MEETINGS REGISTRATION**

7:30 am–2:00 pm **E-MAIL CENTER**

8:00 am–10:55 am **AMS CONTRIBUTED PAPER SESSIONS**

8:00 am–10:55 am **MAA GENERAL CONTRIBUTED PAPER SESSIONS**

AMS SPECIAL SESSIONS

8:00 am–11:50 am *Research in Mathematics by Undergraduates and Students in Post-Baccalaureate Programs, III (AMS-MAA-SIAM)*

8:00 am–11:50 am *Teaching Assistant Development Programs: Why and How?, I*

8:00 am–11:50 am *Ergodic Theory and Dynamical Systems, II*

8:00 am–11:50 am *Minimal Integral Models of Algebraic Curves, I*

8:00 am–11:50 am *Continued Fractions, I*

8:00 am–11:50 am *PDE Analysis on Fluid Flows, I*

8:00 am–11:50 am *Complex Analysis and Special Functions, II*

8:00 am–11:50 am *Mathematics of Signal Processing and Information, I*

8:00 am–11:50 am *New Developments in Noncommutative Algebra & Representation Theory, I*

8:00 am–11:50 am *Advances in Mathematics of Ecology, Epidemiology and Immunology of Infectious Diseases, II*

8:00 am–11:50 am *Open & Accessible Problems for Undergraduate Research, I*

8:00 am–11:50 am *Graphs and Matrices, I*

8:00 am–11:50 am *Analytic Number Theory and Arithmetic, I*

8:00 am–11:50 am *Applications of Partially Ordered Sets in Algebraic, Topological, and Enumerative Combinatorics, I*

8:00 am–11:50 am *Women in Analysis (In Honor of Cora Sadosky), I*

8:00 am–11:50 am *Inverse Problems and Multivariate Signal Analysis, I*

8:00 am–11:50 am *Group Actions and Geometric Structures, I*

8:00 am–11:50 am *Mathematics and Music, II*

MAA INVITED PAPER SESSIONS

8:00 am–11:50 am *Current Trends in Mathematical and Computational Biology*

8:00 am–12:00 pm **ASL INVITED ADDRESSES**

MAA CONTRIBUTED PAPER SESSIONS

8:00 am–12:00 pm *Me and My Gadgets—Teaching with Technology*

8:00 am–12:00 pm *The Advancement of Open Educational Resources*

8:00 am–12:00 pm *PIC Math and Preparing Students for Nonacademic Careers*

8:00 am–12:00 pm *The Creation and Implementation of Effective Homework Assignments*

8:00 am–12:00 pm *Intertwining Mathematics with Social Justice in the Classroom*

8:00 am–12:00 pm **SIAM MINISYMPOSIUM ON MATHEMATICS OF PLANET EARTH**

8:00 am–5:00 pm **AWM WORKSHOP: SPECIAL SESSION ON NUMBER THEORY**

AMS SPECIAL SESSIONS

8:30 am–11:50 am *Recent Progress on Nonlinear Dispersive and Wave Equations, III*

MAA INVITED PAPER SESSIONS

8:30 am–10:50 am *New Directions in Quantitative Literacy for General Education, in honor of Lynn Steen*

9:00 am–9:50 am **AMS INVITED ADDRESS** *Title to be announced.* **Tobias Colding**

9:00 am–9:50 am **NAM PANEL DISCUSSION** *Transforming Post-Secondary Education (TPSE) Mathematics: Implications for the Preparation of African American Undergraduates and Institutions*

9:00 am–10:20 am **MAA PANEL DISCUSSION** *Roadblocks for Implementing Active Learning Strategies in Calculus Courses*

9:00 am–10:20 am **MAA PANEL** *Outside the Equation - Exploring Alternative Forms of Mathematical Communication*

9:00 am–10:20 am **MAA WORKSHOP** *Using Interactive Dynamic Technology in Teaching Introductory Statistics: Simulation-Based Inference*

9:00 am–11:00 am **MAA MINICOURSE #10: PART B** *Teaching an Applied Topology Course*

9:00 am–11:00 am **MAA MINICOURSE #11: PART B** *Teaching an Introduction to the Mathematics of Computer Graphics*

9:00 am–11:00 am **MAA MINICOURSE #9: PART B** *Statistical Education of Teachers*

9:00 am–12:00 pm **EMPLOYMENT CENTER**

10:00 am–10:50 am **NAM BUSINESS MEETING**

10:05 am–10:55 am	**MAA INVITED ADDRESS** *Finding meaningful patterns: the decoding of the human microbiome.* **Susan Holmes**
10:35 am–11:55 am	**MAA PANEL** *The Impact of High School Calculus on the Transition to College Mathematics*
10:35 am–11:55 am	**MAA PANEL** *What We Talk About When We Talk About Mathematics*
11:00 am–12:00 pm	**SIGMAA ON MATH CIRCLES FOR STUDENTS AND TEACHERS (SIGMAA MCST) SPECIAL PRESENTATION** *Math Circle Demonstration*
11:10 am–11:40 am	**MAA BUSINESS MEETING**
11:45 am–12:15 pm	**AMS BUSINESS MEETING**
1:00 pm– 1:50 pm	**NAM CLAYTOR-WOODARD LECTURE** *Paths of minimal lengths on the set of exact differential k-forms.* **Wilfrid Gangbo**
1:00 pm– 2:20 pm	**MAA PANEL** *SAT Test Development Committee Reflections*
1:00 pm– 2:30 pm	**SIGMAA ON MATH CIRCLES FOR STUDENTS AND TEACHERS** *Math Wrangle.*
1:00 pm– 3:00 pm	**MAA MINICOURSE #13: PART B** *Teaching Modeling-First Differential Equations–Technology and Complete End Game Efforts*
1:00 pm– 3:00 pm	**MAA MINICOURSE #15: PART A** *Unraveling Four Interesting Ciphers*
1:00 pm– 3:00 pm	**MAA MINICOURSE #7: PART B** *Mathematical Modeling Contest Papers: Insights for Instructors and Students*
	MAA CONTRIBUTED PAPER SESSIONS
1:00 pm– 5:30 pm	*Women in Mathematics*
1:00 pm– 5:30 pm	*Do Mathematicians Really Need Philosophy?*
1:00 pm– 5:30 pm	*The Teaching and Learning of Undergraduate Ordinary Differential Equations*
1:00 pm– 5:30 pm	*Discrete Mathematics in the Undergraduate Curriculum - Ideas and Innovations for Teaching*
1:00 pm– 5:30 pm	**SIAM MINISYMPOSIUM ON PDES IN BIOLOGY AND MATERIALS SCIENCE**
	AMS SPECIAL SESSIONS
1:00 pm– 5:50 pm	*Research in Mathematics by Undergraduates and Students in Post-Baccalaureate Programs, IV (AMS-MAA-SIAM)*
1:00 pm– 5:50 pm	*Teaching Assistant Development Programs: Why and How?, II*
1:00 pm– 5:50 pm	*The Modeling First Approach to Teaching Differential Equations, I*
1:00 pm– 5:50 pm	*Minimal Integral Models of Algebraic Curves, II*
1:00 pm– 5:50 pm	*Continued Fractions, II*
1:00 pm– 5:50 pm	*PDE Analysis on Fluid Flows, II*
1:00 pm– 5:50 pm	*Mathematics of Signal Processing and Information, II*
1:00 pm– 5:50 pm	*New Developments in Noncommutative Algebra & Representation Theory, II*
1:00 pm– 5:50 pm	*Open & Accessible Problems for Undergraduate Research, II*
1:00 pm– 5:50 pm	*NSFD Discretizations: Recent Advances, Applications, and Unresolved Issues, I*
1:00 pm– 5:50 pm	*Graphs and Matrices, II*
1:00 pm– 5:50 pm	*Advanced Mathematical Programming and Applications, I*
1:00 pm– 5:50 pm	*Analytic Number Theory and Arithmetic, II*
1:00 pm– 5:50 pm	*Measure and Measurable Dynamics (In Memory of Dorothy Maharam, 1917-2014), I*
1:00 pm– 5:50 pm	*Applications of Partially Ordered Sets in Algebraic, Topological, and Enumerative Combinatorics, II*
1:00 pm– 5:50 pm	*Women in Analysis (In Honor of Cora Sadosky), II*
1:00 pm– 5:50 pm	*Pure and Applied Talks by Women Math Warriors Presented by EDGE (Enhancing Diversity in Graduate Education), I*
1:00 pm– 5:50 pm	*Inverse Problems and Multivariate Signal Analysis, II*
1:00 pm– 5:50 pm	*Group Actions and Geometric Structures, II*
1:00 pm– 5:55 pm	**AMS CONTRIBUTED PAPER SESSIONS**
1:00 pm– 5:55 pm	**MAA GENERAL CONTRIBUTED PAPER SESSIONS**
1:00 pm– 6:00 pm	**ASL INVITED ADDRESSES**
2:35 pm– 3:55 pm	**MAA PANEL** *Introductory Statistics: Where Are We and Where Do We Need to Go?*
3:00 pm– 4:00 pm	**MAA-AMS-SIAM GERALD AND JUDITH PORTER PUBLIC LECTURE** *Mathematics for Art Investigation.* **Ingrid Daubechies**
6:30 pm– 7:30 pm	**AMS DINNER RECEPTION**
7:30 pm–10:30 pm	**AMS DINNER CELEBRATION**

2017 Joint Mathematics Meetings Advance Registration/Housing Form

JOINT MATHEMATICS MEETINGS
ATLANTA JAN 4-7, 2017
AMERICAN MATHEMATICAL SOCIETY
MATHEMATICAL ASSOCIATION OF AMERICA

Name _____
(please write name as you would like it to appear on your badge)

Mailing Address _____

_____

Telephone _____ Fax: _____

In case of emergency (for you) at the meeting, call: Day #_____ Evening #:_____

Email Address _____ Additional email address for receipt_____

Acknowledgment of this registration and any hotel reservations will be sent to the email address(es) given here. **Check this box to receive a copy in U.S. Mail:** ☐

Affiliation for badge _____ (company/university) Nonmathematician guest badge name: _____ (Note fee of US$20

☐ **I DO NOT want my program and badge to be mailed to me on 12/9/16. (Materials will be mailed to the address listed above unless you check this box.)**

Registration Fees

Membership please ✓ all that apply. First row is eligible to register as a member.
For undergraduate students, membership in PME and KME also applies.
☐ AMS ☐ MAA ☐ ASL ☐ CMS ☐ SIAM
Undergraduate Students Only: ☐ PME ☐ KME
Other Societies: ☐ AWM ☐ NAM ☐ YMN ☐ AMATYC

Joint Meetings	**by Dec 20**	**at mtg**	**Subtotal**
☐ Member AMS, MAA, ASL, CMS, or SIAM	US$ 316	US$ 416	
☐ Nonmember	US$ 502	US$ 640	
☐ Graduate Student Member (AMS, MAA ASL, CMS, or SIAM)	US$ 71	US$ 83	
☐ Graduate Student (Nonmember)	US$113	US$ 125	
☐ Undergraduate Student (Member AMS, ASL, CMS, MAA, PME, KME, or SIAM)	US$ 71	US$ 83	
☐ Undergraduate Student (Nonmember)	US$113	US$ 125	
☐ High School Student	US$ 7	US$ 13	
☐ Unemployed	US$ 71	US$ 83	
☐ Temporarily Employed	US$ 258	US$ 295	
☐ Developing Countries Special Rate	US$ 71	US$ 83	
☐ Emeritus Member of AMS or MAA	US$ 71	US$ 83	
☐ High School Teacher	US$ 71	US$ 83	
☐ Librarian	US$ 71	US$ 83	
☐ Press	US$ 0	US$ 0	
☐ Exhibitor (Commercial)	US$ 0	US$ 0	
☐ Artist Exhibitor (work in JMM Art Exhibit)	US$ 0	US$ 0	
☐ Nonmathematician Guest of registered mathematician	US$ 20	US$ 20	

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AMS Short Course: *Random Growth Models (1/2-1/3)*

☐ Member of AMS	US$ 112	US$146	
☐ Nonmember	US$ 170	US$200	
☐ Student, Unemployed, Emeritus	US$ 60	US$ 81	

$_____

MAA Minicourses (see listing in text)
I would like to attend: ☐ One Minicourse ☐ Two Minicourses
Please enroll me in MAA Minicourse(s) #_____ and #_____
Price: US$ 100 for each minicourse.
(For more than 2 minicourses, call or email the MMSB.) $_____

Graduate School Fair
☐ Graduate Program Table (includes table, posterboard & electricity) US$ 80 US$ 80 $_____

Receptions & Banquets
☐ Graduate Student/First-Time Attendee Reception (1/4) (no charge)
☐ NAM Banquet (1/6)
#____Chicken #____Braised Short Ribs #____Veg US$ 65
#____Kosher (*Additional fees apply for Kosher Meals.*) US$ 104
Total for NAM Banquet $_____

☐ AMS Dinner (1/7) Regular Price #____US$ 69
Student Price #____US$ 30
Total for AMS Dinner $_____

Total for Registrations and Events $_____

Registration for the Joint Meetings is not required for the short course but it is required for the minicourses and the Employment Center. To register for the Employment Center, go to http://www.ams.org/profession/employment-services/employment-center. For questions, email: emp-info@ams.org.

Payment

Registration & Event Total (total from column on left) $ _____

Hotel Deposit (only if paying by check) $ _____
If you send a hotel deposit check, the deadline for this form is December 1.

Total Amount To Be Paid **$** _____

Method of Payment
☐ **Check**. Make checks payable to the AMS. For all check payments, please keep a copy of this form for your records.

☐ **Credit Card**. All major credit cards accepted. For your security, we do not accept credit card numbers by postal mail, email or fax. If the MMSB receives your registration form by fax or postal mail, it will contact you at the phone number provided on this form. For questions, contact the MMSB at mmsb@ams.org.

Signature: _____

☐ **Purchase Order #** _____ (please enclose copy)

Other Information

Mathematical Reviews field of interest #_____
☐ I am willing to serve as a judge for the MAA Undergraduate Student Poster Session
☐ For planning purposes for the MAA Two-year College Reception, please check if you are a faculty member at a two-year college.
☐ I am a mathematics department chair.
☐ Please do not include my name and postal address on any promotional mailing lists. (The JMM does not share email addresses.)
☐ Please do not include my name on any list of JMM participants other than the scientific program if I am, in fact, making a presentation that is part of the meeting.
☐ Please ✓ this box if you have a disability requiring special services.

Deadlines

To receive badges/programs in the mail:	**Nov. 22, 2016**
Hotel reservations with check deposit:	**Dec. 1, 2016**
Hotel reservations, changes/cancellations through the JMM website:	**Dec. 6, 2016**
Advance registration for the Joint Meetings, short course, minicourses, and tickets:	**Dec. 20, 2016**
50% refund on advance registration, banquets, minicourses, and short course, cancel by	**Dec. 29, 2016***

***no refunds issued after this date.**

Mailing Address/Contact:

Mathematics Meetings Service Bureau (MMSB)
P. O. Box 6887
Providence, RI 02940-6887 Fax: 401-455-4004; **Email:** mmsb@ams.org
Telephone: 401-455-4144 or 1-800-321-4267 x4144 or x4137

2017 Joint Mathematics Meetings Hotel Reservations – Atlanta, GA

Please see the hotel information in the announcement or on the web for detailed information on each hotel.) To ensure accurate assignments, please rank hotels in order of preference by writing 1, 2, 3, etc. in the column on the left and by circling the requested bed confirguration. If your requested hotel and room type is no longer available, you will be assigned a room at the next available comparable rate. Please call the MMSB for details on suite configurations, sizes, availability, etc. All reservations, including suite reservations, must be made through the MMSB to receive the JMM rates. Reservations made directly with the hotels before **December 14, 2016** may be changed to a higher rate. All rates are subject to applicable local and state taxes in effect at the time of check-in; currently 16% state tax, (8% State Sales Tax plus 8% Hotel Occupancy Tax), plus an additional State of Georgia Hotel/Motel fee of US$5 per day. **Guarantee requirements: First night deposit by check (add to payment on reverse of form) or a credit card guarantee. Please note that reservations with check deposits must be received by the MMSB by December 1, 2016.**

☐ **Deposit enclosed (see front of form**)
☐ **Hold with my credit card**. **For your security, we do not accept credit card numbers by postal mail, email or fax.** If the MMSB receives your registration form by postal mail or fax, we will contact you at the phone number provided on the reverse of this form.

Date and Time of Arrival _____ **Date and Time of Departure** _____ **Number of adult guests in room** _____ **Number of children** _____

Name of Other Adult Room Occupant (s) _____ **Arrival Date** _____ **Departure Date** _____

Housing Requests:.(example: rollaway cot, crib, nonsmoking room, low floor) _____

☐ I have disabilities as defined by the ADA that require a sleeping room that is accessible to the physically challenged. My needs are: _____

☐ I am a member of a hotel frequent-travel club and would like to receive appropriate credit. The hotel chain and card number are: _____

☐ I am not reserving a room. I am sharing with _____, who is making the reservation.

Order of choice	Hotel	Single	Double 1 bed-2 people	Double 2 beds- 2 people	Triple 3 adults-2 beds	Quad 4 adults-2 beds	Rollaway Cot Fee (add to special requests if reserving online)
	Hyatt Regency Atlanta (co-hqtrs)	US$ 175	US$ 175	US$ 175	US$ 195	US$ 215	Rollaways available (at no charge) only in king-bedded rooms.
	Student Rate	US$ 140	US$ 140	US$ 140	US$ 160	UD$ 180	
	Marriott Marquis Atlanta (co-hqtrs)	US$ 175	US$ 175	US$ 175	US$ 175	US$ 175	Rollaways available (at no charge) only in king-bedded rooms.
	Student Rate	US$ 140	US$ 140	US$ 140	US$ 140	US$ 140	
	Hilton Atlanta - First Tier (Rooms will be available at this price until they run out. When they run out, rooms will be priced at second tier	US$ 139	US$ 139	US$ 139	US$ 159	US$ 179	Rollaways available (at no charge) only in king-bedded rooms.
	Hilton Atlanta - Second Tier	US$ 149	US$ 149	US$ 149	US$ 169	US$ 189	

People interested in suites should contact the MMSB directly by email at mmsb@ams.org or by calling 800-321-4267, ext. 4137 or 4144; (401-455-4137 or 401-455-4144).

American Mathematical Society
Distribution Center

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